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PREFACE

This appendix, Appendix C to Volume II, Mission Concept Reference Data, presents the detailed mission definitions and user mission requirements for each mission defined in the Space Station Mission Model.

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Page

PLANETARY SCIENCE

EARTH OBSERVATION

SPACE PHYSICS

Page

SPACE PHYSICS (Con't)

ASTRONOMY

SOLAR ASTRONOMY

CONTENTS APPENDIX C (Con't)

CONTENTS APPENDIX C (Con't)

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Planetary Science

TITLE: Venus Radar Mapper (VRM)

PRINCIPAL CONTRACT: D. S. Briggs

ORGANIZATION: NASA/HQ, JPL

MMC CONTRACT: F. Bartko

PROGRAM OBJECTIVE: Perform high resolution (~1 km) geophysical mapping by SAR of the Venus surface.

PROGRAM STATUS: Planned program; new start mission for 1984.

SYSTEM DESCRIPTION: An orbiter spacecraft, based on existing spacecraft hardware, which will accommodate a Synthetic Aperture Radar (SAR), plus required support spacecraft systems.

SYSTEM OPERATION: Free-flyer spacecraft.

SYSTEM INTEGRATION: Provide interfaces for possible onorbit integration.

SUBSYSTEM SUPPORT: N/A

BENEFITS:

Space Station Utilization: Secondary launch platform possible deep space mission data link.

Man's Role: N/A

Synergistic Advantages: ---

Direct Benefits: Scientific research

REFERENCES:

1. National Space Club Converence Proceedings, June 1982, J. Moore: "Effective Planetary Exploration at Low Cost," Astronautics and Aeronautics, October 1982.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Planetary Science

TITLE: Comet Rendezvous

PRINCIPAL CONTRACT: Dr. G. Briggs

ORGANIZATION: NASA/HQ

MMC CONTRACT: F. Bartko

PROGRAM OBJECTIVE: Reconnaissance mission with periodic comet such as Temple II, and possibly providing a sample return of the correlating plasmas.

PROGRAM STATUS: Mission planned for launch in 1992 time frame.

SYSTEM DESCRIPTION: A spacecraft based on Mariner Mark II technology, employing a scientific instrument package for in situ and remote sensing and for aperture/return of a sample of cometary plasma.

SYSTEM OPERATION: Free-flyer spacecraft.

SYSTEM INTEGRATION: Provide interfaces for onorbit integration.

SUBSYSTEM SUPPORT: N/A

BENEFITS:

Space Station Utilization: Secondary launch platform; possible deep space mission data link; possible quarantine/return plasma sample.

Man's Role: N/A

Synergistic Advantages: ---

Direct Benefits: Scientific research.

REFERENCES:

1. National Space Club Conference Proceedings, June 1982, J. Moore: Effective Planetary Exploration at Low Cost," Astronautics and Aeronautics, October 1982.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Planetary Science

TITLE: Mars Geochemistry/Climatology Orbiter

PRINCIPAL CONTRACT: Dr. G. Briggs

ORGANIZATION: NASA/HQ: JPL

MMC CONTRACT: F. Bartko

PROGRAM OBJECTIVE: Orbiter mission to provide extended time-frame detailed mapping of geophysical properties of Martian surface and of long term behavior of mass atmosphere.

PROGRAM STATUS: Mission planned for launch in 1990 time frame.

SYSTEM DESCRIPTION: A pioneer type spacecraft containing a scientific instrument package for remote sensing of the Martian atmosphere and for detailed geophysical mapping of Martian surface.

SYSTEM OPERATION: Free Flyer Spacecraft.

SYSTEM INTEGRATION: Provide interfaces for possible onorbit integration.

SUBSYSTEM SUPPORT: N/A

BENEFITS:

Space Station Utilization: Secondary launch platform; possible deep space mission data link.

Synergistic Advantages: ---

Direct Benefits: Scientific research

REFERENCES:

1. National Space Club Conference Proceedings, June 1982, J. Moore: Effective Planetary Exploration at Low Cost," Astronautics and Aeronautics, October 1982.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Planetary Science

TITLE: Titan Probe

PRINCIPAL CONTRACT: Dr. G. Briggs

ORGANIZATION: NASA/HQ; JPL

MMC CONTRACT: F. Bartko

PROGRAM OBJECTIVE: Detailed, in situ study of the atmosphere of Titan.

PROGRAM STATUS: Mission planned for launch in the 1994 time frame.

SYSTEM DESCRIPTION: Galileo type spacecraft equipped to perform in situ measurements of the structure and composition of Titan's atmosphere.

SYSTEM OPERATION: Free Flyer Spacecraft.

SYSTEM INTEGRATION: Provide interfaces for onorbit integration.

SUBSYSTEM SUPPORT: N/A

BENEFITS:

Space Station Utilization: Secondary launch platform; possible deep space mission data link.

Man's Role: N/A

Synergistic Advantages: ---

Direct Benefits: Scientific research

REFERENCES:

1. National Space Club Conference Proceedings, June 1982, J. Moore: "Effective Planetary Exploration at Low Cost," Astronautics and Aeronautics, October 1982.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Planetary Science

TITLE: Mars Surface Probe Network

PRINCIPAL CONTRACT: Dr. G. Briggs

ORGANIZATION: NASA/HQ; JPL

MMC CONTRACT: F. Bartko

PROGRAM OBJECTIVE: Perform global, geophysical measurements on Martian surface.

PROGRAM STATUS: Mission planned for implementation on 1994 time frame.

SYSTEM DESCRIPTION: A pioneer class spacecraft, with multiple probes, to be deployed at key locations on the Martian surface, to perform global, geophysical measurements.

SYSTEM OPERATION: Free Flyer Spacecraft.

SYSTEM INTEGRATION: Provide interfaces for onorbit integration.

SUBSYSTEM SUPPORT: N/A

BENEFITS:

Space Station Utilization: Secondary launch platform; possible deep space mission data link.

Man's Role: N/A

Synergistic Advantages: ---

Direct Benefits: Scientific research

REFERENCES:

1. National Space Club Conference Proceedings, June 1982, J. Moore: "Effective Planetary Exploration at Low Cost," Astronautics and Aeronautics, October 1982.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Planetary Science

TITLE: Venus Atmospheric Probe

PRINCIPAL CONTRACT: Dr. G. Briggs

ORGANIZATION: NASA/HQ; JPL

MMC CONTRACT: F. Bartko

PROGRAM OBJECTIVE: Perform physical and chemical measurements of the atmosphere of Venus.

PROGRAM STATUS: Mission planned for launch in the 1995 time frame.

SYSTEM DESCRIPTION: A pioneer type spacecraft with scientific instruments to sample the structure and detailed composition of the Venus atmosphere at key locations.

SYSTEM OPERATION: Free Flyer Spacecraft.

SYSTEM INTEGRATION: Provide interfaces for onorbit integration.

SUBSYSTEM SUPPORT: N/A

BENEFITS:

Space Station Utilization: Secondary launch platform; possible deep space mission data link.

Man's Role: N/A

Synergistic Advantages: ---

Direct Benefits: Scientific research

REFERENCES:

1. National Space Club Conference Proceedings, June 1982, J. Moore: "Effective Planetary Exploration at Low Cost," Astronautics and Aeronautics, October 1982.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Planetary Science

TITLE: Lunar Orbiter

PRINCIPAL CONTRACT: Dr. G. Briggs

ORGANIZATION: NASA/HQ; JPL

MMC CONTRACT: F. Bartko

PROGRAM OBJECTIVE: Perform detailed geophysical/geochemical mapping of Lunar surface.

PROGRAM STATUS: Mission planned for launch in 1992 time frame.

SYSTEM DESCRIPTION: A pioneer type spacecraft, with remote sensing scientific instruments to map the geophysical/chemical characteristics of the Lunar surface.

SYSTEM OPERATION: Free Flyer Spacecraft.

SYSTEM INTEGRATION: Provide interfaces for onorbit integration.

SUBSYSTEM SUPPORT: N/A

BENEFITS:

Space Station Utilization: Secondary launch platform; possible deep space mission data link.

Man's Role: N/A

Synergistic Advantages: ---

Direct Benefits: Scientific research

REFERENCES:

1. National Space Club Conference Proceedings, June 1982, J. Moore: "Effective Planetary Exploration at Low Cost," Astronautics and Aeronautics, October 1982.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Planetary Science

TITLE: Mars Aeronomy Orbiter

PRINCIPAL CONTRACT: Dr. G. Briggs

ORGANIZATION: NASA/HQ; JPL

MMC CONTRACT: F. Bartko

PROGRAM OBJECTIVE: Perform detailed operations on the structure, composition and dynamics of the ionosphere of Mars.

PROGRAM STATUS: Mission planned for launch in 1991 time frame.

SYSTEM DESCRIPTION: A pioneer type spacecraft including a complement of scientific instruments to measure the physical and chemical properties of the Martian ionosphere.

SYSTEM OPERATION: Free Flyer Spacecraft.

SYSTEM INTEGRATION: Provide interfaces for onorbit integration.

SUBSYSTEM SUPPORT: N/A

BENEFITS:

Space Station Utilization: Secondary launch platform; possible deep space mission data link.

Man's Role: N/A

Synergistic Advantages: ---

Direct Benefits: Scientific research

REFERENCES:

1. National Space Club Conference Proceedings, June 1982, J. Moore: "Effective Planetary Exploration at Low Cost," Astronautics and Aeronautics, October 1982.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Planetary Science

TITLE: Asteroid Multi Rendezvous (Main-Belt)

PRINCIPAL CONTRACT: Dr. G. Briggs

ORGANIZATION: NASA/HQ; JPL

MMC CONTRACT: F. Bartko

PROGRAM OBJECTIVE: Perform reconnaissance, close-up exploratory observations of several main-belt asteroids.

PROGRAM STATUS: Mission planned for launch in 1993 time frame.

SYSTEM DESCRIPTION: A Mariner Mark II spacecraft with a remote sensing complement of scientific instruments to perform physical characterization and composition studies of sample asteroids on main belt of the solar system.

SYSTEM OPERATION: Free Flyer Spacecraft.

SYSTEM INTEGRATION: Provide interfaces for onorbit integration.

SUBSYSTEM SUPPORT: N/A

BENEFITS:

Space Station Utilization: Secondary launch platform; possible deep space mission data link.

Man's Role: N/A

Synergistic Advantages: ---

Direct Benefits: Scientific research

REFERENCES:

1. National Space Club Conference Proceedings, June 1982, J. Moore: "Effective Planetary Exploration at Low Cost," Astronautics and Aeronautics, October 1982.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Planetary Science

TITLE: Earth Approaching Asteroid Rendezvous

PRINCIPAL CONTRACT: Dr. G. Briggs

ORGANIZATION: NASA/HQ; JPL

MMC CONTRACT: F. Bartko

PROGRAM OBJECTIVE: Reconnaisance mission with asteroids in earth neighborhood.

PROGRAM STATUS: Mission planned for deployment in the 1996 time frame.

SYSTEM DESCRIPTION: A Mariner Mark II spacecraft equipped with scientific instruments to observe the physical and chemical properties of asteroids intersecting near Earth's orbit.

SYSTEM OPERATION: Free Flyer Spacecraft.

SYSTEM INTEGRATION: Provide interfaces for onorbit integration.

SUBSYSTEM SUPPORT: N/A

BENEFITS:

Space Station Utilization: Secondary launch platform; possible deep space mission data link.

Man's Role: N/A

Synergistic Advantages: ---

Direct Benefits: Scientific research

REFERENCES:

1. National Space Club Conference Proceedings, June 1982, J. Moore: "Effective Planetary Exploration at Low Cost," Astronautics and Aeronautics, October 1982.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Planetary Science

TITLE: Saturn Orbiter/Probe

PRINCIPAL CONTRACT: Dr. G. Briggs

ORGANIZATION: NASA/HQ

MMC CONTRACT: F. Bartko

PROGRAM OBJECTIVE: Detailed study of Saturn's atmosphere.

PROGRAM STATUS: Mission planned for launch in the 1994 time frame.

SYSTEM DESCRIPTION: A Galileo type spacecraft with orbiter and probe, equipped with scientific instruments to perform remote sensing and in situ measurements of Saturn's ionosphere and clouds.

SYSTEM OPERATION: Free Flyer Spacecraft.

SYSTEM INTEGRATION: Provide interfaces for onorbit integration.

SUBSYSTEM SUPPORT: N/A

BENEFITS:

Space Station Utilization: Secondary launch platform; possible deep space mission data link.

Man's Role: N/A

Synergistic Advantages: ---

Direct Benefits: Scientific research

REFERENCES:

1. National Space Club Conference Proceedings, June 1982, J. Moore: "Effective Planetary Exploration at Low Cost," Astronautics and Aeronautics, October 1982.

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APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Earth Observations

TITLE: Feature Identfication and Location Experiment

PRINCIPAL CONTACT: Roger Schappell

ORGANIZATION: Martin Marietta Aerospace

MMC CONTACT: Stephen Pompea (303) 977-3808

PROGRAM OBJECTIVE: FILE observes the Earth and classifies the scene as water, bare land, vegetation, clouds, or snow. It has applications as a supervisory sensory that evaluates the scene beneath the Space Station and activates other sensors that are interested in that particular class of scene. FILE sensors allow a reduction in the amount of data transferred to Earth processing stations. It will also permit a power reduction. It has a very wide FOV, wider than other sensors of this type.

PROGRAM STATUS: FILE is operational and has already flown on STS-2 and will be reflown on the Shuttle in 1984. This system cannot differentiate between clouds and snow. A FILE II system that can differentiate between clouds and snow will be flown aboard a fixed wing aircraft in late 1982 and 1983.

SYSTEM DESCRIPTION: FILE would be used in conjunction with other remote sensing systems. It consists of optics, sensors, and software and can rapidly classify earth scenes. Size of system is 6 cubic feet; weight is approximately 70 pounds.

SYSTEM OPERATION: FILE will probably be run nearly continuously to classify scenes and aid in a determination if the area of interest is free of clouds.

SYSTEM INTEGRATION: Earth orientation and altitude are not critical but the sun angle must be larger than 30° from horizon during the light side of the orbit for operation.

SUBSYSTEM SUPPORT:

Power: 100 Watts at 28 volts DC; voltage range 24-32 volts.

Data Management and Communication: TBD

Thermal System: A cold plate to aintain instrument temperature between $0^{\circ}C$ and $25^{\circ}C$.

Point and Stability: Field of view needs to be greater than any other instrument using FILE results. The instrument must be nadir viewing. Pointing requirements are to be determined, but it does need to be highly pointable at different Earth locations.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

BENEFITS:

SPACE STATION UTILIZATION - The space station could be used for maintenance, repair and changeout of this instrument. This is a relatively small instrument. Subsystem elimination is not a significant advantage, since FILE will share power, data, etc with the larger Earth observation instrument it supports. However, FILE can increase the efficiency of other Earth observation instruments.

MAN'S ROLE - Maintenance and repair.

SYNERGISTIC ADVANTAGES - This instrument should always be used in conjunction with a larger instrument such a multispectral mapper or thematic scanner.

DIRECT BENEFITS: FILE provides an efficient way of knowing the feature being observed on the Earth's surface. It enables an efficient allocation of instrument time to be made.

REFERENCES:

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Earth Observations

TITLE: Large Antenna Multifrequency Microwave Radiometer (LAMMR)

PRINCIPAL CONTACT: Larry King

ORGANIZATION: Goddard Space Flight Center

MMC CONTACT: Stephen Pompea

PROGRAM OBJECTIVE: The LAMMR instrument makes passive microwave radiometric observations to develop maps of surface temperature. The LAMMR instrument can also aid in the determination of wind speed, rain rate, and ice characteristics.

PROGRAM STATUS: This is a planned mission.

SYSTEM DESCRIPTION: LAMMR has a large rotating microwave antenna 50^{o} from the local vertical. The antenna will be 4 meters in diameter and rotate once per second. LAMMR has seven to ten channels in the 1.4 to 94 GHz range. Calibration is done with a black body source. The rotating antenna must have a counter-rotating mass so that the net angular momentum is zero.

SYSTEM OPERATION: The instrument could be programmed to turn itself on at specified times. Data needs to be transmitted in near real time for weather forecasting.

SYSTEM INTEGRATION: Orbital altitude preferred is 700 Km, however, other lower altitudes are acceptable. The instrument points 43.6^{o} to nadir. Launch mass is 318 Kg.

SUBSYSTEM SUPPORT:

Power: Operating power is 300 volts.

Data Management and Communication: 64 Kbps is required; Downlink frequency 13,000 MHz.

Thermal System: No cooling required.

Pointing and Stability: Field of view is 100^{o}.

BENEFITS:

SPACE STATION UTILIZATION - Space station can support, maintain and repair this instrument. Dedicated subsystems can be eliminated.

MAN'S ROLE - Man's role is unnecessary.

SYNERGISTIC ADVANTAGES - These measurements can be used in conjunction with atmospheric profile measurements to aid numerical forecasting models.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DIRECT BENEFITS: Surface temperature measurements made by LAMMR at different locations can greatly aid in weather forecasting. Additionally wind speed, rain rate and ice characteristics can also be detected.

REFERENCES:

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Earth Observations

TITLE: Stereo Visual Imager

PRINCIPAL CONTACT: Dr. Sherman Wu

ORGANIZATION: U.S. Geological Survey, Flagstaff, AZ
(602) 779-3311 Ext. 1515

MMC CONTACT: Stephen Pompea (303) 977-3808

PROGRAM OBJECTIVE: To map the Earth's surface accurately using two cameras to obtain a stereo image. This would be particularly valuable for regions previously unmapped by ground or plane. A stereo pair can be obtained using two large format cameras (CCDs are desirable) to photograph an Earth feature as it looms ahead in the orbit and by looking past at it. From the stereo pair of topographic map can be constrcuted.

PROGRAM STATUS: Opportunity; First flight is planned in 1991.

SYSTEM DESCRIPTION: Two large format cameras, utilizing charge coupled devices or photographic film are rigidly attached together. One camera view forward and the other looks behind. The set of photographs produced can give highly accurate topographic maps.

SYSTEM OPERATION:Photos are taken of cloud free areas along with spatial and temporal registration information.

SYSTEM INTEGRATION: Optimum orbit is a polar orbit to obtain world wide coverage. Optimum orbit is: apogee 450 Km, perigee 250 km. If film is used then film changeout is important at regular intervals.

SUBSYSTEM SUPPORT:

Power: TBD

Data Management and Communication: TBD

Thermal System: Nominal 10-30^{o}C

Pointing and Stability: TBD

BENEFITS:

SPACE STATION UTILIZATION - Maintenance, repair, changeout, calibration. Film replacement at regular intervals if film is used. Space platform can provide sophisticated data reduction system. Dedicated subsystems can be eliminated.

MAN'S ROLE - Maintenance and repair

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

SYNERGISTIC ADVANTAGES - Can be used with Synthetic Aperture Radar and multispectral instruments to produce topographic maps with biogeographic features labeled.

DIRECT BENEFITS: Maps can be constructed with greater accuracy using this system. These maps can aid third world developing nations.

REFERENCES:

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Earth Observations

TITLE: Earth radiation Budget Instrument

PRINCIPAL CONTACT: Dr. Ron Greenwood

ORGANIZATION: Ball Aerospace Systems Division, P.O. Box 1062,
Boulder, CO 80306 (303) 441-4854

MMC CONTACT: Stephen Pompea (303) 977-3808

PROGRAM OBJECTIVE: The objective of the Earth radiation budget experiment is tc promote a better understanding of the Earth's energy balance and its effect on climatology. It is particularly concerned with the wavelength band from 0.2 to 50 micrometers.

PROGRAM STATUS: Operational

SYSTEM DESCRIPTION: The instrumentation consists of a set of radiometers covering the spectral band from 0.2 to 50 microns. Simultaneously it will observe the sun at similar and shorter wavelengths. It off points from the Earth in order to calibrate the radiometers by viewing deep space. It uses a bolometer type detector.

SYSTEM OPERATION: This instrument is a free flyer although the instrument could be placed on a space platform. There is a need for supply of attitude control fuels, changeout, maintenance, and inspection.

SYSTEM INTEGRATION:

Orbital Altitude: 450 Km

Inclination: 94°

View Direction: Earth and sun

Launch Mass: 50 Kg

A variety of orbits are possible and desirable. The instrument occasionally points to deep space for self calibration. Instrument is nadir and sun pointing.

SUBSYSTEM SUPPORT:

Power: 55 Volts DC continuous.

Data Management and Communication: 1.3 Kbits per second.

Thermal System: Active

Pointing and Stability: Unknown

SPACE STATION USERS CONCEPT

BENEFITS:

SPACE STATION UTILIZATION - Space station could be used for servicing of free flying ERB satellites. If ERB package is placed on board a space station dedicated subsystems could be eliminated.

MAN'S ROLE - None

SYNERGISTIC ADVANTAGES - This satellite can interact synergistically with solar observing instruments such as UV spectrometers, solar monitors, etc.

DIRECT BENEFITS: These measurements greatly aid climatic models by refined measurements of the solar input reaching the Earth and of Earth radiation being emitted.

REFERENCES:

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Earth Observations

TITLE: Color Scanner

PRINCIPAL CONTACT: Dr. Warren Hovis

ORGANIZATION: NOAA/Ness Code S-32, FOB4 Washington, DC

MMC CONTACT: Stephen Pompea (303) 977-3808

PROGRAM OBJECTIVE: The color scanner maps chlorophyll concentration, sediment distribution, and the temperature of coastal water and the open ocean. Additionally it can monitor ocean pollution by noting water color changes.

PROGRAM STATUS: Operational on Nimbus VII.

SYSTEM DESCRIPTION: The color scanner is a small, imaging instrument.

SYSTEM OPERATION: Looks at coastal ocean areas.

SYSTEM INTEGRATION: Need exists for maintenance and inspection of the Color Scanner while it is on board the platform. Orbital altitude is optimally 800 km, but lower orbits are still feasible. Sun synchronous orbit is preferred.

SUBSYSTEM SUPPORT:

Power: 11.4 Watts

Data Management and Communication: TBD

Thermal System: Nominal

Pointing and Stability: Unknown

BENEFITS:

SPACE STATION UTILIZATION - Changeout, calibration, maintenance, repair.

MAN'S ROLE - Maintenance and repair.

SYNERGISTIC ADVANCTAGES - The color scanner data set can combine with the imaging spectrometer to produce a synergistic effect.

DIRECT BENEFITS: Detection of current boundaries and ocean pollution, sediment distribution, fish distribution.

REFERENCES:

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Earth Observations

TITLE: Ocean Microwave Package

PRINCIPAL CONTACT:

ORGANIZATION:

MMC CONTACT: Stephen Pompea (303) 977-3808

PROGRAM OBJECTIVE: To measure ocean directional wave spectra (Directional wave spectrometer) and to do wide swath current mapping (Multibeam altimeter).

PROGRAM STATUS: Opportunity; funding level unknown.

SYSTEM DESCRIPTION: Consists of two instruments:

1. Multibeam Altimeter - The multibeam altimeter used two antenna interferometric techniques to generate multiple beams on either side of the nadir. It measures elapsed time until the reflected pulse returns.

2. Directional Wave Spectrometer - Conically scans 10^{o} off nadir and measures modulation of backscattered signal at multiple angles.

SYSTEM OPERATION: Supply, changeout, maintenance, and inspection only.

SYSTEM INTEGRATION:

Orbital altitude: 200 Km

Pointing accuracy needs to be 1100 arc seconds.

Launch mass: 200 Kg

Dimensions: 0.5 meters x 0.5 meters x 0.25 meters

Deployed Externally on platform

SPECIAL CONSIDERATIONS

1) 2-1 meter antennas separated by 11 meters
2) 1-3 meter scanning antenna
3) 2 meter diameter X 0.8 m high (one instrument)
4) Needs clear field of view $\pm 10^{o}$ of subplatform track

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

SUBSYSTEM SUPPORT:

Power: 200 volts DC

Data Management and Communication: Data rate 20 Kbits per second; data dump frequence (3.7 GHz)

Thermal System: TBD

Pointing & Stability: Pointing to 1100 arc seconds

BENEFITS:

SPACE STATION UTILIZATION - Recommended to go on platform. Platform can provide dedicated subsystem elimination, long-term operation. Maintenance, changeout, calibration and repair can also be provided to these instruments, probably through STS.

MAN'S ROLE - Maintenance, changeout and repair only.

SYNERGISTIC ADVANTAGES - The data from these instruments can interact synergistically with TOPEX data, scatterometer data, and color scanner data.

DIRECT BENEFITS: - Many benefits to fisheries industries, ship navigation (to take advantage of favorable currents) and to weather forecasting.

REFERENCES:

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Earth Observations

TITLE: Scatterometer

PRINCIPAL CONTACT:

ORGANIZATION: Goddard Space Flight Center, Greenbelt, MD

MMC CONTACT: Stephen Pompea (303) 977-5808

PROGRAM OBJECTIVE: To measure wind speed and direction over a wide swath either side of the point directly below the instrument.

PROGRAM STATUS: Planned; funding level unknown.

SYSTEM DESCRIPTION: This is an active microwave system. The instrument uses the measured amplitude of the back scattered signal from the ocean surface at various angles.

SYSTEM OPERATION: System employs six antennas. It requires an auxiliary rain detection system to make the data more meaningful.

SYSTEM INTEGRATION:

Orbital Altitude: TBD
Low Earth Orbit desired
Polar Orbit desired

Size of one antenna:
Deployed: 3.1 meters x 1 meter x 0.15 meter
Stowed: 1.15 meters x 0.55 meter x 0.31 meter

Launch Mass: 160 Kg

SPECIAL REQUIREMENTS: Clear field of view from nadir to 45° either side of track.

SUBSYSTEM SUPPORT:

Power: 215 volts DC

Data Management and Communication: Data rate 4 kilobits per second.

Thermal System: Nominal

Point and Stability: Pointing requirement - 1000 arc seconds
Earth pointing

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

BENEFITS:

SPACE STATION UTILIZATION - We recommend that this instrument be placed on a platform in polar orbit. The platform can provide dedicated subsystem elimination, long-term operation. Maintenance, changeout, calibration, and repair can also be provided, probably through STS.

MAN'S ROLE - Maintenance, changeout and repair only.

SYNERGISTIC ADVANTAGES - The data from the Scatterometer can function synergistically with LIDAR data, ocean microwave package data and microwave and infrared sounder data.

DIRECT BENEFITS: Wind speed and direction measurements benefit weather forecasting, small pleasure craft navigation, military, and commercial airlines (coastal and island airports particularly).

REFERENCES:

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Earth Observations

TITLE: Tethered Magnetometer (THM)

PRINCIPAL CONTACT:

ORGANIZATION: U.S. Geological Survey, Reston, VA

MMC CONTACT: Stephen Pompea (303) 977-3808

PROGRAM OBJECTIVE: The objective is to make high resolution measurements of the Earth's magnetic field in order to perform a magnetic survey to aid in the determination of the field configuration and to look for magnetic anomalies indicative of mineral resources.

PROGRAM STATUS: Planned

SYSTEM DESCRIPTION: The THM has a fluxgate or total field magnetometer coupled to a tethered system. A SQUID magnetometer, cooled by Liquid Helium might also be used. The tether system would be a 100 km tether with a deployment boom.

SYSTEM OPERATION: Tether system is controlled by tether operator on STS.

SYSTEM INTEGRATION: Controlled by STS crew. Magnetometer observations data recorded on high density magnetic storage. Changeout, replacement of cryogen, repair accomplished on STS or after mission. Data is voluminous, hence the need for high density storage. No need for real time data transmission.

Polar orbit required. Low altitude required. Preferred orbit is 200 Km with 100 Km tether.

SUBSYSTEM SUPPORT:

Power: TBD

Data Management and Communication: TBD

Thermal System: Magnetometer needs to be cooled to $-273^{\circ}C$.

Point and Stability: TBD

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

BENEFITS:

SPACE STATION UTILIZATION - Since low orbit and long tether are required for maximum sensitivity, the space station or platform could not be utilized.

MAN'S ROLE - Deployment and retrieval of tethered satellite.

SYNERGISTIC ADVANTAGES - Data could interact synergistically with gravity gradiometer data, and with magnetometer data from airplanes.

DIRECT BENEFITS: Geophysical knowledge. Mapping of magnetic anomalies ultimately helps in military area of submarine detection.

REFERENCES:

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Earth Observations

TITLE: Gravity Gradiometer (GG)

PRINCIPAL CONTACT:

ORGANIZATION:

MMC CONTACT: Stephen Pompea (303) 977-3808

PROGRAM OBJECTIVE: The objective of the gravity gradiometer is to determine geoidal figure of the Earth as a function of location in orbit. The instrument allows local vertical to be determined for each orbital point.

PROGRAM STATUS: Planned; funding level unknown.

SYSTEM DESCRIPTION: The gradiometer consists of a set of masses mechanically linked to each of them either in a rod shape or a dumb bell configuration so that the second order of gravity gradient will align the rod to the local vertical. It is necessary for the GG to eliminate or compensate for such outside forces as solar pressure or atmospheric drag.

SYSTEM OPERATION: TBD

SYSTEM INTEGRATION: The spacecraft carrying the gravity gradiometer needs to be as drag free as possible. Spacecraft must have minimal perturbations to its orbit by non-gravitational forces. This precludes the use of a tether.

- Measurement sensitivity falls off as the orbital altitude to the fourth power, so low altitude orbits are preferred if drag forces can be controlled or modified.
- High inclination orbit preferred so world wide mapping can occur. Prefer not to have sun synchronous.
- Mass and size unknown.

SUBSYSTEM SUPPORT:

Power: TBD

Data Management and Communication: TBD

Thermal System: Probably will require liquid helium cooling (40^{o}K).

Point and Stability: TBD

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

BENEFITS:

SPACE STATION UTILIZATION - It is doubtful that the gravity gradiometer could be on the space station. Perhaps it could fly in a similar orbit to the polar orbiting platform. GG needs to be isolated from other gravitational influences.

MAN'S ROLE - Maintenance, changeout, and resupply of cryogen. Cryogen resupply would be at yearly intervals.

SYNERGISTIC ADVANTAGES - Data can interact synergistically with magnetic gradiometer, another non-space station experiment.

DIRECT BENEFITS: Benefits are to:

- basic geophysical research
- mapmaking
- petroleum prospecting

REFERENCES:

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Earth Observations

TITLE: Ocean Topography Experiment (TOPEX)

PRINCIPAL CONTACT: Dr. Robert Steward (213) 354-5079

ORGANIZATION: Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91109

MMC CONTACT: Stephen Pompea (303) 977-3808

PROGRAM OBJECTIVE: The primary objective is to measure ocean surfce topography for at least five years to determine: 1) general ocean circulation and its variability; 2) ocean dynamics; 3) heat transfer, and 4) interaction of currents with waves and sea ice.

PROGRAM STATUS: Planned; funding level unknown. Program is currently under design development. No critical technology developments needed for implementation.

SYSTEM DESCRIPTION: The proposed altimetric mission (called TOPEX) has the following nominal characteristics, stated together with a brief recapitualtion of their rationale:

(a) A dual-frequency altimeter to measure the height of the satellite independently of the electrons in the ionosphere. As a by-product this will provide global measurements of that quantity.

(b) A nonscanning radiometer to correct for the influence of water vapor on the altimeter measurements.

(c) A precise determination of the satellite orbit through a combination of dynamical models of the satellite and precision tracking. The tracking may be done using either laser or radio methods; but we strongly recommend that the all-weather capability of radio techniques be explored as a feasible method. Without precise orbits, useful oceanic measurements cannot be made.

(d) A complete, documented, data-handling system, in place no later than six months before the launch of the satellite. Data must be analyzed in a timely manner and without long delays once the first data become available after launch.

(e) A comprehensive program to evaluate and apply the data produced by the experiment in order to fully exploit the information content of the TOPEX data.

SYSTEM OPERATION: The basic mode of operation is a 10-day frozen orbit but the mission will retain the ability to modify the ground track coverage from time-to-time for special purposes. This sampling interval should provide adequate temporal coverage of the great bulk of the ocean surface. Repeat orbits are desirable because they greatly simplify the data analysis and make it possible to study oceanic variabilityu even at special scales where the geoid is inadequate.

SYSTEM INTEGRATION: An orbit with an altitude of 1300 km and an inclination of 65° is needed. This altitude is high enough to minimize the effect of atmospheric drag, and to slightly reduce the influence of errors in the Earth s gravity field, although radiation forces will be slightly larger. The inclination provides high crossing angles between ascending and descending tracks at mid-latitudes, while providing good coverage of the world's oceans.

- The center of gravity of the TOPEX satellite must be well established to a fraction of a cm for accurate orbit determination.
- Pointing/stability requirements are very important, but are not established. The radar altimeter position needs to be known to ±5 cm. These extreme requirements can be met only by a high degree of spacecraft stability, a low area/mass ratio for the spacecraft, and simultaneous laser range finding off a retroreflector on the spacecraft.

SUBSYSTEM SUPPORT:

Power: TBD

Data Management and Communication: TBD. Ground data management is very important and would require a dedicated computer system.

Thermal System: TBD

Point and Stability: TBD

BENEFITS:

SPACE STATION UTILIZATION - TOPEX requires an orbit vastly different from a space station or platform and cannot utilize either as an operational base.

MAN'S ROLE - Changeout, servicing, and repair only.

SYNERGISTIC ADVANTAGES - Data interacts synergistically with GRAVSAT data and with LIDAR.

DIRECT BENEFITS: Many important benefits to an understanding. The TOPEX program provides fundamental ocean circulation data that is extremely valuable to an understanding of the changing ocean currents. These oceanographic models in turn can make predictions of great impoprtance to the fisheries

SPACE STATION USERS CONCEPT

industry. Additionally, the economics of commercial shipping depend on a ship's ability to avoid dangerous areas and to take advantage of known current systems (The Gulf Stream). Ocean currents are also a part of the acoustical barrier so important to our Navy.

REFERENCES:

1. Satellite Altimetric Measurements of the Ocean. Report of the TOPEX Working Group, Jet Propulsion Laboratory, March 1, 1981.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Earth Observations

TITLE: Geosynchronous Satellite Sensor Intercalibration

PRINCIPAL CONTACT: Professor T. Vonder Haar (303) 491-8566

ORGANIZATION: Colorado State University, Dept of Atmospheric Sciences

MMC CONTACT: Stephen Pompea (303) 977-3808

OBJECTIVE: The objective of the program is to calibrate the instruments on the geosynchronous GOES satellites using highly calibrated standard instruments. By intercalibrating these geosynchronous instruments the data can become more useful to world climate models and to international research programs.

PROGRAM STATUS: Opportunity; Funding level needed: TBD

SYSTEM DESCRIPTION: A specially calibrated instrument, flown under a GOES would take measurements of the same Earth location simultaneously with the GOES instrumentation. A radiometer would be a good candidate instrument. After the comparison measurements are taken the instrument would be returned to Earth where it will undergo testing to insure that its calibration is still valid.

SYSTEM OPERATION: Instruments would be installed on the space station, aligned, and checked out. Then this instrument would make observations of the Earth's atmosphere or surface simultaneous to the same measurement being made on a geosynchronous GOES satellite. After a sufficient number of such measurements on a given satellite, the long-term degradation of the satellite intrument may be seen. More importantly each satellite's sensor may be calibrated by the reference standard instrument on the space station and the reference standard insrument on the ground.

SYSTEM INTEGRATION: Orbital altitude is not critical. Pointing and stability to be determined. Size and weight of the instrument are small and are similar to radiometers now in orbit. Thermal control and calibration would have to be very precise, so these measurements could be exactly compared. Extensive documentation of instrument condition is important.

SUBSYSTEM SUPPORT:

Power: Approximately 200 Watts DC

Data Management and Communication: TBD. Instrument will be approximately 5 hours/day.

Thermal System: TBD

Pointing and Stability: TBD

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

BENEFITS:

SPACE STATION UTILIZATION - This instrument can greatly benefit from frequent visitation to the space station by STS. Instrument changeout would be relatively frequent. It is hoped that each instrument on each geosynchronous weather satellite can be calibrated every few months. Maintenance, calibration and checkout of these instruments can also be accomplished easily on board a space station.

MAN'S ROLE - Calibration, checkout, and repair, if necessary.

SYNERGISTIC ADVANTAGES - This sensor calibration mission has a tremendous synergistic benefit. Each instrument on a geosynchronous satellite can benefit. This mission will allow the GOES data to become enormously more useful.

DIRECT BENEFITS: International climate study programs will benefit enormously from the sensor intercalibration.

REFERENCES:

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Earth Observations

TITLE: Thermal Infrared Multispectral Imager

PRINCIPAL CONTACT: Dr. Anne Kahle

ORGANIZATION: Jet Propulsion Laboratory, (213) 354-7265

MMC CONTACT: Stephen Pompea

PROGRAM OBJECTIVE: The objective of the thermal IR imager is to distinguish different geologic features by their reflectance in the 10 micron band. This information can be used in mineral prospecting and geologic map construction.

PROGRAM STATUS: Opportunity; Funding Level: Unknown

SYSTEM DESCRIPTION: This is a multispectral instrument operating in the thermal infrared (10 microns). It is cooled to liquid nitrogen or liquid helium temperature and can sense a number of thermal infrared bands. This instrument is under development at the Jet Propulsion Laboratory. More research on which spectral bands can give the most information is needed.

SYSTEM OPERATION: Real time data is not necessary. Resupply of cryogen is needed at yearly intervals. There is a need for maintanence, inspection, and repair of the instrument. The instrument scans Earth features, constructing an image using a scanning mirror or a pushbroom array.

SYSTEM INTEGRATION: Orbital altitude preferred is 400 km. Polar orbit is preferred, probably sun synchronous. Twenty to 30 meter ground resolution is needed. FOV TBD. This system is very sensitive to contaminants since this is a cooled system. Inclination of 70° or higher would be acceptable if 90° is not possible.

SUBSYSTEM SUPPORT:

Power: TBD

Data Management and communication: High Data Rate

Thermal System: Active. Liquid nitrogen or liquid helium cooled.

Pointing and Stability: Need 20-30 meter ground resolution.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

BENEFITS:

SPACE STATION UTILIZATION - We recommend that this instrument be placed on a platform in polar orbit. The platform can provide dedicated subsystem elimination, long-term operation. Maintenance, changeout, calibration, and repair can also be provided, probably through STS.

MAN'S ROLE - Maintenance and repair.

SYNERGISTIC ADVANTAGES - This instrument can be used with the Synthetic Aperture Radar to produce a synergistic effect.

DIRECT BENEFITS: This instrument is important for geologic mapping. It can complement the imaging spectrometer and help produce a detailed biogeographical/geological map.

REFERENCES:

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Earth Observations

TITLE: LIDAR - Light Detection and Ranging

PRINCIPAL CONTACT: Dr. Freeman Hall

ORGANIZATION: Wave Propagation Lab, NOAA Environmental Research Laboratories, R45X2 Boulder, CO 80303 (303) 497-6261

MMC CONTACT: Stephen Pompea (303) 977-3808

PROGRAM OBJECTIVE: To make measurements that give altitude profiles of the wind vector. These wind measurements serve as an impact to global circulation models.

PROGRAM STATUS: Planned; Current funding level: approximately $1,000 K.

SYSTEM DESCRIPTION: This is an infrared doppler LIDAR instrument incorporating a 1 meter diameter mirror and a CO_2 laser to measure the doppler shift from wind borne aerosol particiles. The laser is incorporated into the telescope base and does not move with telescope rotation.

SYSTEM OPERATION: Scanning pattern of the instrument would be controled by computer program. Data needs to be reduced and transmitted in near real time to be of maximum benefit to the users. Conical scan path is needed. Flash tube reliability is an important unsolved problem. System will probably need flasttube changeout at three-month interval, assuming flashtube life is extended to that level.

SYSTEM INTEGRATION:

Orbital Altitude: 400-800 km

Inclination: Polar

Nadir Pointing Instrument

Equipment Description:

Telescope Weight: 365 kg

Laser Transmitter: 210 kg

Support Structure and Cooling: 120 kg

Total Weight of Major Components: 833 kg

Telescope scans about nadir in a half angle cone of 62°.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

SUBSYSTEM SUPPORT:

Power: Prime power: 2123-2346 Watts; Warmup power: 574 Watts; Standby power: 209 Watts.

Data Management and Communication: Some raw data needs to be transmitted to ground station. Most doppler processing could occur on instrument.

Data Transmission Rate: 6.4 Mbps (no processing), 84 Kbps (doppler processing).

Thermal System: Total payload heat dissipation is 2.2 K Watts; waste heat could be removed using something similar to Spacelab pallet freon loop (capacity 7 K Watts).

Pointing and Stability: Very important for this instrument.

o Pointing Accuracy for for ± 5 Km Target	16.7 mrad	0^{o} scan angle
	16.1 mrad	10^{o} scan angle
	0.8 mrad	70^{o} scan angle
o Pointing Jitter	2 microrad/5 msec	

BENEFITS:

SPACE STATION UTILIZATION - We recommend that this instrument be placed on a platform in polar orbit. The platform can provide dedicated subsystem elimination, long-term operation. Maintenance, changeout, calibration, and repair can also be provided, probably through STS.

MAN'S ROLE - Maintenance, repair and changeout of flash tube.

SYNERGISTIC ADVANTAGES - These LIDAR measurements potentiate nearly every other atmospheric measurement. It can interact synergistically with CLIR, scatterometer and the sounder instruments.

DIRECT BENEFITS: Can be extremely valuable in weather forecasting and modeling. Could save $1.0 billion in commercial airline operations (according to NASA study) alone, with better routing of airline traffic. This is mainly fuel savings from knowing at which altitudes a plane can fly most efficiently and with the most favorable winds. Better forecasting can save construction industry $1.5 Billion/year.

REFERENCES:

1. Global Wind Measuring Satellite System - WINDSAT, Final Report, April, 1981, NOAA.

2. Feasibility Study of Satellite-Borne LIDAR Global Wind Monitoring System, NOAA Technical Memorandum, ERL WPL-63, August, 1980.

3. Feasibility Study of Satellite-Borne LIDAR Global Wind Monitoring System, NOAA Technical Memorandum, ERL WPL-37, September, 1978.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

Instrument Field of View: 0.2 x 12 mrad.

Detector will probably require cryogen or thermoelectric cooler.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Earth Observations

TITLE: CLIR - Cryogenic Limb Scanning Interferometer and Radiometer

PRINCIPAL CONTACT: Dr. John Gille

ORGANIZATION: NCAR, Table Mesa Road, Boulder, CO 80307 (303) 494-5151

MMC CONTACT: Stephen Pompea (303) 977-3808

PROGRAM OBJECTIVE: Study infrared emission of the middle atmosphere to obtain important information on atmospheric chemistry, dynamics, solar terrestrial coupling. Key research areas: Atmospheric spectroscopy, atmospheric chemistry, atmospheric dynamics, solar-terrestrial coupling, troposphere - stratosphere exchange.

PROGRAM STATUS: The CLIR instrument is based on a predecessor instrument designed by the AMPS Spectroscopy Facility Definition Team. It was also submitted for development for Spacelab flight. It was also proposed for the UARS satellite but was not selected for the istrument complement.

CLIR is an advanced instrument based on previously flown instruments. Infrared radiometers were flown on Tiros, ESSA, and the Nimbus series of satellites. The first satellite-borne Michelson interferometers were flown on Nimbus 3 and 4. No critical development needed.

SYSTEM DESCRIPTION: The instrument incorporates a low scatter, high off axis rejection telescope with two instruments in the focal plane, an interferometer and a radiometer. Th instrument is cryogenically cooled by solid hydrogen.

SYSTEM OPERATION:

Ground Operation: Driven by cryogen handling and servicing, protecting cold optics from contamination, verification of system readiness for flight. Safety constraints on handling solid cryogen require that fill/venting be performed in special hazard isolated facility.

On Orbit Operation: Requires replacement of solid H_2 cryogen after two years. Duty cycle 1 day on, 2 days off.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

SYSTEM INTEGRATION:

Telescope Aperture: 25 cm

Total Weight: 1700 lb (includes cryogen for 2-year life).

Envelope: Diameter 96 cm
Length 480 cm

SUBSYSTEM SUPPORT:

Power: Nominal power 120 Watts; Peak power (during cryogen dumping)600 Watts.

Data Management and Communication: No need for real time acquisition. Data level TBD.

Thermal System: Baseline system consists of a solid hydrogen cryogenic coller utilizing vapor cooling to maintain detector at 10^{o}K, optics at 30^{o}K, and baffles at 115^{o}K. Precise thermal control is important.

Pointing and Stability: Microgravity levels are unimportant. Needs pointing stability to 375 m $\pm$40 m in the atmosphere. Needs stability through one scan through limb.

Characteristic	Center of Gravity Mount	End Mount
Pointing FOV	180^{o} (Spherical)	90^{o} (Spherical)

BENEFITS:

SPACE STATION UTILIZATION - We recommend that this instrument be placed on a platform in polar orbit. The platform can provide dedicated subsystem elimination, long-term operation. Maintenance, changeout, calibration, and repair can also be provided, probably through STS.

There are two major advantages to using a space platform. First, the long duration of this experiment when on board a space platform creates a continuity that is valuable to the atmospheric scientist. Additional the ability to replenish the cryogen is important. The instrument can obtain global coverage for sufficient time to follow the development of dynamic systems, and to follow seasonal and long-term trends.

MAN'S ROLE - Maintenance and repair.

SYNERGISTIC ADVANTAGES - Can interact synergistically with LIDAR, Imaging Spectrometer.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DIRECT BENEFITS:

Scientific:

1. Measurement of global ozone distribution.

2. Study of upper atmosphere global dynamics.

3. Study of thermal and non-thermal infrared radiation in the atmosphere and its relation to the atmospheric energy budget.

Political, Social, Economic: The primary objective of this instrument is to study the ozone layer. In recent years, it has been demonstrated that anthropogenic chloroflurromethanes have a profound influence on our ozone layer which protects us from solar ultraviolet radiation. The political, social, and economic effects resulting from the destruction of the ozone layer would be severe.

REFERENCES:

1. Investigations of Limb Infrared Emissions with CLIR (UARS Proposal).

2. Cryogenic Limb-Scanning Interferometer and Radiometer (CLIR). Report of the Spectroscopy Facility Definition Team.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Earth's Observations

TITLE: Imaging Spectrometer

PRINCIPAL CONTACT: Dr. A. Kahle, (213) 354-7265

ORGANIZATION: Jet Propulsion Laboratory

MMC CONTACT: Stephen Pompea (303) 977-3808

PROGRAM OBJECTIVE: To analyze earth surface features with finer spatial and better spectral resolution than the thematic mapper on LANDSAT D. With detailed spectral information, discrimination between rock types, soils, crops, etc, can be made.

PROGRAM STATUS: Opportunity. Funding level unknown. This instrument is under development at JPL. Two critical development areas are: (1) development of array sensors, and (2) software for data reduction and discrimination.

SYSTEM DESCRIPTION: An imaging spectrometer utilizes area array detectors to scan a multitude of wavelengths in the near IR simultaneously. The sensors are designed to look in the 0.4-2.5 micron band.

SYSTEM OPERATION: Instrument would function automatically, turning itself on when it need to make observations and take data. A microprocessor could be used to prioritize potential observations. This instrument generally will scan cloud free ground areas, but can also be used to scan ocean areas (like the color scanner). A tremendous amount of data is generated (300 Mbps) so data reduction onboard the station is essential.

SYSTEM INTEGRATION: Preference is for obits with inclinations greater than 70 degrees in order to provide coverage of arctic and polar regions. Instrument is nadir looking, however pointability over 2 pi SR is desirable. Instrument will be cooled; level of cooling not yet determined. Orbital altitude desired is 400-500 km. Size and weight are TBD.

SUBSYSTEM SUPPORT:

POWER: TBD

DATA MANAGEMENT & COMMUNICATION: 300 Mbits per second requires extensive data processing on the station.

THERMAL SYSTEMS: Detector cooling necessary, but detector temperature to be determined. Thermal stability of instrument is important.

POINTING & STABILITY: TBD

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

BENEFITS:

SPACE STATION UTILIZATION: Ease of maintenance and repair are available if instruments are on the space station. Imaging spectrometer can be used for mapping equatorial regions of the world. It is expected that the instrument will be taking data for at least ten years; this long life would not be possible on a free-flyer.

MAN'S ROLE: Maintenance, calibration, and repair.

SYNERGISTIC ADVANTAGES: The imaging spectrometer can have a synergistic effect on color scanner data and on synthetic aperture radar data.

DIRECT BENEFITS: Can aid in crop identification, rock identification, land use planning, and crop disease maps.

REFERENCES:

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Earth Observations

TITLE: Microwave Radiometer

PRINCIPAL CONTACT: Dr. P. Gloeren, Code 913

ORGANIZATION: Goddard Space Flight Center
Greenbelt, Maryland 20771

MMC CONTACT: Stephen Pompea (303) 977-3808

PROGRAM OBJECTIVE: To measure remotely:

- o Sea surface temperature,
- o Atmospheric water vapor levels,
- o Extent of ice cover.

PROGRAM STATUS: Operational, was flown on Nimbus.

SYSTEM DESCRIPTION: A 5 channel scanning radiometer measure microwave emission from the ocean surface. The scanning microwave radiometer on Nimbus VII can give ocean momentum and energy transfer parameters on a nearly all weather operational basis. It derives low altitude parameters such as winds, water vapor, liquid water content, and mean cloud droplet size.

SYSTEM OPERATION: Real time operation needed. Changeout, maintenance, inspection, and repair of the microwave radiometer are needed.

SYSTEM INTEGRATION:

Physical Dimensions: 0.15x0.49x0.20 meters with 0.8 meter diameter antenna

Weight: 55 kilograms

Requires Field of View ±25 degrees either side of nadir.

Antenna boresight is 40 degrees aft or forward of nadir.

Preferred orbital inclination: 98 degrees.

SUBSYSTEM SUPPORT:

POWER: 65 watts

DATA MANAGEMENT & COMMUNICATION: TBD

POINTING & STABILITY: Pointing to ±0.5 degrees. Three axis pointing is needed.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

BENEFITS:

SPACE STATION UTILIZATION: A microwave radiometer on a space station can function successfully for many years, if given adequate repair and service. It can provide data on equatorial ocean regions for a dozen years or so. It is a relatively inexpensive instrument, since most development has been completed.

MAN'S ROLE: Checkout and maintenance.

SYNERGISTIC ADVANTAGES: The microwave radiometer can interact synergistically with the geosynchronous satellite sensor intercalibration, since one of the first instruments to be calibrated would be a radiometer.

DIRECT BENEFITS: There are direct benefits to weather forecasting. Will furnish information valuable in fishery management.

REFERENCES:

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Earth Observation

TITLE: Synthetic Aperture Radar

PRINCIPAL CONTACT: Dr. Gerald Schaber (602) 779-3311

ORGANIZATION: USGS Astrogeologic Studies Branch
2255 N. Gemini Drive, Arizona

MMC CONTACT: Stephen Pompea (303) 977-3808

PROGRAM OBJECTIVE: (1) Geologic mapping of hyperarid regions, (2) topographic mapping of cloud covered areas, (3) sea ice mapping, (4) wave spectra, and (5) eddy location in oceans.

PROGRAM STATUS: First spaceborne SAR was flown on SEASAT in 1978. Shuttle Imaging Radar was carried in November 1981 on Columbia. SIR-B is scheduled for a later Shuttle flight.

SYSTEM DESCRIPTION: Synethetic aperture radar with adjustable look angle, similar to SEASAT SAR, SIR-A, and SIR-B.

SYSTEM OPERATION: Duty cycle 100 percent initial; 20 percent later stages.

SYSTEM INTEGRATION:

Weight: 125 kg

Dimensions: 10 x 2 meter antenna

Requires clear Field of View from 17 to 23 degrees of nadir (one side only)

Polar orbit preferred

SUBSYSTEM SUPPORT:

POWER: 5 KWatts

DATA MANAGEMENT & COMMUNICATION: 100 Mbits/sec. Onboard data processing.

THERMAL SYSTEM: TBD

POINTING & STABILITY: Pointing ±1 degree, 3 axes. Need very rigid mount.

SPACE STATION USERS CONCEPT

BENEFITS:

SPACE STATION UTILIZATION: Service, repair, alignment. Can benefit from space station high power capability and by space station data processing facility.

MAN'S ROLE: Repair and maintenance.

SYNERGISTIC ADVANTAGES: Can be used with imaging spectrometer for strong synergistic effect.

DIRECT BENEFITS:
1) Fundamental oceanographic research,
2) Cartography - could be employed in stereo mode to map terrain,
3) Sea Ice Studies (on polar platform),
4) Anthropology - Studies of neolithic cultures that lived in playas revealed under desert sand by the SAR.

REFERENCES:

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Earth Observations

TITLE: Active Microwave

PRINCIPAL CONTACT:

ORGANIZATION: NOAA

MMC CONTACT: Stephen Pompea (303) 977-3808

PROGRAM OBJECTIVE: Measure precipitation levels at different altitudes.

PROGRAM STATUS: Opportunity. Funding level unknown.

SYSTEM DESCRIPTION: Radar type instrument working in wavelengths to detect and classify precipitation types.

SYSTEM OPERATION: TBD

SYSTEM INTEGRATION: Polar orbiting, low earth orbit.

SUBSYSTEM SUPPORT:

POWER: TBD

DATA MANAGEMENT & COMMUNICATION: TBD

THERMAL SYSTEM: TBD

POINTING & STABILITY: TBD

BENEFITS:

SPACE STATION UTILIZATION: Maintenance and Repair.

MAN'S ROLE: Maintenance and Repair.

SYNERGISTIC ADVANTAGES: Can interact synergistically with microwave sounder, LIDAR, LAMMR.

DIRECT BENEFITS: Direct measurement of precipitation particularly over the ocean.

REFERENCES:

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Earth Observations

TITLE: Advanced Meteorological Infrared and Microwave Sounder

PRINCIPAL CONTACT: Dr. A. Kahle, (213) 354-7265

ORGANIZATION: Jet Propulsion Laboratory
Bldg 183, 4800 Oak Grove Dr, Pasadena, CA

MMC CONTACT: Stephen Pompea (303) 977-3808

PROGRAM OBJECTIVE: Pressure and temperature profile of the atmosphere.

PROGRAM STATUS: Opportunity. Funding level unknown.

SYSTEM DESCRIPTION: An advanced version of microwave sounders currently flying.

SYSTEM OPERATION: TBD

SYSTEM INTEGRATION: TBD

SUBSYSTEM SUPPORT:

POWER: TBD

DATA MANAGEMENT & COMMUNICATION: TBD

THERMAL SYSTEM: Cooling required; temperature level unknown.

POINTING & STABILITY: TBD

BENEFITS:

SPACE STATION UTILIZATION: We recommend that this instrument be placed on a platform. The platform can provide dedicated subsystem elimination, long term operation. Maintenance, changeoug, calibration, and repair can also be provided, probably through STS.

MAN'S ROLE: Maintenance and repair.

SYNERGISTIC ADVANTAGES: Can interact synergistically with LAMMR, geosynchronous microwave sounder.

DIRECT BENEFITS: Vertical temperature and pressure profile is useful for weather forecasting.

REFERENCES:

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Earth Observations

TITLE: Microwave Sounder (Geosynchronous)

PRINCIPAL CONTACT: Dr. William L. Smith
Associate Director of Space Science and Engineering Center
(608) 263-3434

ORGANIZATION: NOAA, NESS, University of Wisconsin, Madison

MMC CONTACT: Stephen Pompea, (303) 977-3808

PROGRAM OBJECTIVE: Perform microwave soundings from geosynchronous orbit.

PROGRAM STATUS: Opportunity. Funding level unknown.

SYSTEM DESCRIPTION: 100 meter diameter microwave instrument.

SYSTEM OPERATION: TBD

SYSTEM INTEGRATION: TBD

SUBSYSTEM SUPPORT:

POWER: TBD

DATA MANAGEMENT & COMMUNICATION: TBD

THERMAL SYSTEM: TBD

POINTING & STABILITY: TBD

BENEFITS:

SPACE STATION UTILIZATION: Assembly and calibration on orbit; checkout on orbit, launch to geosynchronous

MAN'S ROLE: Assembly on orbit.

SYNERGISTIC ADVANTAGES: Interacts synergistically with advanced infrared and microwave sounder.

DIRECT BENEFITS: Atmospheric pressure and temperature profile.

REFERENCES:

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APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Space Physics

TITLE: Space Plasma Effects Upon Large Spacecraft - Extended Exposure (SPE)

PRINCIPAL CONTACT: Stanley D. Shawhan

ORGANIZATION: University of Iowa

MMC CONTACT: J.E. Freidell

PROGRAM OBJECTIVE: To determine and monitor the impacts and effects of the space plasma environment upon large spacecraft purely due to the physical presence of the spacecraft itself. A space station would represent an evolving very large spacecraft. Effects upon such a spacecraft could be so great as to impact operations thus continual monitoring may be necessary.

PROGRAM STATUS: NASA sponsored efforts began with STS-3 and will continue with future STS flights.

SYSTEM DESCRIPTION: Instrumentation developed for STS-5 and future STS flights/Spacelabs could be used to measure and assess material degradation, Space Station surface potentials, Kapton effects, and space station "Glow" from the very onset and evolving throughout space station construction.

SYSTEM OPERATION: Initial operation via STS during space station construction/assembly is envisioned. Once the station becomes permanently manned, operation responsibility should revert to continuous on-board monitoring. This is important should observed effects be cause for reactionary alarm to ongoing experiments or operations due to change in this surrounding plasma or changes to the space station itself.

SYSTEM INTEGRATION: This mission should be accomplished at the space station location. Physical integration provisions dependent upon space station design.

SUBSYSTEM SUPPORT:

Data Management & Communications: Real-time control, data acquisition and processing may be required as space station evolves from construction to operation phases.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

BENEFITS:

Space Station Utilization: Operation, maintenance changeout, calibration, etc., all are envisioned.

Mans Role: Operations reaction, instrument set-up, calibration and actual operation.

Synergistic Advantages: Other Space Plasma Physics missions such as "Large Spacecraft Impact Upon Proximate Space Plasma" will be synergistic.

Direct Benefits: From a scientific standpoint we will have a better understanding of the effects, particularly long term effects, of space plasma exposure to large spacecraft in orbit. Space station operations may be impacted by results of this on-going research.

REFERENCES: Forthcoming STS/Space Plasma Physics experiments final reports.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Space Physics

TITLE: Large Spacecraft Impact Upon Proximate Space Plasma

PRINCIPAL CONTACT: Peter M. Banks

ORGANIZATION: Stanford University

MMC CONTACT: J.E. Freidell

PROGRAM OBJECTIVE: Determine the evolving impact upon large spacecraft (even underlying construction/assembly have upon the local space plasma.

PROGRAM STATUS: A new program which would require NASA support would likely use technology developed for the Subsatellite Facility.

SYSTEM DESCRIPTION: One or more subsatellites similar to the tested (STS-3) Plasma Diagnostics Package are envisioned. Table 1 indicates subsatellite types and equipment evolution.

SYSTEM OPERATION: Operation will be dependent upon the subsatellite class in use. Class 1 and 2 type subsatellites will involve the shuttle for deployment and, for Class 2, recovery. Class 3 subsatellites are intended for permanent space station support.

SYSTEM INTEGRATION: Orbital location is dependent upon location of space station(s) and/or other large spacecraft particularly those that may involve experiments in space plasma physics.

SUBSYSTEM SUPPORT: See Table 1

BENEFITS:

Space Station Utilization: Satellite servicing, maintenance, repair, equipment changeout, calibration, onorbit refurbishment, and long term operation may be provided by the space station.

Mans Role: Quick response may serve to some advantage:

Synergistic Advantages: The requirements for a large spacecraft in itself allows the opportunity for this mission.

Table 1 Evolution of Proximate Space Plasma Measuring Subsatellites

Subsatellite Requirements & Performance	Subsatellite Classifications (& Alternatives)		
	"Throw-Away" Single Mission (Class 1) - P.I. Class	Recoverable (Class 2) - P.I. Class	Maneuverable (Class 3) - Facility Class
Evolution & Mission Reqmts Including # Required	1 Class 1 Sub-Sat Reqd per SS Assembly Stage Starting with first SS "Module" & Continuing Until Class 2 Replacement of Capability	2-4 Total (min); 1-2 in Orbit at all Times; Initial Support By Shuttle Evolving to SS Support; This Class to be used at Least until Class 3	Permanent Support On-Orbit 1-2 Reqd. Throughout SS Duration
Development Status	Developed STS-3 Tested; to be used in Spacelab 2	Under Development (Spacelab 6)	Study Complete
Equipment Description No. of Instruments Size Weight Antennas and Booms Sketch	 3-8 42" Dia, 27" H 25 to 250 kg 10M, 1 Shot Deployment None Available	 6-12 60 Dia, 42" H 250-500 kg 10M, Retractable See Figure 1	 10-16 60" Dia, 42" H 500 kg 100M, Retractable None Available
Altitude/Orbit Adj	None, Spin Stabilized	Crude ACS for Spin Axis	3 Axis Stabilized/ \~2500 ft/sec
On-Orbit Lifetime	Days	Months	Month up to Many Years, Servicing (Periodic) Interval: TBD
Elect Power	20-40 Watts (Batteries)	50-150 Watts (Batteries & Solar Cells)	100-1000 Watts (Batteries & Solar Cells or Fuel Cell)
Data Management	Data to be Recorded, Stored, & Returned by Shuttle		
Telemetry Tape Recorder Commands	10-100 Kbps + 50 KHz None None - 6 (Discrete)	16-512 Kbps +250 KHz 512 Kbps + 250 KHz 16-64 (Serial)	256 Kbps + 250 KHz + TV Mbps + 250 KHz + TV 7256

SPACE STATION USERS CONCEPT

DIRECT BENEFITS: For research purposes, continue with an overall study efrort as started with STS-3. Certain other space plasma investigations, most notably those in the STO Program, may require this monitoring support. Understanding any problems with large spacecraft longevity may be a benefit.

REFERENCES: STS-3 Space Plasma experiments final and interim reports. Stanley D. Shawhan, University of Iowa. "Subsatellite Studies of Wave, Plasma, and Chemical Injections from Spacelab," a paper by Stanley D. Shawhan, James, L. Burch, and Robert W. Fredricks.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Space Physics (Solar - Terrestrial Physics)

TITLE: Initial Solar Terrestrial Observatory (ISTO)

PRINCIPAL CONTACT: Dr. Charles R. Chappel

ORGANIZATION: MSFC

MMC CONTACT: J.E. Freidell

PROGRAM OBJECTIVE: The first major orchestral step toward understanding the physical processes that couple the major regions of solar terrestrial space (i.e., the solar atmospheric, the interplanetary medium, the Earth's magnetosphere and ionosphere, and the entire atmosphere of the Earth).

PROGRAM STATUS: NASA Candidate Mission; Science Working Group Final Report published.

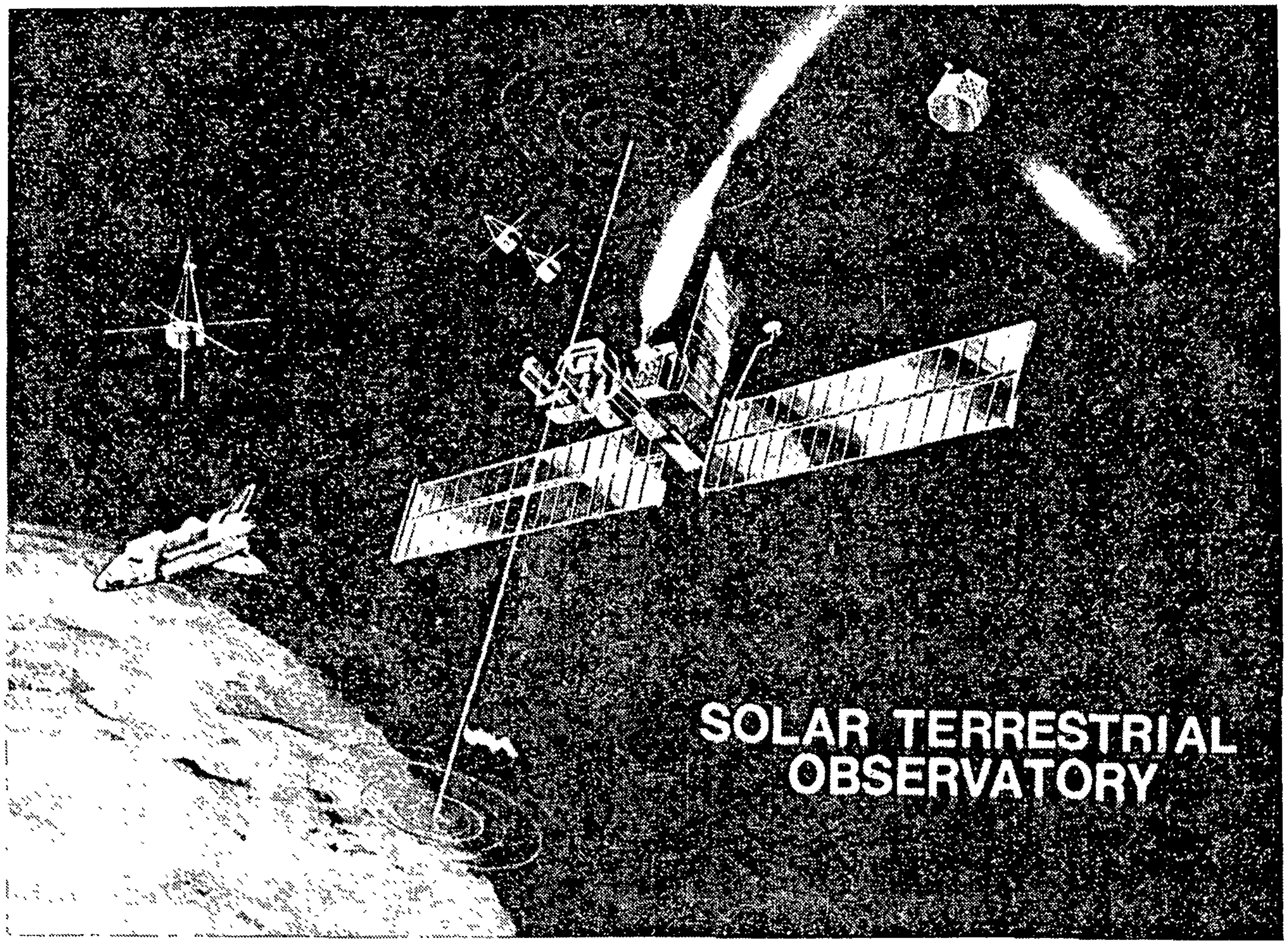
SYSTEM DESCRIPTION: ISTO will incorporate large Shuttle-class instrumentation and take advantages of long duration in orbit, high power, manned control, multi-directional pointing, and regular in-orbit servicing. A artist's concept is provided in Figure 1. A preliminary equipment list will be found in Table 1. ISTO will evolve into becoming part of ASTO, another portion of the overall Solar Terrestrial Observatory Program.

SYSTEM OPERATION: ISTO instrument control will be by man; either on-board, remote operation from another space locations, or via ground operations. Automation may be of considerable use once experience is gained thus requiring real time operation. Instrument supply maintenance and changeout will be required over the long operational term. Pointing requirements demand simultaneous pointing at sun, Earth nadir and anti-nader, and a general purpose, roughly 4 sr, capability. Rought pointing to by automatic, fine acquisition to require man inputs. Unless man is considered for onboard operation, real time data rates may be very high.

SYSTEM INTEGRATION: Orbit required: 57^{o}, 400 km. Pointing accuracy: 10 sec. Stability: 0.02 sec/sec worst case. Envelope dimensions 80 x 15 x 9 M (Platform Dim). Mass 20 - 60,000 kg. Contamination requirements: No intentional H_2O releases, controlled cryogen vents, and well characterized outgassing.

Figure 1

Space Physics–Solar Terrestrial Observatory



MARTIN MARIETTA

Table 1 Consolidated ISTO Equipment

Instrument	Function	Specifications	Solar Variability	Wave-Particle Processes	Magnetosphere-Ionosphere Interaction	Global Electric Circuit	Upper Atmospheric Dynamics	Middle Atmospheric Chemistry & Energetics	Lower Atmospheric Turbidity	Planetary Atmospheric Waves	Notes
			Overall STO Program Objectives Compatability & Time Phased Utilization Aboard STO Spacecraft								
Total Irradiance Monitor (Solar Constant Monitor)	Integral of Solar Irradiance Over Full Spectrum	0.1% Uncertainty, 0.01% 27-Day Precision	X					X	X		
UV Irradiance Monitor	Spectral Irradiance UV Spectral Range	Spectral Interval: 200-450 nm; Spectral Resolution: 0.5 nm; Uncertainty: 1%; 27-Day Precision: 0.5%	X			X	X	X	X	X	
Soft X-Ray Telescope	Magnetic Field Morphology of Inner Corona, Coronal Holes, Active Regions	∿3 $\widehat{sec}$ Spatial Resolution; ∿10 R_s FOV, 5-60 Å Broad-Band Filters	X								
White Light Coronagraph	Magnetic Field Morphology of Outer Corona, Electron Density, Transient Eruptions	∿5-10 $\widehat{sec}$ Spatial Resolution; ∿1.2 R_s 5-10 R_s FOV	X								
Resonance Line Coronagraph	Corona Radial Motion Amplitude & Morphology, Temperature Distribution	∿10-20 $\widehat{sec}$ Spatial Resolution; ∿1.2 R_s to 5-10 R_s FOV	X								
Chemical Release Module(s)	Perpendicular & Parallel E-Field Determination & Conductivity Modification	⩾1 Maneuverable Reusable Release Module with Set of Release Canisters using Ba, Li, O, SF_6			X						
Particle (Electron/Ion) Injector	Modification of Local Plasma & Injection of Electrons & Ions	Variable Energy Density, Species: H^+, He^{++}, N^+, O^+, Xe^+; Elect Energies 100 ev to 100 keV; Ion Energies 100 eV to 100 keV Variable Pitch Angles & Controlled Pulse Pattern		X	X	X					
Plasma Wave Injector	Wave-Particle Processes Simulation via Wave Injection at Various Wave Normal Angles WRT B	1 Hz to ⩾30 MHz Transmitters & Antennas; Variable Power		X							
Low Light Level TV	Auroral Imaging. Visible, UV, Vacuum UV	10m x 10m/Pixel, 10 sec/Frame		X	X	X	X	X	X	X	
X-Ray Telescope	Imaging of Backscattered X-Ray Radiation	X-Ray (10-500 keV) Imaging Capability		X	X	X					
Multiple Subsatellites	Multipoint Auroral & Ionospheric Characteristics Determination (In-Situ Measurement)	Ions/Electrons 0-100 MeV; Ion Drift >10 m/s; Ion Comp Density 10^1 to 10^6 cm^{-3}; Magnetic Field > 1 nt			X	X	X	X	X	X	
Recoverable Subsatellite(s)	Plasma & Plasma Wave Characteristics Measurement (Remote & In-Situ)	Plasma Waves 1-10^7 Hz; Ion & Electron Composition & Distribution 0-100 MeV; Neutral Density & Mag. Field		X	X	X	X	X	X	X	

Table 1 (concl)

Instrument	Function	Specifications	Solar Variability	Wave-Particle Processes	Magnetosphere-Ionosphere Interaction	Global Electric Circuit	Upper Atmospheric Dynamics	Middle Atmospheric Chemistry & Energetics	Lower Atmospheric Turbidity	Planetary Atmospheric Waves	Notes
			Overall STO Program Objectives Compatability & Time Phased Utilization Aboard STO Spacecraft								
Maneuverable Subsatellite(s)	Same as Above	Same as Above But with Propulsion Capability		X	X	X	X	X	X	X	1
LIDAR	Aerosol Layer & Thin Cloud Height, Thickness, & Distribution in Troposphere	NADIR Pointed: 1m Receiver; ∿20w Transmitted at 2 or 3 λ (∿0.33 -1.5 μm); Verticle Resolution < 1 km							X		
Radiation Balance Monitor	Meas. Outgoing Reflected Solar & Emitted Radiation Reaching S/C From Below	Earth Radiation Budget Sensor: 2-Channel Radiometer 0.3-3.0 μm, 1-20 μm							X		
IR Emission Spectrometer	Verticle Profiles & Latitude of Minor & Trace Species; Mesosphere & Lower Thermosphere Energetics	Limb Viewing; Cryogenic Interferometer Spectrometer 2-20 μm (500-5000 cm^{-1} Spectral Resolution, Scan Time $\leqslant$ 10 sec						X		X	
IR Absorption Spectrometer	Same as Above—Plus Mesosphere & Lower Thermosphere Dissociation Levels	High Resolution Occultation Interferometer 2-16 μm (600-5000 cm^{-1}), 0.01 cm^{-1} Spectral, Solar Acq & Trk, 1 sec Scan Time					X	X		X	
UV & Visible Spectrometer	Spatial Distribution & Variability of Ionized & Excited-State Species Down to 80 km (Thermosphere) Excited-State Species 10 ∿40 km (Mesosphere/Stratosphere	Multichannel Rating Spectrometer -20 -120 nm, 0.5 Å Spectral Resol 1 km Imaging Field Resolution			X		X	X			
Upper Atmospheric Wind Sensor	Horizontal Wind Field Components: Upper Stratosphere, Mesosphere, & Lower Thermosphere	Zonal & Meridional Wind, Velocity to 4 m/s 25-100 km Altitude Range, 2 km Verticle Resolution					X			X	
Upper Atmospheric Temperature Sounder	3-D Temp Field Meas (Tropopause to ∿120 km)	Temp Uncertainty = 3K, Precision 1K, V'ert Resolution < 100 km Horiz Sampling; Limb Emission Radiometer to 60 km, PM or Advanced Temp Sounder to 30 km. Combination of Emission or Absorbtion Spectrometer & PMR Above LTE Limit					X			X	

Note:

[1]Optional Replacement for Recoverable Satellite Exercizable Throughout ISTO Misison

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

SUBSYSTEM SUPPORT:

Power: 10 kw

Thermal System: Active, 70^{o}K

Pointing Stability: *0.02* sec/sec worst case

BENEFITS:

Space Station Utilization: ISTO could be integrated onboard space station.

Mans Role: Man is required for Episodic Event Response. Man's ability at pattern recognition and processing can mitigate the otherwise heavy data communication requirements.

Synergistic Advantages: An Interplanetary Companion Satellite is required; the OPEN IPL may meet this requirement in the short run. Data correlation with other experiments desirable, equipment time sharing possible.

Direct Benefits: The long-term goals of the overall solar terrestrial observatory program are: 1) vastly improved long term weather forecasting, 2) climatology change prediction, ionospheric perturbation prediction (recommendations and electrical power disruption), and the ability at some future point in time to modify local weather/climate to man's benefit. ISTO presents a multidisciplinary starting point in this direction.

REFERENCES:

1) Solar Terrestrial Observatory: Final report of the Science Study Group, Oct. 1981.

2) Guntersville Workshop on Solar Terrestrial Studies, Oct. 1977

3) NASA Workshop on Solar Terrestrial Studies from a Manned Space Station, Feb. 1977

4) *The Solar Terrestrial Observatory, AIAA Conference on Large Space* Platforms: Future Needs and Capabilities, Sept. 1978

5) Spacelab-1: An Early Space Station for Science and Technology; Knott, Feuerbacher, and C.R. Chappel

6) Subsatellite Studies of Wave, Plasma, and Chemical Injections from Spacelab; Shawhan, Burch, Fredricks

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Space Physics

TITLE: Advanced Solar Terrestrial Observatory (ASTO)

PRINCIPAL CONTACT: Dr. Charles R. Chappel

ORGANIZATION: MSFC

MMC CONTACT: J.E. Freidell

PROGRAM OBJECTIVE: ASTO is the follow on to the ISTO mission in continuing toward understanding the physical processes that couple the major regions of the solar terrestrial space (i.e., the solar atmosphere, the interplanetary medium, the Earth's magnetosphere and ionosphere, and the entire atmosphere of the Earth).

PROGRAM STATUS: NASA candidate mission listed, in combination with ISTO, as simply STO; Science Working Group Final Report published.

SYSTEM DESCRIPTION: ASTO will evolve from ISTO and incorporate a second spacecraft (polar orbit) in addition to the original ISTO spacecraft (57^{o} LEC). Large Shuttle Class instrumentation will be used, many of which will be ISTO upgrades. A preliminary equipment list (for each of the two spacecraft) is provided in Table 1. Figure 1 is an artists concept of a STO spacecraft implemented on a platform. Now shown in the figure are tethered upper atmospheric probes.

SYSTEM OPERATION: ASTO instrument operation will still be predominately by man; either on-board, remote operation from another space location or via ground operations. The state of automation at IOC will be greater than during ISTO and will likely increase throughout the long term (11-22 year) mission. Supply, maintenance, and changeout will be required. Pointing requirements are the same as in ISTO, namely Solar, Earth, anti-Earth and 4 SR simultaneously. Unless man is considered for onboard operation, real time data rates may be very high at least over the short term.

SYSTEM INTEGRATION: Orbits required: 57^{o}, 400 km and 90^{o} $\pm$ 10^{o}, 250 km. Pointing accuracy 10 sec. Stability 0.02 sec/sec worst case. Envelope dimensions approximately 80 x 15 x 9 M (Platform Dimensions). Mass 30,000 to 60,000 kg. Contamination requirements: No intentional H_2O releases, controlled cryogen vents, and well characterized outgassing.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

SUBSYSTEM SUPPORT:

Power: 10.5 kw avg.

Data Management and Communication: Data rates and volume dependent upon man onboard.

Thermal System: Active, $70^{o}K$

Pointing Stability: 0.02 sec/sec worst case

BENEFITS:

Space Station Utilization: Either ASTO spacecraft, or both, could be manifest as a space station(s).

Mans Role: Man is required for Episodic Event Response. Man's ability at pattern recognition and processing, if available onboard to control instruments and data recording/transmission, can mitigate the otherwise heavy real time data communication requirements.

Synergistic Advantages: An Interplanetary Companion Satellite is required. During a portion of ISTO, this requirements may be met via the OPEN IPS spacecraft. Subsequently, the AIE and/or PTE missions could perhaps satisfy the requirement. Data correlation with experiments outside the STO program are highly desirable, ASTO equipment time sharing may be feasible.

Direct Benefits: The long-term goals of the overall solar terrestrial observatory program are: 1) vastly improved long term weather forecasting, 2) climatology change prediction, ionospheric perturbation prediction (RF communication and electric power distribution disruptions), and the ability at some future point in time to modify local weather/climate to man's benefit. ASTO continues from the ISTO pioneering effort up to the point where benefit No. 1 above may become reality.

REFERENCES:

1) Solar Terrestrial Observatory: Final report of the Science Study Group, Oct. 1981.

2) Guntersville Workshop on Solar Terrestrial Studies, Oct. 1977.

3) NASA Workshop on Solar Terrestrial Studies from a Manned Space Station, Feb. 1977.

REFERENCES: (Con't)

4) The Solar Terrestrial Observatory, AIAA Conference on Large Space Platforms: Future Needs and Capabilities, Sept. 1978

5) Spacelab-1: An Early Space Station for Science and Technology; Knott, Feuerbacher, and C.R. Chappell

6) Subsatellite Studies of Wave, Plasma, and Chemical Injections from Spacelab; Shawhan, Burch, Fredricks

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Space Physics

TITLE: Geosynchronous Solar Terrestrial Observatory (GEO-STO)

PRINCIPAL CONTACT: Peter M. Banks

ORGANIZATION: MSFC

MMC CONTACT: J.E. Freidell

PROGRAM OBJECTIVE: The central scientific goal of the entire overall STO Program is to understand the physical processes that couple the major regions of solar terrestrial space (i.e., the solar atmosphere, the interplanetary medium, the Earth's magnetosphere and ionosphere, and the entire atmosphere of the Earth). Many of the STO Program objectives cannot be fully accomplished without instrumentation outside the plasmasphere. Hemispheric imaging and exo-plasmapheric measurement capability predominate the GEO-STO particular objectives.

PROGRAM STATUS: ISTO and ASTO missions should proceed GEO-STO. NASA sponsorship will be required.

SYSTEM DESCRIPTION: One or more GEO spacecraft will be required. A preliminary instrument list for each spacecraft is provided as Table 1.

SYSTEM OPERATION: Remote operation is most likely with some real time operation required. Due to the ability of long duration mission possibilities, supply, changeout, and maintenance will likely be required.

SYSTEM INTEGRATION: Approximately GEO. North American geostationary preferred for first GEO-STO spacecraft (necessary for nearly constant access to a single magnetic field line and to perform full time auroral imaging opportunity). Second and third locations to provide full earth coverage (hemisphere-at-a-time). Solar, Earth, and general purpose pointing is simultaneously required on a "full time" basis.

SUBSYSTEM SUPPORT:

BENEFITS:

Space Station Utilization: Launch, maintenance, repair, equipment changeout, resupply, and perhaps operation over the long term are all support functions the space station could bring to GEO-STO.

Table 1 GEO-STO Equipment/Instrumentation List

Instrument or Functional Requirement	Notes
Microwave, Visible & Infrared Imagers	Global Distribution of Water Vapor, Liquid H2O, Clouds, & Ionizing Radiation (for Atmospheric Conductivity Determinations)
Tellurograph	Similar to Solar Coronagraph for Earth Limb UV Measurements
Total and Spectral Irradiance Monitors	Instruments Similar to those for ASTO; GEO Utilization Will Provide Nearly Unrestrained Measurement 2-5 sec Spatial Resolution
Visible, XUV, & Soft X-Ray Telescopes	Instruments Similar to those for ASTO; to Provide Unbroken Sequences of Diffraction Limited Operation and Concomitant Observation
White Light Coronagraph	Duplicate of ASTO Instrument
Solar Magnetograph & Velocity Field Measurer	All Stoke's Parameters
XUV & Soft X-Ray Spectroheliographs	
Coronal Emission Polarimeter	
Charged Particle Accelerator	Similar to ASTO Instruments - Perhaps a Scanning Detector/Imager - 304A EUV Resonance Fluorescence Line of He+ of Particular Interest
Low Light TV	
X-Ray Imaging System	
EUV Imaging System	
Coherent Scatter Radar	Similar to ASTO Equipment
Forward Incoherent Scatter Radar Antenna & Rcvr	
ELF/VLF Antenna & Transmitter	
Radially Tethered Remote Probes	Measure Radial Variation of Magnetospheric Qauntities (Close Proximity)
Radiation Balance Monitor	Similar to ASTO Instruments but Smaller Spatial Resolution
IR Emission Spectrometer	
UV & Visible Spectrometer	
Upper Atmosphere Temp Sounder	

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

Synergistic Advantages: Shortly following ASTO IOC, GEO-STO is expected to support that long term mission. Additional experiments would probably be welcomed, time sharing of GEO-STO equipment may be possible.

Direct Benefits: The long-term goals of the overall solar terrestrial observatory program are: 1) vastly improved long term weather forecasting, 2) climatology change prediction, ionospheric perturbation prediction (R.F. communications and electric power distribution disruption) and the ability at some future point in time to modify local weather/climate to man's benefit. GEO-STO will be required to satisfy the first two goals. The goal of modification can only come after success is achieved with the first two goals. An additional benefit will be increased understanding of natural magnetic plasma confinement.

REFERENCES:

1) NASA Workshop on Solar Terrestrial Studies, Feb. 1977

2) Guntersville Workshop on Solar Terrestrial Studies, Oct. 1977

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Space Physics

TITLE: Very Large Radar

PRINCIPAL CONTACT: Peter M. Banks

ORGANIZATION: Stanford University

MMC CONTACT: J.E. Freidell

PROGRAM OBJECTIVE: It is highly desirable to perform three dimensional remote imaging of the plasmasphere and magnetosphere boundaries. This effort will support very long range STO program objectives as well as space plasma physics objectives, particularly natural magnetic confinement of plasma.

PROGRAM STATUS: NASA sponsorship, long term development.

SYSTEM DESCRIPTION: Multiple, perhaps up to 4, 1 to 2 km synthetic array radar systems located outside the Earth's plasmasphere.

SYSTEM OPERATION: Remote control is most likely, perhaps under the auspices of ASTO. Some real-time but mostly preprogrammed operation is envisioned. GEO satellite servicing will probably be required.

SYSTEM INTEGRATION: GEO will provide acceptable altitude to maximize orbit outside plasmosphere. Inertial pointing may require up to 4 SR. Size: 1 to 2 km.

SUBSYSTEM SUPPORT:

Data Management and Communications: Some real-time operation and monitoring.

BENEFITS:

Space Station Utilization: Large Space structure constructions/assembly, boost to GEO, maintenance, repair, resupply, equipment changeout are all required.

Synergistic Advantage: STO program advantage and benefit likely.

Direct Benefits: The primary benefit will be scientific knowledge regarding dynamic magnetic confinement of plasma particularly associated dynamic boundary conditions.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

REFERENCES:

1) Stanley Shawhan, University of IOWA is a contributor to this concept.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Space Physics

TITLE: Origin of Plasma in Earth's Neighborhood (OPEN)

PRINCIPAL CONTACT: Joseph K. Alexander

ORGANIZATION: GSFC

MMC CONTACT: J.E. Freidell

PROGRAM OBJECTIVE: The OPEN mission is a key element in NASA's program to understand solar-terrestrial relations. Its objectives are to determine the energy flow through the coupled heliosphere-magnetosphere-ionosphere system; to provide our understanding of plasma processes that are important in controlling the Earth's nearby space environment and to trace their cause and effect relationships on a global scale; and to assess the importance to the terrestrial environment of variations in energy input to the Earth's atmosphere that are caused by heliospheric or magnetospheric plasma processes.

PROGRAM STATUS: This NASA mission is currently afforded planned status. Launch prior to 1990 is likely.

SYSTEM DESCRIPTION: The OPEN mission is comprised of four separate spacecraft. The four spacecraft are an Interplanetary Physics Laboratory (IPL) to be stationed in the upstream solar wind at the sunward libration point, a Geomagnetic Tail Laboratory (GTL) which uses lunar swingbys to maintain an apogee of 80 to 240 R_e in the magnetotail, a Polar Plasma Laboratory (PPL) in an eccentric polar orbit apogee of 15 R_e, and a Equatorial Magnetospheric Laboratory (EML) in an eccentric equatorial orbit with an apogee of 12 R_e. The four spacecraft are to be launched over a 12-month period. The spacecraft share a common basic design based upon similar complements of instruments and mission orbit requirements.

SYSTEM OPERATION: Delayed Execution of commands (1 day storage); maintenance of resupply very unlikely. Inertial pointing except IPC which is Solar looking.

SYSTEM INTEGRATION: IPL is a heliocentric orbit at the sunward libration point. EMC and PPL have altitude range of 2 to 15 Earth radii and inclination of 0^o and 80^o respectively. GTC uses multiple lunar linear swingbys at one to four month interludes with 5 to 15 lunar radii encounter distance. Pointing accuracy (worst case) is 0.06 sec. Each satellite will be 3 m DIA. by 3.5 m high and have an operational mass of approximately 1000 kg.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

SUBSYSTEM SUPPORT:

Data Management and Communications: In addition to the planned TDRSS communication link, space station interception of IPL data and possibly data from the other satellites would greatly enhance utility of that data in supporting STO program objectives.

BENEFITS:

Space Station Utilization: Space station could facilitate interception of IPL data (see above). Presently planned launch date precludes additional support.

Synergistic Advantages: Observations with the four spacecraft are to be coordinated with each other and with ground-based research programs for magnetic field, ionosphere and auroral observations. The IPL may in the short term satisfy the STO program requirements for an interplanetary companion satellite.

Direct Benefits: Immediate benefits will be limited to scientific purposes. As a planned mission of NASA's Solar Terrestrial Program, long term benefits feed and support the objection and benefits of that program. Those include climatology prediction and long range weather forecasting.

REFERENCES:

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Space Physics

TITLE: Advanced Interplanetary Explorer (AIE)

PRINCIPAL CONTACT: William D. Hibbard

ORGANIZATION: GSFC

MMC CONTACT: J.E. Freidell

PROGRAM OBJECTIVE: The AIE mission will intensively study the transient particle phenomena and associated electromagnetic emissions which are occurring locally in the solar system. These include phenomena related to solar flares, interplanetary shocks, corotating interactive regions, electrons emitted by the Sun and Jupiter, and solar modulation. In addition, the elemental, isotopic, and charge state compositions of various particle populations will be measured and compared.

PROGRAM STATUS: NASA lists as OPPORTUNITY.

SYSTEM DESCRIPTION: The spacecraft will be spin stabilized with spin axis normal to the ecliptic plane. A despun solar-oriented platform will house solar wind composition measurement instrumentation.

SYSTEM OPERATION: Most probably autonomous with command update capability. Launch from LEO to the L_1 libration point likely. Real-time data accessibility by ISTO and late ASTO would allow this mission to qualify as an interplanetary companion for the STO Program.

SYSTEM INTEGRATION: Orbit will be a 50^o x 15^o halo orbit around the L_1 sunward libration point.

SUBSYSTEM SUPPORT:

Data Management and Communications: It is conceivable that space station could support this function as opposed to TDRSS. Such would provide the near real-time data required by the STO program.

BENEFITS:

Space Station Utilization: Launch support is quite possible as is sustained data communication/processing as opposed to TDRSS dedicated downlink.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

Synergistic Advantages: This mission could serve also as one of the Interplanetary Companion Satellites required by the STO program. This presumes both ASTO spacecraft could obtain data in real-time.

Direct Benefits: To advance our scientific understanding in the areas outlined previously in Objectives.

REFERENCES:

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Space Physics

TITLE: Plasma Turbulence Explorer

PRINCIPAL CONTACT: Richard A. Wallace

ORGANIZATION: JPL

MMC CONTACT: J.E. Freidell

PROGRAM OBJECTIVE: The general purpose of this mission is to investigate and describe the mechanisms of plasma turbulence in the Sun-Earth environment, including deep space as well as near-Earth regions.

PROGRAM STATUS: Mission concepts were formulated with a Science Panel created in 1979 to investigate science rationale for a mission exploring plasma turbulence. Science requirements/goals will be an output of the panel, and publication was released in late 1980. No additional work has been done.

SYSTEM DESCRIPTION: Multiple spacecraft traveling in both deep space and near-Earth space regions are envisioned. Tethered spacecraft and/or instruments may be desirable for temporal and spatial calibration requirements.

SYSTEM OPERATION:

SYSTEM INTEGRATION:

Space Station Utilization: Launch support may be possible. Definitive determination must await further definition of this mission.

Synergistic Advantages: It may be possible to consider one or more of these spacecraft to be additionally outfitted such that it (they) could also serve as an Interplanetary Compansion Satellite in satisfaction of STO program requirements.

Direct Benefits: To obtain superior scientific understanding of turbulent plasma characteristics.

SUBSYSTEM SUPPORT:

BENEFITS:

REFERENCES:

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Space Physics

TITLE: Chemical Release Module (CRM) Facility

PRINCIPAL CONTACT: Leo O. Richards

ORGANIZATION: MSFC

MMC CONTACT: J.E. Freidell

PROGRAM OBJECTIVE: The Chemical Release Module (CRM) facility will have the capability of multiple releases of liquids and gases into the magnetosphere/ionosphere system. The releases are used to trace the motions of neutral gases, plasmas, and energetic particles and to map magnetic and electric fields.

PROGRAM STATUS: The first CRM currently holds NASA Approved Status.

SYSTEM DESCRIPTION: The CRM is currently planned to be an expendable module deployed via Shuttle and using an onboard kick motor into a free-flying orbit. Chemicals will be released via pyrotechnic means. Later CRM versions for later missions may be recoverable.

SYSTEM OPERATION: Chemicals are released on command from the ground through TDRSS or STDN. Each release is to be observed by ground-based facilities, aircract, existing spacecraft, and in some cases, by Shuttle/Spacelab instruments. As extension of this mission continues to mature through the 1990's, operation via one or more of the STO spacecraft, if manned, or possibly a Space Station is highly likely.

SYSTEM INTEGRATION: The expendable module is carried into Orbit by Shuttle/Spacelab and is deployed into a free-flying orbit. Orbit apoapse is raised to 1200 km by a kick motor. Later missions might use the SUSS-A or -D for a higher apoapse (up to 25 Earth radii). The CRM is 3m in diameter by 2 m high and has a mass of 2700 kg.

SUBSYSTEM SUPPORT:

BENEFITS:

Space Station Utilization: Particularly as the CRM evolves into the space station era and is required to support the STO program objectives the support of a space station may be purposeful. Launch, maintenance, repair, changeout, calibration, and recovery all are likely to be used for the next generation CRMs which should be reusable.

SPACE STATION USERS CONCEPT

Synergistic Advantages: Both ISTO and ASTO mission require CRMs.

Direct Benefits: The benefits are of a purely scientific nature.

REFERENCES:

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APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Astronomy

TITLE: Cosmic Background Explorer (COBE)

PRINCIPAL CONTRACT: Dr. J. Mather

ORGANIZATION: NASA/GSFC

MMC CONTRACT: F. Bartko

PROGRAM OBJECTIVE: Full sky survey to measure diffuse infrared and microwave cosmic background emission from one micron to thirteen mm.

PROGRAM STATUS: Approved Mission: Launch in 1985

SYSTEM DESCRIPTION: Free-flyer explorer-class spacecraft which houses far IR absolute spectrophotometer, a diffuse IR background experiment, and a differential microwave radiometer, along with supporting subsystems.

SYSTEM OPERATION: Free Flyer Spacecraft

SYSTEM INTEGRATION: Retrieval/Deployment Interfaces. Also interface for cryogen replenishment.

SUBSYSTEM SUPPORT: N/A

BENEFITS:

Space Station Utilization: Extend lifetime.

Man's Role: Work retrieval/deployment and replenishment interfaces.

Synergistic Advantages: N/A

Direct Benefits: Scientific Research, IR detection, and cryogenic technology benefits.

REFERENCES:

1) National Academy of Sciences, Astronomy Survey Committee: Astronomy and Astrophysics for the 1980's, 1982

2) NASA: Space Systems Technology Model, Vol 1,2,3 Sept 1981.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

REFERENCES: (Con't)

3) National Academy of Sciences, Committee on Space Astronomy and Astrophysics: A Strategy for Space Astronomy and Astrophysics for the 1980s, 1979.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Astronomy

TITLE: Far Ultraviolet Spectrographic Explorer (FUSE)

PRINCIPAL CONTRACT: Dr. R. Chapman; Dr. A. Boggess

ORGANIZATION: NASA/GSFC

MMC CONTRACT: F. Bartko

PROGRAM OBJECTIVE: Perform high and low resolution spectroscopy of stars, galaxies and interstellar matter in the 90-120NM spectral region.

PROGRAM STATUS: Opportunity Mission: Launch 1990

SYSTEM DESCRIPTION: Free-flyer explorer class spacecraft which houses cassegrain telescope/spectrograph and supporting subsystems, and which operate under real-time control from geosynchronous orbit.

SYSTEM OPERATION: Free Flyer Spacecraft at Geosynchronous Orbit

SYSTEM INTEGRATION: Work interfaces for instrument changeout.

SUBSYSTEM SUPPORT: N/A

BENEFITS:

Space Station Utilization: Extend lifetime; replace scientific instruments.

Man's Role: Program instrument replacement.

Synergistic Advantages: N/A

Direct Benefits: Scientific research: technology development of UV sensors.

REFERENCES:

1) National Academy of Sciences, Astronomy Survey Committee: Astronomy and Astrophysics for the 1980's, 1982

2) NASA: Space Systems Technology Model, Vol 1,2,3 Sept 1981.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

REFERENCES: (Con't)

3) National Academy of Sciences, Committee on Space Astronomy and Astrophysics: A Strategy for Space Astronomy and Astrophysics for the 1980s, 1979.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Astronomy

TITLE: X-Ray Timing Explorer (XTE)

PRINCIPAL CONTRACT: Dr. W. Hibbard

ORGANIZATION: NASA/GSFC

MMC CONTRACT: F. Bartko

PROGRAM OBJECTIVE: Measure temporal variability of x-ray objects for time scales ranging from microseconds to years.

PROGRAM STATUS: Planned mission launch in 1989.

SYSTEM DESCRIPTION: Free-flyer explorer-class spacecraft which house a large area proportional counter and a wide field optical camera.

SYSTEM OPERATION: Free Flyer Spacecraft

SYSTEM INTEGRATION: Interfaces for retrieval/deployment

SUBSYSTEM SUPPORT: N/A

BENEFITS:

Space Station Utilization: Extend lifetime.

Man's Role: Perform retrieval.

Synergistic Advantages: N/A

Direct Benefits: Scientific research, technology development.

REFERENCES:

1) National Academy of Sciences, Astronomy Survey Committee: Astronomy and Astrophysics for the 1980's, 1982

2) NASA: Space Systems Technology Model, Vol 1,2,3 Sept 1981.

3) National Academy of Sciences, Committee on Space Astronomy and Astrophysics: A Strategy for Space Astronomy and Astrophysics for the 1980s, 1979.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Astronomy

TITLE: Extreme Ultraviolet Explorer (EUVE)

PRINCIPAL CONTRACT: Dr. S. E. Willis

ORGANIZATION: NASA/GSFC

MMC CONTRACT: F. Bartko

PROGRAM OBJECTIVE: Sky surveyed for EUV sources in solar neighborhood for studies of stellar evolution and properties of the interstellar medium.

PROGRAM STATUS: Planned mission launch in 1987.

SYSTEM DESCRIPTION: Free-flyer explorer class spacecraft which houses 3 EUV telescopes and supporting subsystems.

SYSTEM OPERATION: Free Flyer Spacecraft

SYSTEM INTEGRATION: Retrieval/deployment interfaces.

SUBSYSTEM SUPPORT: N/A

BENEFITS:

Space Station Utilization: Extend lifetime

Man's Role: Perform retrieval/deployment

Synergistic Advantages: N/A

Direct Benefits: Scientific Research, EUV sensor technology development.

REFERENCES:

1) National Academy of Sciences, Astronomy Survey Committee: Astronomy and Astrophysics for the 1980's, 1982

2) NASA: Space Systems Technology Model, Vol 1,2,3 Sept 1981.

3) National Academy of Sciences, Committee on Space Astronomy and Astrophysics: A Strategy for Space Astronomy and Astrophysics for the 1980s, 1979.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Astronomy

TITLE: Gamma Ray Timing Explorer (GTE)

PRINCIPAL CONTRACT: Dr. W. Hibbard; Dr. C. Fichtel

ORGANIZATION: NASA/GSFC

MMC CONTRACT: F. Bartko

PROGRAM OBJECTIVE: Perform high time resolution measurements of gamma ray bursters and solar flare gamma ray spectra.

PROGRAM STATUS: Opportunity Mission: Launch in 1983.

SYSTEM DESCRIPTION: Free-flyer explorer class spacecraft containing high resolution gamma ray spectrometers, Dicke-type cameras, and x-ray sky monitors, plus supporting subsystems.

SYSTEM OPERATION: Free Flyer Spacecraft

SYSTEM INTEGRATION: Retrieval/deployment; cryogen replenishment

SUBSYSTEM SUPPORT: N/A

BENEFITS:

Space Station Utilization: Extend lifetime.

Man's Role: Retrieve/deploy, replenish cryogens.

Synergistic Advantages: N/A

Direct Benefits: Scientific research; technology development.

REFERENCES:

1) National Academy of Sciences, Astronomy Survey Committee: Astronomy and Astrophysics for the 1980's, 1982

2) NASA: Space Systems Technology Model, Vol 1,2,3 Sept 1981.

3) National Academy of Sciences, Committee on Space Astronomy and Astrophysics: A Strategy for Space Astronomy and Astrophysics for the 1980s, 1979.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Astronomy

TITLE: Heavy Nuclei Explorer (HNE)

PRINCIPAL CONTRACT: Dr. W. Hibbard

ORGANIZATION: NASA/GSFC

MMC CONTRACT: F. Bartko

PROGRAM OBJECTIVE: Study the origin, composition, and propagation of cosmic rays, emphasizing nuclei from IR on and beyond in the periodic table.

PROGRAM STATUS: Opportunity Mission: Launch in 1995.

SYSTEM DESCRIPTION: Free-flyer explorer class spacecraft containing Ion chambers and solid state detectors with supporting subsystems.

SYSTEM OPERATION: (a) Free flyer spacecraft, (b) Could be adapted for attached payload.

SYSTEM INTEGRATION: (1) Retrieval/deployment interface; (b) nominal Space Station support services.

SUBSYSTEM SUPPORT: N/A if free flyer; if attached, provide thermal control, power, and structural support for 400 kg payload.

BENEFITS:

Space Station Utilization: (a) Extend lifetime; (b) Provide platform for experiment.

Man's Role: Maintenance

Synergistic Advantages: N/A

Direct Benefits: Scientific research.

REFERENCES:

1) National Academy of Sciences, Astronomy Survey Committee: Astronomy and Astrophysics for the 1980's, 1982

SPACE STATION USERS CONCEPT

REFERENCES: (Con't)

2) NASA: Space Systems Technology Model, Vol 1,2,3 Sept 1981.

3) National Academy of Sciences, Committee on Space Astronomy and Astrophysics: A Strategy for Space Astronomy and Astrophysics for the 1980s, 1979.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Astronomy

TITLE: Starlab

PRINCIPAL CONTRACT: Dr. R.W. O'Connell

ORGANIZATION: University of Virginia

MMC CONTRACT: F. Bartko

PROGRAM OBJECTIVE: Perform far UV high resolution imaging and spectrograph of planets, stars, galaxies and interstellar medium.

PROGRAM STATUS: Planned Mission: Launch in 1989.

SYSTEM DESCRIPTION: Astronomical facility consisting of 1 meter telescope and focal plane instrumentation for wide field imaging and high resolution spectroscopy and spectropolarimetry, plus all supporting subsystems provided by Spacelab.

SYSTEM OPERATION: Intended as Spacelab payload originally. Could be used as attached or nearby platform to space station.

SYSTEM INTEGRATION: Provide platform interfaces for experiment operation. Also provide interface for instrument changeout.

SUBSYSTEM SUPPORT: Platform mount would require pointing/stabilization for 0.1" resolution, thermal control, structural/mechanical support, data interfaces and power support.

BENEFITS:

Space Station Utilization: Operate as a platform experiment, with frequent instrument update; extended life for operation.

Man's Role: Perform servicing functions and instrument changeout.

Synergistic Advantages: Supports programs such as ST.

Direct Benefits: Scientific research; technology; technology development for UV detectors.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

REFERENCES:

1) National Academy of Sciences, Astronomy Survey Committee: Astronomy and Astrophysics for the 1980's, 1982

2) NASA: Space Systems Technology Model, Vol 1,2,3 Sept 1981.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Astronomy

TITLE: Shuttle Infrared Telescope Facility (SIRTF)

PRINCIPAL CONTRACT: Mr. J. Murphy

ORGANIZATION: NASA/JRC

MMC CONTRACT: F. Bartko

PROGRAM OBJECTIVE: Perform photometric, spectroscopic and polarimeric observations, in the infrared (2 microns to 1 mm), on stars, galaxies, and interstellar matter.

PROGRAM STATUS: Planned mission: Launch in 1989.

SYSTEM DESCRIPTION: SIRTF if an IR astronomical facility being developed initially for spacelab operation. SIRTF employs a Cassegrain telescope, cryogonically cooled, with a multiple instrument chamber (2-6 instruments).

SYSTEM OPERATION: Originally planned as Spacelab experiment. Free flyer with extended life desired. Could possibly operate on platform in proximity to space station.

SYSTEM INTEGRATION: Provide interfaces for cryogen replenishment; possible instrument changeout. Extreme contamination sensitivity.

SUBSYSTEM SUPPORT: (a) Free flyer: N/A; (b) As a platform experiment, stabilized pointing platform for 2" resolution; power data interface, structural support would be required.

BENEFITS:

Space Station Utilization: Extended lifetime, instrument changeout possible.

Man's Role: Cryogen replenishment; possible instrument changeout.

Synergistic Advantages: N/A

Direct Benefits: Scientific research; IR detector, cryogenic technology and possible military surveillance benefit.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

REFERENCES:

1) National Academy of Sciences, Astronomy Survey Committee: Astronomy and Astrophysics for the 1980's, 1982

2) NASA: Space Systems Technology Model, Vol 1,2,3 Sept 1981.

3) National Academy of Sciences, Committee on Space Astronomy and Astrophysics: A Strategy for Space Astronomy and Astrophysics for the 1980s, 1979.

APPENDIX C MISSION CONCENT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Astronomy

TITLE: Large Area Modular Arry of Reflectors (LAMAR)

PRINCIPAL CONTACT: Dr. E. Mercanti

ORGANIZATION: NASA/MSFC

MMC CONTACT: F. Bartko

PROGRAM OBJECTIVE: Perform a full sky survey at x-ray wavelengths (0.2 - 4 kev) with high sensitivity and moderate spatial resolution.

PROGRAM STATUS: Candidate mission: Launch in 1992.

SYSTEM DESCRIPTION: LAMAR is planned as an x-ray spacelab facility intially and will be developed for a free flyer mode at a later date. The Instrument module, consisting of multiple co-aligned x-ray concentrators for imaging, can be increased in collecting area by addition of mutliple modules.

SYSTEM OPERATION:

SYSTEM INTEGRATION:

SUBSYSTEM SUPPORT:

BENEFITS:

DIRECT BENEFITS:

RFERENCES:

APPENDIX C MISSION CONCENT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Astronomy

TITLE: Orbiting Very Long Baseline Interferometer (OVLBI)

PRINCIPAL CONTACT: Dr. B. Burke, Dr. M. Nein

ORGANIZATION: MIT: NASA/MSFC

MMC CONTACT: F. Bartko

PROGRAM OBJECTIVE: Perform very long baseline radiometry (1-22 GHZ) using 50M orbiting antenna in conjunction with ground based antennas. For high angular resolution observations of galaxies, quasars, pulsars and supervavae remnants.

PROGRAM STATUS: Candidate Mission: Launch in 1991.

SYSTEM DESCRIPTION: Deployable 50M antenna, with on-board frequency standard, and low-noise cryogenic receivers, operating in conjunction with ground based network of antennas.

SYSTEM OPERATION: Perform demonstration equipment from Shuttle. Free-flyer operation is desired; at moderate orbit indentation (45^{o}).

SYSTEM INTEGRATION: Provide interfaces for instrument changeout, cryogen replenishment and building of antenna areas.

SUBSYSTEM SUPPORT: N/A

BENEFITS:

DIRECT BENEFITS:

Space Station Utilization: Extend lifetime; increase performance capabilities.

Man's Role: Perform instrument changeout, cryo replenishment; possible antenna buildup.

Synergistic Advantages: Perform instrument changeout, cyro replenishment; possible antenna buildup.

Direct Benefits: Scientific research; antenna technology development.

APPENDIX C MISSION CONCENT REFERENCE DATA

SPACE STATION USERS CONCEPT

REFERENCES:

1) National Academy of Sciences, Astronomy Survey Committee; Astronomy and Astrophyics for the 1980s, 1982.

2) NASA: Space Sstems Technology Model, Vol 1,2,3 Sept 1981.

3) Technology for Space Astrophyrics: The next 30 years Conference Proceedings, (AIAA SPIE, OSA) Danbury, CT Oct 1982

4) National Academy of Sciences, Committee on Space Astronomy & Astrophysics: A Strategy for Space Astronomy and Astrophysics for the 1980s, 1979.

APPENDIX C MISSION CONCENT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Astronomy

TITLE: Orbiting IR Submiller Telescope (OIST)

PRINCIPAL CONTACT: Dr. P. Swanson

ORGANIZATION: JPL

MMC CONTACT: F. Bartko

PROGRAM OBJECTIVE: Perform high angular spatial and spectral resolution observations of molecular clouds, galaxies and interstellar medium in the far IR to sub-MM ranges.

PROGRAM STATUS: Opportunity Mission: Launch in 1994

SYSTEM DESCRIPTION: OIST is a 10-15M deployable antenna employing super heterodyate receivers and bolometers, cryogenically cooled for high sensitivity, plus all support systems ina free flyer mode.

SYSTEM OPERATION: Desire free-flyer operation.

SYSTEM INTEGRATION: Provide interfaces for instrument changeout; crogen replenishment.

SUBSYSTEM SUPPORT: N/A

Space Station Utilization: Extend useful lifetime; instrument update

Man's Role: Perform replenishment of cryogen; instrument changeout;

Synergistic Advantages: N/A

BENEFITS:

DIRECT BENEFITS: Scientific research; antenna, cryogen, IR detector technology developement

APPENDIX C MISSION CONCENT REFERENCE DATA

SPACE STATION USERS CONCEPT

REFERENCES:

1) National Academy of Sciences, Astronomy Survey Committee: Astronomy and Astrophysics for the 1980s, 1982.

2) NASA: Space Systems Technology Model, Vol 1,2,3 Sept 1981

3) National Academy of Sciences, Committee on Space Astronomy and Astrophysics: A Strategy for Space Astronomy and Astrophysics for Space Astronomy and Astrophysics for the 1980s, 1979.

APPENDIX C MISSION CONCENT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Astronomy

TITLE: Faint Objective Telescope (FOT)

PRINCIPAL CONTACT: A. D. Davidsen

ORGANIZATION: Johns Hopkins University

MMC CONTACT: F. Bartko

PROGRAM OBJECTIVE: Perform Far UV Imaging and spectroscopy of active galatic nuclei, quasars, galaxies and stars in the range 900-2000 angstroms .

PROGRAM STATUS: Approval Mission: Launch 1985

SYSTEM DESCRIPTION: Faint object telescope is a spacelab developed 1 meter far OV telecscope/spectrograph and required support systems.

SYSTEM OPERATION: Spacelab experiment; could possible operate and platform experiment.

SYSTEM INTEGRATION: Provide interfaces for instrument changeout.

SUBSYSTEM SUPPORT: Stabilized pointing platfor for resolution; need modest power, data handling, structural support.

BENEFITS:

Space Station Utilization: Extended lifetime/operations; instrument update.

Man's Role: Provide changeout of instruments.

Synergistic Advantages: N/A

DIRECT BENEFITS: Scientific research; UV latest on technology development.

APPENDIX C MISSION CONCENT REFERENCE DATA

SPACE STATION USERS CONCEPT

REFERENCES:

1) National Academy of Sciences, Astronomy Survey Committee: Astronomy and Astrophysics for the 1980s, 1982

2) National Academy of Sciences, Committee on Space Astronomy and Astrophysics: A Strategy for Space Astronomy and Astrophysics for the 1980s, 1979.

APPENDIX C MISSION CONCENT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Astronomy

TITLE: Space Telescope (ST)

PRINCIPAL CONTACT: Dr. C. R. O'Dell

ORGANIZATION: NASA/MSFC

MMC CONTACT: F. Bartko

PROGRAM OBJECTIVE: Perform far UV/otpical imaging and spectroscopic observations, at high angular resolution, of galaxies, quasars, stars, planets satellites, comets and asteroids.

PROGRAM STATUS: Approved mission: Launch 1985

SYSTEM DESCRIPTION: A major astronomical observation facility employing at 2.4 optical telescope in conjunction with 5 scientific instruments and all required supporting subsystems, designed for a 10-15 year lifetime.

SYSTEM OPERATION: Large free-flyer observatory.

SYSTEM INTEGRATION: Provide interfaces for instrument changeout.

SUBSYSTEM SUPPORT: N/A

BENEFITS:

Space Station Utilization: Extend lifetime update instruments.

Man's Role: Provide instrument changeout; repair services.

Synergistic Advantages: N/A

DIRECT BENEFITS: Scientific research.

APPENDIX C MISSION CONCENT REFERENCE DATA

SPACE STATION USERS CONCEPT

REFERENCES:

1) National Academy of Sciences, Astronomy Survey Committee: Astronomy and Astrophysics for the 1980s, 1982.

2) NASA: Space Systems Technology Model, Vol 1,2,3 Sept 1981

3) Technology for Space Astrophysics: The Next 30 Years Conference Proceedings, (AIAA, SPIE, OSA), Danbury, CT Oct 1982

4) National Academy of Sciences, Committee on Space Astronomy and Astrophysics: A Strategy for Space Astronomy and Astrophysics for the 1980s, 1979.

APPENDIX C MISSION CONCENT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Astronomy

TITLE: Advanced X-Ray Astrophysics Facility (AXAF)

PRINCIPAL CONTACT: Dr. B. G. Davis

ORGANIZATION: NASA/MSFC

MMC CONTACT: F. Bartko

PROGRAM OBJECTIVE: Perform high angular resolution imaging and spectroscopy at the x-ray range (0.1-10 Kev) of x-ray background quasars, galaxies, pulsars and stars.

PROGRAM STATUS: Planned mission: Launch in 1992.

SYSTEM DESCRIPTION: AXAF is a major astronomical observatory facility which employs 1.2 M Wolter I mirror in conjunction with a multiple instrument carousel at the focal plane, with all required supporting systems.

SYSTEM OPERATION: Large free-flyer spacecraft.

SYSTEM INTEGRATION: Provide interfaces for instrument changeout.

SUBSYSTEM SUPPORT: N/A

BENEFITS:

Space Station Utilization: Extended lifetime; update instruments.

Man's Role: Provide instrument update of repair services.

Synergistic Advantages: N/A

DIRECT BENEFITS: Scientific research.

APPENDIX C MISSION CONCENT REFERENCE DATA

SPACE STATION USERS CONCEPT

REFERENCES:

1) National Academy of Sciences, Astronomy Survey Committee: Astronomy and Astrophysics for the 1980s, 1982.

2) NASA: Space Systems Technology Model, Vol 1,2,3 Sept 1982

3) Technology for Space Astrophysics: The Next 30 Years Conference Proceedings, (AIAA, SPIE, OSA), Danbury, CT Oct 1982

4) National Academy of Sciences, Committee on Space Astronomy and Astrophysics: A Strategy for Space Astronomy and Astrophysics for the 1980s, 1979.

APPENDIX C MISSION CONCENT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Astronomy

TITLE: Large Deployable Reflector (LDR)

PRINCIPAL CONTACT: Dr. P. Swanson, Mr. J. Murphy

ORGANIZATION: JPL: NASA/ARC

MMC CONTACT: F. Bartko

PROGRAM OBJECTIVE: Perform high angular resolution imaging and spectroscopy in the far IR, sub mm range (30 microns to 1 mm) of interstellar clouds, dust, galaxies, quasars and planets.

PROGRAM STATUS: Candidate mission: Launch in 1995.

SYSTEM DESCRIPTION: A large, dedicated astronomical observatory, consisting of 20 meter diameter segmented optics, actively-controlled. The facility will include an array of focal plane instruments, and all required free-flyer support systems.

SYSTEM OPERATION: Large free flyer observatory.

SYSTEM INTEGRATION: Needs passive thermal control; requires special orbit for constant solar illumination. Provide interfaces for possible assembly of large structures. Provide interfaces for instrument changeout.

SUBSYSTEM SUPPORT: N/A

BENEFITS:

Space Station Utilization: Provide capability for on orbit assembly test. Provide extended life. Provide instrument changeout/update.

Man's Role: Perform on orbit assembly/alignment of large structures, provide instrument changeout repair services.

Synergistic Advantages: Use technologies developed for assembly of Space Station.

DIRECT BENEFITS: Scientific research; large structures assembly/test technology development.

APPENDIX C MISSION CONCENT REFERENCE DATA

SPACE STATION USERS CONCEPT

REFERENCES:

1) National Academy of Sciences, Astronomy Survey Committee: Astronomy and Astrophysics for the 1980s 1982.

2) NASA: Space Systems Technology Model, Vol 1,2,3 Sept 1981.

3) Technology for Space Astrophysics: The Next 30 Years Conference Proceedings, (AIAA, SPIE, OSA) Danbury, CT Oct 1982.

4) National Academy of Sciences, Committee on Space Astronomy and Astrophysics: A Strategy for Space Astronomy and Astrophysics for the 1980s, 1979.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Astronomy

TITLE: Gama Ray Observatory (GRO)

PRINCIPAL CONTACT: Dr. D. Kniffen

ORGANIZATION: NASA/GSFC

MMC CONTACT: F. Bartko

PROGRAM OBJECTIVE: Perform imaging and spectroscopic measurements of gamma ray background, bursters, quasars, and galaxies, over the energy range 0.03 to 100 MEV.

PROGRAM STATUS: Planned Mission: Launch in 1989

SYSTEM DESCRIPTION: GRO is a multiple instrument free-flyer facility including support systems and instruments for gamma ray spectroscopy, imaging and high time resolution observations.

SYSTEM OPERATION: Large free-flyer, observatory.

SYSTEM INTEGRATION: Provide interfaces for instrument changeout.

SUBSYSTEM SUPPORT: N/A

BENEFITS:

SPACE STATION UTILIZATION: Extended lifetime; instrument update.

MAN'S ROLE: Provide instrument changeout, repair services.

SYNERGISTIC ADVANTAGES: N/A

DIRECT BENEFITS: Scientific research; x-ray detector technology development.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

REFERENCES:

1) National Academy of Sciences, Astronomy Survey Committee: Astronomy and Astrophysics for the 1980s, 1982.

2) NASA: Space Systems Technology Model, Vol 1,2,3 Sept 1981.

3) Technology for Space Astrophysics: The Next 30 Years Conference Proceedings, (AIAA, SPIE, OSA), Danbury, CT Oct 1982

SPACE STATION USERS CONCEPT

DISCIPLINE: Astronomy

TITLE: Coherent Optical System of Modular Imaging Collectors (COSMIC)

PRINCIPAL CONTACT: Dr. M. Nein

ORGANIZATION: NASA/MSFC

MMC CONTACT: F. Bartko

PROGRAM OBJECTIVE: Perform very high angular resolution (.001 arc sec) imaging observations of galaxies, cosmic jets, quasars, stars and planets by inter ferometeric techniques.

PROGRAM STATUS: Opportunity Mission: Launch in 2001

SYSTEM DESCRIPTION: A very large, complex facility consisting of an array of modularized telescopes which, by interferometery collect, and synthesize, coherently the images to obtain very high angular resolution. The system is designed to grow in capability by adding additional telescope modules to the array.

SYSTEM OPERATION: Large free-flyer, specialized observatory.

SYSTEM INTEGRATION: Provide interfaces for assembly, alignment, test, and modular increase in observatory size.

SUBSYSTEM SUPPORT: N/A

BENEFITS:

SPACE STATION UTILIZATION: Provide capabilities for assembly, optical alignment, test; and increase in performance capabilities.

MAN'S ROLE: Provide assembly, test services.

SYNERGISTIC ADVANTAGES: Technique useful for other large space structures.

DIRECT BENEFITS: Scientific research; large structural astrophysics technology development.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

REFERENCES:

1) National Academy of Sciences, Astronomy Survey Committee: Astronomy and Astrophysics for the 1980s, 1982.

2) NASA: Space Systems Technology Model, Vol 1,2,3 Sept 1981.

3) Technology for Space Astrophysics: The Next 30 Years Conference Proceedings, (AIAA, SPIE, OSA), Danbury, CT Oct 1982

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Astronomy

TITLE: Thinned Aperture Telescope (TAT)

PRINCIPAL CONTACT: Dr. H. Gursky; Dr. M. Nein

ORGANIZATION: Naval Research Lab,; NASA/MSFC

MMC CONTACT: F. Bartko

PROGRAM OBJECTIVE: Perform high angular resolution imaging and high precision astrometry for studies of clusters of paint galaxies, galaxies and quasars, and planetary system searches.

PROGRAM STATUS: Opportunity Mission: Launch in 2005

SYSTEM DESCRIPTION: TAT is a large, complex astronomical facility consisting of a 100 M diameter, plus focal plane instrumentation, and all supporting systems. The system will require construction assembly, alignment test and servicer on orbit.

SYSTEM OPERATION: Very large free-flyer observatory.

SYSTEM INTEGRATION: Provide interfaces for assembly, alignment, test and operation of very large, complex structure. Provide interfaces for instrument changeout.

SUBSYSTEM SUPPORT: N/A

BENEFITS:

SPACE STATION UTILIZATION: Provide capability for assembly, alignment test. Provide services for extended systems.

MAN'S ROLE: Provide services for assembly, test of large stable structures.

SYNERGISTIC ADVANTAGES: Techniques useful for other large space structures.

DIRECT BENEFITS: Scientific research; large space structure and active optics technology development.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

REFERENCES:

1) National Academy of Sciences, Astronomy Survey Committee: Astronomy and Astrophysics for the 1980s, 1982.

2) NASA: Space Systems Technology Model, Vol 1,2,3 Sept 1981.

3) Technology for Space Astrophysics: The Next 30 Years Conference Proceedings, (AIAA, SPIE, OSA), Danbury, CT Oct 1982

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Astronomy

TITLE: Cosmic Ray Observatory (CRO)

PRINCIPAL CONTACT: Dr. J. Ormes

ORGANIZATION: NASA/GSFC

MMC CONTACT: F. Bartko

PROGRAM OBJECTIVE: Perform measurements of the composition and energy spectrum of primary cosmic rays.

PROGRAM STATUS: Candidate Mission: Launch in 1993

SYSTEM DESCRIPTION: A large spacecraft consisting of many experiment modules plus required supporting subsystems.

SYSTEM OPERATION: Large free-flyer observatory. Could operate as attached payload.

SYSTEM INTEGRATION: Provide interfaces for platform/attached mode of operations.

SUBSYSTEM SUPPORT: a) Free flyer N/A. b) Attached payload, would require structural support for heavy payload; coarse pointing platform, and modest power, thermal and data support requirements.

BENEFITS:

SPACE STATION UTILIZATION: Extend lifetime; provide feasible platform for operations.

MAN'S ROLE: Repair, maintenance services.

SYNERGISTIC ADVANTAGES: N/A

DIRECT BENEFITS: Scientific research.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

REFERENCES:

1) National Academy of Sciences, Astronomy Survey Committee: Astronomy and Astrophysics for the 1980s, 1982.

2) NASA: Space Systems Technology Model, Vol 1,2,3 Sept 1981.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Astronomy

TITLE: X-Ray Observatory (XRO)

PRINCIPAL CONTACT: Dr. E. Boldt

ORGANIZATION: NASA/GSFC

MMC CONTACT: F. Bartko

PROGRAM OBJECTIVE: Perform spectroscopic and high time resolution measurements over the range 0.1 to 300 MEV of background, galaxies, quasars, and stars.

PROGRAM STATUS: Candidate Mission: Launch in 1998

SYSTEM DESCRIPTION: A free-flyer spacecraft consisting of instrument modules and required support systems.

SYSTEM OPERATION: Large free-flyer observatory.

SYSTEM INTEGRATION: Provide interfaces per instrument changeout.

SUBSYSTEM SUPPORT: N/A

BENEFITS:

SPACE STATION UTILIZATION: External lifetime.

MAN'S ROLE: Instrument changeout.

SYNERGISTIC ADVANTAGES: N/A

DIRECT BENEFITS: Scientific research.

REFERENCES:

1) NASA: Space Systems Technology Model, Vol 1,2,3 Sept 1981.

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APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Solar Astronomy

TITLE: Solar Optical Telescope (SOT) MMCX-0200

PRINCIPAL CONTACT: Dr. Richard W. Fisher

ORGANIZATION: High Altitude Observatory

MMC CONTACT: Dennis Schneibel (Ball Aerospace Corp)

PROGRAM OBJECTIVE: The SOT objectives are to observe details of the sun, from 0.1 to 0.5 arc seconds in size, in the wavelength range of 1175A to 1.24 . The interaction between solar magnetic and hydrodynamic processes will be studied.

PROGRAM STATUS: SOT is the first of the eight proposed solar astronomy missions to receive hardware development funding. SOT is currently scheduled to fly as a Spacelab payload in 1988, then be reflown as an attached payload or a free-flyer and ultimately to be incorporated into the Advanced Solar Observatory.

SYSTEM DESCRIPTION: The SOT is a 7.0 m by 4.0 m diameter telescope facility containing a 1.25 m diameter primary mirror with a 3.0 m focal length. A gregorian pod directs the focused energy to any of several instruments located at the gregorian focal plane. The SOT will also accommodate co-observing instruments which do not make use of the primary mirror and optical subsystem.

SYSTEM OPERATION: SOT will be designed to operate from the shuttle bay in a sortie mode, as a free flyer operated by ground command, or as a part of a cluster of telescope attached to a space platform or station. Instrumentation selected for SOT may require film change on a routine basis. Both real time and pre-planned observing will be done. Targets of opportunity will be identified and pointed to by either ground based or on-board operators. Video displays and electronic readouts will be transmitted to ground.

SYSTEM INTEGRATION: SOT will operate from almost any orbit above 400 km. The optimum orbit would be sun synchronous to maximize solar viewing time. Pointing accuracy and stability should be in the few arc second range which will require a sophisticated pointing system such as the Instrument Pointing System (IPS). Contamination must be minimized due to the sensitivity of ultra-violet reflecting mirrors.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

SUBSYSTEM SUPPORT: The SOT is a facility telescope and as such its subsystem support requirements will change dramatically depending on the configuration of the instrumentation. An estimate of the support required can be made from requirements for SOT instrumentation such as the SSXTF.

BENEFITS: Space station will provide SOT with a stable base from which to conduct long term observations. Mans presence will assure timely servicing, repair and maintenance as well as rapid response to unpredicted occurrences. Synergistic advantages are the capability to compare data with earth and stellar viewing telescopes.

Direct benefits in the form of improved weather and communication prediction may result from a better understanding of the sun. It is possible that basic research into how the sun operates may have application on earth to produce vast quantities of energy. In addition, knowledge applicable to stellar astronomy may be gained by studying the sun as an average star.

REFERENCES:

Individuals

Name:	Dr. E. Reeves	Title:	Chief, Instrument Development
Agency:	NASA HQ EM-8	Phone:	(202) 755-3294
Name:	Dr. S. Jordan	Title:	SOT Project Sci
Agency:	GSFC 680.0	Phone:	(301) 344-6184
Name:	Dr. E. Chipman	Title:	SOT Program Sci
Agency:	NASA HQ EZ-7	Phone:	(202) 755-3546
Name:	Mr. George Hogen	Title:	SOT Program Mgr.
Agency:	GSFC 425.0	Phone:	(301) 344-7929

Papers

"The Advanced Solar Observatory", Report of the Science Definition Team, November 1982

SPACE STATION USERS CONCEPT

DISCIPLINE: Solar Astronomy

TITLE: Solar Soft X-Ray Telescope Facility (SSXTF) MMCX-0201

PRINCIPAL CONTACT: Dr. A. Krieger

ORGANIZATION: American Science and Engineering

MMC CONTACT: Dennis Schneibel (Ball Aerospace Corp.)

PROGRAM OBJECTIVE: The SSXTF objectives are to provide a diagnostic capability for the study of the solar corona and transient events, such as solar flares, which are predominantly high temperature phenomena.

PROGRAM STATUS: Phase A studies completed by American Science and Engineering (1976). Final report of facility definition team published (1982). Program is awaiting Phase B funding.

SYSTEM DESCRIPTION: The SSXTF is a 6.15 m x 1.3 m diameter telescope containing an 80 cm Wolter 1, grazing incidence, nested mirror with 0.5 arc second resolution capability. The SSXTF definition team has identified a number of candidate focal plane instruments which will operate in a 1.5 A to 300 A wavelength region.

SYSTEM OPERATION: The SSXTF will ultimately be incorporated into the Advanced Solar Observatory (ASO). It may operate in the shuttle sortie mode or as a free-flyer, but will most likely fly as a co-observing instrument within the SOT facility; therefore, its operation will be similar to that described for SOT.

SYSTEM INTEGRATION: See SOT system integration

SYSTEM SUPPORT: The AS&E final report contains estimates of 240 watts operating power and 25 kbps telemetry downlink for the SSXTF. In addition, a 4.2 MHz video link and a 5 word per second command rate is suggested. Thermal control and pointing is assumed to be provided by the SOT mounted in an IPS pointer.

BENEFITS: See SOT benefits.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

REFERENCES:

Individuals

Dr. G. Withbroe, Smithsonian Astrophysical Observatory

Papers

"Solar EUV, XUV and Soft X-Ray Telescope Facilities" Final Report of the Facility Definition Team, January 1982.

"Preliminary Definition Study, Soft X-Ray Telescope Facility for the NASA Shuttle Solar Physics Laboratory" Final Report, May 1976.

"The Advanced Solar Observatory", Report of the Science Definition Team, November 1982.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Solar Astronomy

TITLE: Pinhole/Occulter Facility (P/OF) MMCX-0202

PRINCIPAL CONTACT: Dr. H. Hudson

ORGANIZATION: University of California, San Diego

MMC CONTACT: Dennis Schneibel (Ball Aerospace Corp.)

PROGRAM OBJECTIVE: The P/OF objectives are to study non-thermal phenomena of plasma dynamics in the solar corona and to observe the acceleration of non-thermal particles in solar flares and in coronal disturbances with both x-ray and coronagraphic instruments.

PROGRAM STATUS: The Science Working Group has published their report "The Pinhole/Occulter Facility". The project is awaiting funding to initiate concept studies.

SYSTEM DESCRIPTION: The P/OF consists of a 50m boom that separates an occulting mask from an array of detectors and telescopes. The name "pinhole" derives from the use of a remote occulter (from coronagraphic studies) containing an array of small apertures to obtain high angular resolution of hard X-radiation.

SYSTEM OPERATION: The P/OF is being conceptually designed to fly in the shuttle sortie mode and eventually to be incorporated into the ASO. A unique feature of the P/OF is its ability to study both solar and stellar x-ray sources. To take advantage of this capability, the P/OF would have to be placed in a low inclination orbit and re-pointed frequently and probably independently of other solar viewing instruments. The ultimate configuration for the P/OF would consist of two stable platforms, perhaps as much as 2 km apart. The occulter will be located on one platform and the telescopes and detectors on a second, perhaps the space station.

SYSTEM INTEGRATION: The P/OF will be integrated onto the space station as a part of the ASO.

SUBSYSTEM SUPPORT: Total mass of the P/OF is estimated to be 4200 kg. Power requirements are estimated at 570 watts and telemetry downlink at 1.5 Mbps. Pointing and stability are critical as for all occulter type solar instruments - in this case sub arc second stability may be required and is certainly desirable.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

BENEFITS: Direct benefits in the form of improved weather and communication prediction may result from a better understanding of the sun. It is possible that basic research into how the sun operates may have application on earth to produce vast quantities of energy. In addition, knowledge applicable to stellar astronomy may be gained by studying the sun as an average star.

REFERENCES:

Individuals

Dr. R. Munro, High Altitude Observatory, Boulder, Colorado

Papers

"The Pinhole/Occulter Facility", Science Working Group Report

"The Advanced Solar Observatory", Report of the Science Definition Team, November, 1982

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Solar Astronomy

TITLE: Advanced Solar Observatory (ASO) MMCX-0203

PRINCIPAL CONTACT: Dr. A. B. C. Walker

ORGANIZATION: Stanford University

MMC CONTACT: Dennis Schneibel (Ball Aerospace Corp.)

PROGRAM OBJECTIVE: The ASO general objective is to provide the solar astronomy community with a solar observatory in earth orbit on a long term basis. From the science standpoint, the ASO objectives are to understand the varied structures and phenomena responsible for the generation and transport of energy in the solar interior and atmosphere.

PROGRAM STATUS: The Astronomy Survey Committee has made the development of ASO the major recommendation for solar astronomy. Of the four major instrument groupings which comprise ASO, the SOT is the only approved program to date.

SYSTEM DESCRIPTION: The ASO minimum configuration consists of four major instrument groupings:

- The Solar Optical Telescope (SOT)
- The Pinhole/Occulter Facility (P/OF)
- The Solar Soft X-Ray Telescope Facility (SSXTF)
- The Solar EUV/XUV Telescope Facility (SEXTF)

ASO is the name being given to the ultimate goal of an orbiting solar astronomy dedicated cluster of instruments and facilities. The minimum configuration complement listed above is one version of many possible combinations of instruments.

SYSTEM OPERATION: ASO will be operated in much the same way as a ground based solar observatory is operated. Different telescopes will be used in various combinations to study solar phenomena simultaneously in many wavelengths and at different heights in the solar atmosphere. Some observations may be done by pre-programmed, computer generated commands while others may require the dynamic and versatile command structure provided only by man. It is likely that frequent re-supply of expendables such as film and tape will be necessary.

SYSTEM INTEGRATION: As the ASO is the only solar astronomy mission currently planned for space station integration, the integration task for solar astronomy should be relatively easy. The minimum ASO configuration will consist of four major groupings of instruments, all of which will have been flown numerous times prior to being incorporated into ASO. Most of these same grouping will have been integrated together during SSF or one of the ASO shuttle development flights. The integration, as well as the operation, of these instruments will be mature procedures by the time ASO is integrated onto the space station or onto a platform.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

Because of its size, more than one shuttle flight may be required to transport the ASO to the space station. Additional shuttle flights, on an average once a year basis, should be anticipated in order to exchange one or more of the instruments. It is conceivable that an entire facility such as SSXTF could be removed and replaced by some other large solar facility during the later stages of the ASO mission.

SUBSYSTEM SUPPORT: The ASO is envisioned as a space based solar observatory which will support a variety of solar facilities such as SOT and SSXTF as well as smaller solar telescopes. This observatory concept implies an evolutionary and frequently changing combination of solar observing instruments. In order to estimate the level of subsystem support required by ASO, the sun of the requirements of the various components of ASO must be derived. The requirements for the four major instrument groupings are given under the grouping name elsewhere in this appendix.

BENEFITS: Space station will provide ASO with a stable base from which to conduct long term observations. Mans presence will assure timely servicing, repair and maintenance as well as rapid response to unpredicted occurrences. Synergistic advantages are the capability to compare data with earth and stellar viewing telescopes.

Direct benefits in the form of improved weather and communication prediction may result from a better understanding of the sun. It is possible that basic research into how the sun operates may have application on earth to produce vast quantities of energy. In addition, knowledge applicable to stellar astronomy may be gained by studying the sun as an average star.

REFERENCES:

Individuals

Mr. W. T. Roberts, NASA/MSFC

Papers

"The Advanced Solar Observatory" AIAA-83-0511" Report of the (ASO) Science Definition Team" Draft Copy

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Solar Astronomy

TITLE: Solar Shuttle Facility (SSF) MMCX-0204

PRINCIPAL CONTACT: Dr. A. B. C. Walker

ORGANIZATION: Stanford University

MMC CONTACT: Dennis Schneibel (Ball Aerospace Corp.)

PROGRAM OBJECTIVE: The SSF is intended to be a shuttle based forerunner of the Advanced Solar Observatory (ASO). Like ASO, the SSF objectives are to understand the fundamental plasma processes underlying cyclic activity and transient high-energy phenomena on the sun and other stars.

PROGRAM STATUS: The Astronomy Survey Committee has recommended the SSF for development. The ASO Science Definition Team has defined four shuttle based missions consisting of ASO instrumentation. These missions and SSF are most likely the same.

SYSTEM DESCRIPTION: SSF is a cluster of telescopes to be flown together in the shuttle sortie mode, most likely on a single pointing system. Some of the facilities for inclusion in this cluster are the Solar Optical Telescope (SOT), the Solar Soft X-Ray Telescope Facility (SSXTF), a European developed Grazing Incidence Solar Telescope (GRIST) and the Pinhole/Occulter Facility (P/OF).

SYSTEM OPERATION: SSF will be operated as an integrated observatory for short periods of time, probably less than seven days, by both on-board crewmembers and by ground or station based observers. Orbital parameters will be dictated by shuttle requirements; however, the ideal orbit would be full sun at altitudes above 450 km. Depending on the ASO development schedule, SSF could be supported by the space station during its initial phase.

SYSTEM INTEGRATION: There are no plans to physically integrate the SSF with the space station.

SUBSYSTEM SUPPORT: None required with possible exception of operational support.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

BENEFITS: In addition to the science benefits as described for other solar telescopes, the SSF will serve as a flight test for the ASO before ASO is integrated with the space station.

REFERENCES:

Papers

"Astronomy and Astrophysics for the 1980's, Volume 1: Report of Astronomy Survey Committee", Appendix A.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Solar Astronomy

TITLE: Solar Interplanetary Satellite (SIS) MMCX-0205

PRINCIPAL CONTACT: Dr. R. MacQueen

ORGANIZATION: High Altitude Observatory

MMC CONTACT: Dennis Schneibel (Ball Aerospace Corp.)

PROGRAM OBJECTIVE: The SIS objectives are to observe the solar corona and transient events from a position 90o behind the earth in the elliptic, following an ellipse identical to that of earths orbit but oriented 90o to it.

PROGRAM STATUS: The SIS Science Definition Team has published their final report and are requesting funds to support Phase A conceptual design studies.

SYSTEM DESCRIPTION: The SIS is a boxed-shaped spacecraft containing solar viewing instruments, support electronics and propulsion elements. A STAR-27 solid rocket motor is located within a central circular opening in the spacecraft. Thrusters are located at the upper and lower ends of two solar panel supports.

SYSTEM OPERATION: Because of its unique orbit about the sun as opposed to about the earth, the SIS can only be operated by remote command from the earth or from the space station.

SYSTEM INTEGRATION: SIS is being designed as a free flyer for orbiting about the sun; therefore, SIS will not be physically integrated onto an earth orbiting space station.

SUBSYSTEM SUPPORT: SIS has been conceptually developed to support the International Solar Polar Mission (ISPM) being conducted by a consortium of European scientists. As such, the SIS will be launched before the flight elements of a space station will be placed in orbit. However, the five year or longer mission lifetime of SIS makes it a candidate for space station operational and communication support.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

BENEFITS: SIS will provide a profile view of solar events seen against the solar disk by observers on earth. By comparing information collected simultaneously but from two angles separated by 90°, solar astronomers will be able to develop three dimensional models of solar phenomena.

REFERENCES:

Individuals

Dr. T. Thorpe, NASA/JPL Study Manager

Papers

"Solar Interplanetary Satellite Study Report" April 27, 1982

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Solar Astronomy

TITLE: Solar Internal Dynamics Mission MMCX-0206

PRINCIPAL CONTACT: Dr. E. Rhodes

ORGANIZATION: California Institute of Technology

MMC CONTACT: Dennis Schneibel (Ball Aerospace Corp.)

PROGRAM OBJECTIVE: The SIDM objectives are to study the internal structure of the sun; to study the solar dynamo and the solar cycle; to study large scale circulation and convection in the solar envelope.

PROGRAM STATUS: The SIDM concept has not been developed at the Phase A study level as of this date although some of its concepts are derived from the Solar Cycle and Dynamics Mission (SCADM).

SYSTEM DESCRIPTION: The SIDM is a 1 m class telescope facility containing up to five solar observing instruments which operate in the 3500 A to 7500 A wavelength region. SIDM has evolved from the Solar Cycle and Dynamics Mission (SCADM) concept which are divided into two moderate mission concepts, the SIDM and the Solar Coronal Diagnostic Mission (SCDM).

SYSTEM OPERATION: SIDM is being planned as a free flying spacecraft to be placed at the Earth-Sun libration point, L_1. SIDM operations will necessarily be remotely controlled from either earth based observers or from the space station.

SYSTEM INTEGRATION: There are no plans to integrated SIDM to the space station.

SUBSYSTEM SUPPORT: Space station support to SIDM will necessarily be limited to operational and communication support when the station is within "line-of-sight" of the SIDM. Launch support could also be provided to boost the SIDM to its far out orbital mission.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

BENEFITS: Direct benefits in the form of improved weather and communication prediction may result from a better understanding of the sun. It is possible that basic research into how the sun operates may have application on earth to produce vast quantities of energy. In addition, knowledge applicable to stellar astronomy may be gained by studying the sun as an average star.

REFERENCES:

Papers

"Solar Cycle and Dynamics Mission" Final report, NASA/GSFC, July 1980

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Solar Astronomy

TITLE: Solar Coronal Diagnostic Mission (SCDM) MMCX-0207
(Solar Corona Explorer)

PRINCIPAL CONTACT: Dr. A. Polland

ORGANIZATION: NASA/GSFC

MMC CONTACT: Dennis Schneibel (Ball Aerospace Corp.)

PROGRAM OBJECTIVE: The SCDM objectives are to investigate the structure, dynamics and evolution of the corona, globally and in the required physical detail, to study the close coupling between the inner corona and the heliosphere.

PROGRAM STATUS: The SCDM has been defined by a science working group at NASA/GSFC under the name "Solar Corona Explorer." Like SIDM, the SCDM is a candidate for approval as a solar astronomy mission new start.

SYSTEM DESCRIPTION: The SCDM is a 1 m class telescope facility containing up to five solar observing instruments which operate in a 3 A to 1000 A wavelength region. SCDM has evolved from the Solar Cycle and Dynamics Mission concept as has the SIDM.

SYSTEM OPERATION: SCDM could be developed as either a free flying spacecraft or as a telescope to be incorporated into the ASO. As a free flyer, it would be remotely operated by ground or space station based observers but would otherwise require very little space station support. As an integrated ASO telescope, the SCDM would be operated as a portion of the observatory.

SYSTEM INTEGRATION: If developed as a free flyer, SCDM would not be integrated onto the space station. As a part of ASO, the integration would be done with the ASO complement of instruments.

BENEFITS: The SCDM would provide the earth view of the two views of the sun as discussed for the SIS. The two spacecraft contain similar instruments for studying solar phenomena from two angles.

SPACE STATION USERS CONCEPT

DIRECT BENEFITS: Direct benefits from SCDM are the same as those listed for other solar instrumentation.

REFERENCES:

Individuals

D. W. Neupert, NASA/GSFC

Papers

"Solar Corona Explorer (A Mission for the Physical Diagnosis of the Solar Corona)", Science Working Group Report, NASA GSFC, July 1981

SPACE STATION USERS CONCEPT

DISCIPLINE: Life/Biological/Medical Sciences

TITLE: Operational Medicine (MMCX-0601)

PRINCIPAL CONTACT: Col. William Harvey, M.D.

ORGANIZATION: Brooks AFB - School of Aerospace Medicine

MMC CONTACT: A.K. Wildgen

PROGRAM OBJECTIVE: The Operational Medicine Program provides for the health and safety of the crewmembers and it promotes research to improve definition of the optimal human operational envelope for spaceflight. As such, it will always remain of the highest priority within the NASA manned space program. Activities in this area include medical certification, inflight biomedical observation, and postflight certification for return to duties of SS crews; contingency and emergency medical support to SS missions; development and validation of countermeasures for adverse effects of space flight; advanced planning to refine medical selection and retention standards; and improved definition of human capabilities for space flight.

The Space Station era will introduce a shift in the emphasis of Operational Medicine as the SS activities shift to construction and servicing of large space structures and commercial ventures in contrast to the primarily scientific endeavors of the current shuttle program. With longer missions, more industrial activities and routine EVA, the Operational Medicine program will focus upon the study of the myriad problems associated with long-duration exposure to zero-g and the emergency treatment of industrial accident traumas.

The Operational Medicine "mission" differs from the other Life Sciences missions discussed in this section since it includes the actual medical support of SS in addition to the research required to develop adequate medical support. The medical support is envisioned to progress through four categories representing increasing levels of support capabilities in close conjunction with the evolving capabilities of the SS. These categories are discussed below in the "System Description". The research objectives for the Operational Medicine mission include such activities as the assessment of wound healing, burn therapy, trauma treatment techniques, drug distribution and pharmakinetics, fluid therapy and surgical interventions in the space flight environment. The overriding goal of the research activities is the continuing definition and development of medical support requirements for the SS.

PROGRAM STATUS: The Medical Operations Program is currently funded in support of the STS program. As the space program shifts its emphasis from Shuttle missions to longer duration industrial/commercial SS missions, the research objectives in this area will shift. However, it will always remain of the highest priority within the NASA manned space program.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

SYSTEM DESCRIPTION: All medical operations and human experiments will be implemented in the Health Maintenance Facility (HMF) which is located in the Habitability Module. The Health Maintenance Facility will accommodate the SS medical operations as well as the biomedical research activities since there is a great deal of redundancy in the equipment item requirements as well as methods and techniques employed. The HMF will evolve as dictated by SS requirements for increased capability in conjunction with the increasing diversity and complexity of SS activities.

The HMF requirements presented here were drawn from two NASA documents: NASA/JSC TM58248 Medical Operations and Life Sciences Activities on Space Station, 10/82, and NASA/HQ Operational Medicine Support to Long Duration Manned Missions in Low Earth Orbit and Beyond, 2/82. An attempt was made to utilize the terminology initiated by NASA to provide consistency and minimize confusion. Categories I through IV discussed below represent the increasing levels of medical operations and research capabilities to be employed in SS. Deviations from the concepts set forth in the NASA documents were based upon inputs from our contact pool and in-house analyses.

The deviations from the NASA concepts represent a general belief that the initial SS buildup and construction activities will pose uniquely hazardous situations, particularly in the early phases with relatively inexperienced crewmembers. It is suggested to initiate an ambitious health care program capable of handling these unique contingencies earlier in the SS program than was initially conceptualized. With experience, the HMF capability can be expanded or descoped as considered appropriate with actual data in hand. Strongly suggested requirements include: 1) recompression capability as soon as SS buildup is initiated, 2) a dynamic imaging system as soon as long term habitation missions are initiated, 3) a computerized early detection diagnostic capability (individual medical record keeping, etc), 4) close proximity to habitation compartments and easily accessible for emergencies, 5) quarantine capability to isolate contagious crewmembers, and 6) isolation from areas designated for animal research.

Category I

During SS buildup (1988-1990) STS will provide the necessary medical support until the first Habitability Module is activated at which time the Category II HMF will be operational. The Category I medical equipment will resemble an expanded SOMS. The medical operations will be assigned to a highly trained, flight experienced crewmember physician. All other crewmembers will have emergency trauma treatment training with one crewmember more extensively trained than the others to fill in for the physician if he is somehow incapacitated. Little biomedical experimentation was proposed for this phase by our user contingent since the missions would be of short duration and the crew members will most probably be heavily scheduled with construction activities. Due to the nature of the anticipated buildup operations, it was considered to be imperative that a means of recompression be available in this phase for contingency decompression sickness. This could conceivably be a collapsable device designed for rapid deployment available on the Shuttle. A type of repressurization system to be implemented in an airlock was also proposed.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

Category II

The Category II (1990-1995) capability will be available as soon as the first Habitability Module is operational containing the HMF. At this time crews of up to four will be able to stay without STS support for up to 90 days. The HMF will primarily support routine and contingency medical operations and health maintenance (such as exercise). Some human experiments could easily be accommodated at this time in conjunction with routine medical evaluations, however, research will have lower priority than basic medical support. The user community would like to see a computerized early detection diagnostic system implemented on SS as soon as possible since it would enable sufficient warning to schedule STS emergency crewmember(s) evacuation to ensure crew health and safety. This system would preferably be employed during Category II, but no later than the Category III phase. The HMF will be under the jurisdiction of an experienced physician crewmember as in Category I even though his time may not be totally committed to medical or research activities. Requirements for the training of the remaining crewmembers remain the same as in Category I.

Category III

Category III will be employed in the 1995 time frame in support of 8 to 12 crewmembers. The medical support capabilities will be expanded in response to requirements developed through SS onboard experience and previous STS and SS biomedical experiment data. It is anticipated that the HMF will be expanded to resemble a physician's office with minor surgery and trauma treatment capability. Some invasive experimental techniques can be readily accommodated and an expanded area provided for exercise and instrumentation for human research. A quarantine capability should be available no later than the Category III phase. State-of-the-art automated analyses and diagnostic instrumentation will be incorporated for both medical operations and human research. Some advanced form of computer-aided dynamic imaging system must be implemented. (Imaging systems will be utilized previously inflight on STS and SS as experiment specific items. However, it was strongly suggested by the user community that a multi-purpose system be made readily available on SS.) The facility should be manned by a trained and experienced physician assigned to the HMF as his primary duty. His duties will include research as well as medical support. The research activities could be additionally supported by qualified payload specialists.

Category IV

The Category IV (2000+) HMF will expand upon the Category III capabilities as required by changes in SS operations. It would be desired to increase the area devoted to human experimentation. Imaging devices currently experimental in nature, such as Positron Emission Tomography (PET), Nuclear Magnetic Resonance (NMR) and the Multi-Wire Proportional Counter (MWPC), may be ready for implementation in medical/research applications. Enthusiastic researchers have also expressed a desire to integrate a cyclotron on SS to support the PET system. In addition to the physician, a clinical researcher may be assigned to support the research activities with additional help from technical payload specialists as required.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

The suggested equipment complements for the HMF are provided in Tables 1 through 4. Examples of the types of pharmaceuticals to be provided are shown in Table 5. The medical support equipment lists were obtained from the NASA documents previously cited. The research items were drawn from the human experiment equipment lists for the subdiscipline missions. The time phasing was derived from the contacts' expressed desires.

Table 1: Category I Equipment List

Exam equipment
- Stethoscope
- Blood pressure measurement device
- Otoscope
- Ophthalmoscope
- Reflex hammer
- Guaiac cards
- Thermometer

Physiological status monitoring

Bends recompression capability to 3 ATA

Medical checklist:
- Procedures and instruction manual

Bandages, tape, burn type

Respiratory equipment
- O_2, O_2 masks
- Oral airway
- Ambu-bag
- Laryngoscope
- Ventilator with positive pressure capability
- Chest tube and suction

Hot packs, cold packs

Pharmaceuticals

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

Table 2: Category II Equipment List

Dynamic imaging system

Computerized diagnostic system

EKG or echocardiography monitoring with downlink capability

Pulmonary function test apparatus

Tracheotomy tray

Paracentesis, thoracentesis trays

Peritoneal lavage tray

Lumbar puncture tray

Woods light fluorescein

Medical treatment area and equipment

Environmental monitoring

Exercise machinery and facilities

LBNP

Mass/center of gravity measuring device (LMMI)

Anthropometry

Dental Care Equipment

Limb plethysmograph

Refrigerator (+4 C) and freezer storage (-10 to -20 C)

Radiological storage/handling capability

Minor surgery tray and instruments

- IV fluids
  - Tubing
  - Catheters
  - Pumps
  - CVP lines
  - Pressure transducers

- Orthopedic equipment
  - Splints
  - Cast material
  - Wraps

Anaesthesia, local

Laboratory equipment
Microscope, centrifuge(s)' blood drawing supplies, laminar flow workbench (GPWS)

Hematology
Circulating Blood Cells (CBS) -
Differential and platelets, reticulocytes, coagulation, erythrocyte indices' set rate, prothrombin time (PT), and partial thromboplastin time (PTT)

Urinalysis (UMS)

Arterial blood gases, carboxyhemoglobin, methemoglobin

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

Table 3: Category III Equipment List

Medical support and equipment - expanded
- Urinary catheter
- Wall suction and nasogastric tubes

Surgical equipment - expanded
- Burr hole screws
- Irrigation fluids
- Dentistry instruments

Orthopedic Equipment - expanded
- Pins
- Closed reduction traction equipment

Anaesthesia
- Local and general

Chemistry
- Serum sodium, potassium, chloride, carbon dioxide, glucose, creatinine, (SGOT, SGPT, GGTP), alkaline phosphatase, bilirubin, amylase, cholesterol, triglyceride, and cardiac isoenzymes

Toxicology
- Carbon monoxide, and other atmospheric trace contaminant gases

Microbiology
- Culture and antibiotic sensitivity, staining characteristics

Expanded medical treatment, exercise and research areas

Quarantine capability

Retinal photography

Airblast ocular tonometry

Retinal pressure

Saline ingestion kit

EMG

Bone densitometry

Automated blood analysis system

Muscle biopsy kit

SPACE STATION USERS CONCEPT

Table 4: Category IV Equipment List

PET, NMR or MWPC

Radiological materials generator (cyclotron)

Acceleration devices

Visual Field motion system

Artificial g-inducing system

SPACE STATION USERS CONCEPT

Table 5: Examples of Pharmaceuticals (A008)

Allergy relief

Analgesics, antipyretics

Anaesthetics--injectable, local

Antacids

Antiasthmatics, bronchial dilators

Antibacterials, antibiotics

Anticoagulants

Anticonvulsants

Antidiarrheals, antiflatulents

Antihistamines

Anti-inflammatories

Antiseptics, germicides

Antimotion sickness, antinauseants

Antispasmodics

Bowel evacuants

Cardiovascular preparations
- Antiarrhythmics
- Antihypertensives
- Digoxin
- Vasodilators
- Vasopressors

Dermatologicals

Decongestants

Electrolytes

Hemorroidal preparations

Hemostatics

Hormones - glucocorticoids

Hypnotics

Laxatives

Muscle relaxants

Nutritional aids
- Peripheral and central hyper-alimentation fluid

Ophthalmologicals
- Irrigants
- Antibacterial
- Mydriatics and cycloplegics

Otic preparations

Plasma expanders
- Plasma fractions

Radiopharmaceuticals
- X-ray contrast media

Sedatives

Throat lozenges

Psychotropic agents

Vitamins

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

SYSTEM OPERATION: It is anticipated that the Health Maintenance Facility will be fully operational continuously throughout manned occupation of the space station. The medical operations will be the primary activity within the HMF with research implemented as schedules allow. Research activities will increase as greater space is allocated with the increasing SS capabilities.

The HMF should have a fully trained and flight experienced physician available to support contingency medical operations at all times from Category II initiation in 1990 to Category IV in the year 2000 and beyond. It is preferred by the contact pool to have a physician with clinical research experience to support their human experiments. It is anticipated that the medical crewmember will not be totally dedicated to medical operations or research operations particularly in the early phases of the space station buildup activities. As the priorities for biomedical research increase, it would be beneficial to have a clinical researcher (PhD or MD) to serve in the capacity of a payload specialist with his/her primary assignment to research during periods of high experiment work loads. This person could possibly have dual responsibilities for human and non-human research as experiment schedule requirements fluctuate.

The Shuttle will provide consumables resupply and biological sample and data return at approximately 90 day intervals. Routine module/facility repair/maintenance is anticipated.

SYSTEM INTEGRATION: All medical operations and human life science research will be implemented in the Health Maintenance Facility. The HMF will be part of the first Habitability Module to be integrated in the SS in 1990 and fully operational with IOC. The Health Maintenance Facility will support primarily medical operations and secondarily the human research activities. As the SS facility evolves from Category II (1990) to Category III (1995) and Category IV (2000), the research equipment items will be incorporated in a phased manner in the order of relative priorities.

SUBSYSTEM SUPPORT: It is anticipated that 1.5 KW power will be sufficient to support the conceptual biomedical experiments to be implemented in the HMF. Since the human experiments and the routine medical operations schedules will be phased, the power system should not be heavily impacted by activities in the HMF. The HMF should be continuously capable of supporting medical emergencies, so standby power will be continuous during manned missions.

Environmental control in the HMF should be closely maintained and continuously monitored during experimental operations. Fluctuations in environmental parameters will confound measurements in some subdisciplines by altering metabolic activity of the subjects.

Data management strategies will vary with the experiment. The computerized diagnostic system will be downlinked in real-time, and a confidential voicelink is required for medical consultations. Biological samples obtained onboard will be stored for return via Shuttle for ground-based analysis.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

BENEFITS: The primary benefits derived from the Operational Medicine Program on SS are 1) the assured health and operational efficiency of the SS crew and 2) the earth-based medical applications of the biomedical data and technology. As data are obtained from research in the earlier SS phases, the subsequent SS facility's design and instrumentation can be developed to adequately meet actual medical requirements with minimal SS impact. The health care technologies developed for SS will be invaluable in remote health care facilities applications such as oil rigs, submarines, and remote scientific and military bases.

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A015	Furukawa, S., Operational Medicine Support in Long-Duration Manned Space Missions - Low Earth Orbit and Beyond, McDonnel Douglas Technical Services Company - KSC, February 1982.

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B021	W. Carter Alexander, Ph.D	USRA - (Brooks AFB)
B001	Richard S. Johnston	Texas Medical Ctr, Inc.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Life/Biological/Medical Sciences

TITLE: Cardiovascular/Cardiopulmonary (MMCX-0602)

PRINCIPAL CONTACT: Gary E. Musgrave, Ph.D.

ORGANIZATION: Virginia Commonwealth University - Richmond

MMC CONTACT: A. K. Wildgen

PROGRAM OBJECTIVE: Functional cardiovascular abnormalities have consistently been demonstrated in astronauts during the immediate postflight period. Weight loss and hypovolemia, associated with orthostatic intolerance, have been recorded after flights as short as 8 hours. The data suggest that the postflight impairment of cardiovascular function is the result of an appropriate adaptation to the altered distribution of fluids at zero-g, suddenly rendered inappropriate by the return to normal gravity. However, the data to date do not clearly support the view of some investigators that adequate cardiovascular functional adaptation to zero-g is achieved. (A004) During long duration missions, actual changes in myocardial integrity may occur and chronic alterations affecting both the heart and central nervous system may follow changes in the cardiac output. (A005). Almost all the information on cardiovascular deconditioning in weightlessness has come from the necessarily limited studies on crews of manned missions. It is not clear from the available data just what are the relative contributions of hormones and reflexes in controlling fluid balance. Analyses of electrolytes and hormones in blood and urine of astronauts gave values which were not predicted.

If STS biomedical data confirms cardiovascular deterioration, SS studies should determine to what extent these early signs are progressive/chronic and if so, to what degree are they irreversible. Preliminary observations in humans indicate that long-term morbidity might result from excessive red cell deformation, cardiopulmonary congestion, changes in myocardial mass and contractility, and fundamental defects in neurogenic and overall cardiovascular control. (A006)

Specific areas of investigation should include assessment of the magnitude of long-term cardiopulmonary congestion and the final disposition of early cephalic fluid shifts; the design of interventions that maintain red cell and plasma volume; detailed assessment of the cardiovascular response to imposed workloads; and the development of strategies to prepare the cardiovascular system for reentry to the terrestrial environment after prolonged exposure to space. Experiments should be designed to study various species, and bipeds, in particular, since the cardiovascular, hemodyanmic and hematopoietic alterations may be more pronounced in those species which normally function in an upright posture. (A006)

PROGRAM OBJECTIVE: (Con't)

An effective means of preventing postflight orthostatic intolerance should be explored. Current efforts along this line include the use of anti-g suits, ambulatory lower body negative pressure devices, water and electrolyte replacement and nonconstrictive and salt-retentive pharmaceutical interventions.

Attention must also be given to devising an effective, practical exercise regimen for all major muscle groups, including the antigravity muscles. And the roles of the capacitance walls or veins and the elusive fatigue factor must be assessed in the deconditioning phenomenon. (A005)

It would also be desirable to determine whether an artificial gravitational force would reverse or prevent the adaptive cardiovascular changes that occur in a zero-g environment and to determine the minimum gravitational force necessary to accomplish this objective. Information gained from this type of experiment may have a significant impact on the design of future space facilities. (B002)

Cardiovascular Experiment Concept 1: 02/1/01 (A001)

A variety of techniques may be employed to answer the question regarding central hemodynamics and cardiovascular reflex regulation. The basic study design will include a standard set of measurements and procedures to be performed repeatedly during flight at appropriate intervals and also pre- and post-flight. Pre- and post-flight studies may be more extensive and will be designed to include validation of the more indirect and non-invasive procedures that by necessity have to be employed during the in-flight studies.

Principal techniques and procedures to be used during flight may include echocardiography (2-dimensional, real-time image system), which will provide a wide range of cardiovascular data, dimensional as well as functional. Such data include left and right ventricular cross sectional areas and diameters, and left atrial, aortic, and pulmonary artery dimensions. Dimensional data, particularly data obtained during end-systole and end-diastole, contain information on contractile state, and indirectly also on venous pressure. It is also possible to derive reasonably accurate data on stroke volume and cardiac output from the measurements of left ventricular volume. Changes in left muscle mass may also be estimated.

Supplementary cardiovascular measurements may include ECG, indirect arterial blood pressure, and leg volume. Serial data on plasma volume and red blood cell mass should also be obtained. (See Hematology User Sheet) Response to fluid-related hormones to this environment may be measured.

Important additional information on cardiovascular function during prolonged space flight may be collected during provocative tests. Various interventions may be considered, including pharmacological test of autonomic function and reflex regulation. Measurements during lower body negative pressure (LBNP)

Experiment Concept 1 (Con't)

appears to be the safest and most appropriate of the established test procedures. The set of data to be collected during serial LBNP studies may include cardiac dimensions and stroke volume and cardiac output (by echocardiography), heart rate (ECG), indirect arterial pressure, and leg volume changes. Leg volume changes will provide data on pooled blood volume and venous pressure-volume relationships.

Equipment Requirements:

- o Echocardiography
- o Blood pressure kit
- o Pharmacological testing kit
- o LBNPD
- o Electrocardiography (ECG)
- o Leg volume (limb plethysmograph)

Crewtime Requirements:

- o Extensive crew involvement

Cardiovascular Experiment Concept 2: 02/1/02 (A001)

There is suggestive evidence that the cranial and cerebral circulation may remain abnormal for the duration of exposure to zero-g. Direct techniques that may provide definitive information on the nature of these abnormalities are in general not applicable to space flight conditions. However, important information on cerebral circulation and tissue pressures may be obtained by indirect methods, including retinal photography, ocular tonometry, and indirect pressure measurement in the retinal vessels. Post-mission cardiovascular responses to orthostasis should be measured using LBNP and upright and reclining exercise.

Equipment Requirements:

- o Retinal photography
- o Ocular tonometry (air blast)
- o Retinal pressure

Crewtime Requirements:

TBD

Cardiovascular Experiment Concept 3: 02/1/03 (A001)

There is good evidence from bedrest studies that saline ingestion coupled with lower body negative pressure (LBNP) for several hours is capable of reversing, for as long as 18 hours, the orthostatic intolerance induced by bed rest and, presumably by space flight. A provocative LBNP test could be accomplished several days prior to reentry to assess the degree of orthostatism in the subject(s). Prior to reentry the subject(s) would be given 1 liter of saline

Experiment Concept 3 (con't)

to ingest coupled with simultaneous LBNP for several hours. Alternatively, this procedure could be accomplished as soon as possible after return to one g. Other countermeasures such as fluid intake alone, capstan counterpressure garments, or pharmacological intervention could also be considered to determine how each affects the cardiovascular response to orthostasis during the immediate post-flight period.

Equipment Requirements:

- o Saline ingestion kit
- o LBNPD

Crewtime Requirements:

- o Provocative LBNPD testing all crewmembers 1 day the last week of the mission
- o Saline ingestion and LBNP countermeasure within hours of return

Cardiovascular Experiment Concept 4: 02/2/04 (A002)

Species: Rhesus Monkey

Procedures: Four restrained rhesus monkeys will be maintained in weightlessness for 60 days maximum. Crew members will attend the specimens daily.

Equipment Requirements:

- o Large Primate Facility (Restrained) N=4

Crewtime Requirements:

- o Daily animal maintenance required.

Cardiovascular Experiment Concept 5: 02/1/05 (A004)

The basic study on human central hemodynamics and cardiovascular reflex regulation would include a standard set of measurements and procedures to be performed repeatedly during flight at appropriate intervals and also pre- and postflight. The data would consist of echocardiographic measurements, ECG, indirect blood pressure, and leg volume obtained both at rest and during provocative tests such as the application of lower body negative pressure and pharmacological interventions. The echocardiographic measurements of cardiac dimensions would provide information on contractile state, and indirectly on venous pressure. In addition, it would be possible to derive from these measurements reasonably accurate estimates of cardiac output, stroke volume, and left muscle mass. Supplementary cardiovascular data may include serial measurements of plasma volume, red cell mass, and levels of fluid-related hormones.

Experiment Concept 5 (con't)

Collection of data required to detect abnormal changes in cerebral circulation due to exposure to zero-g may be combined with the basic study outlined above. Important information on cerebral circulation and tissue pressures may be obtained by indirect methods, including retinal photography, ocular tonometry, and indirect pressure measurement in the retinal vessels.

Equipment Requirements:

- o Echocardiography
- o Electrocardiography
- o Blood pressure
- o Leg volume (limb plethysmograph)
- o LBNPD
- o Pharmacological kit
- o Blood processing - see Hematology
- o Retinal photography
- o Ocular tonometry
- o Retinal pressure

Crewtime Requirements

- o Involvement by all crewmembers

Cardiovascular Experiment Concept 6: 02/1/06 (A004)

The effectiveness of countermeasures such as fluid intake, capstan counterpressure garments, and pharmacological interventions could be studied in separate investigations. The required cardiovascular measurements include ECG, indirect blood pressure, leg volume changes, and cardiac dimensions by echocardiography.

Equipment Requirements:

- o Electrocardiography
- o Blood Pressure Kit
- o Leg volume (limb plethysmograph)
- o Echocardiography
- o Countermeasure devices (TBD)
  - capstan counterpressure garments
  - pharmacological kit

Crewtime Requirements:

- o Periodic crewmember involvement

Cardiovascular Experiment Concept 7: 02/2/07 (A004)

Four restrained rhesus monkeys would be maintained in weightlessness for a maximum of 60 days in a typical non-human investigation of the cardiovascular changes in zero-g. Crewmembers would attend the specimens daily and record measurements of cardiovascular variables such as heart rate, blood pressure, flow rate, and stroke volume. The investigations could include measurements

Experiment Concept 7 (con't)

of these and other variables in response to treatments such as the application of lower body negative pressure, the application of drugs, and sectioning of nerves.

A mission on investigations of cardiovascular effects of zero-g exposure using large primates could help delineate the gross changes in the heart such as changes in total mass and size of chambers as well as the changes in the histology of cardiac tissue -- number, size, type of muscle fibers, and amount of connective tissue, nerve fibers, and neuromuscular junctions. Pre-, in-, and post-flight measurements of heart rate, blood pressure, cardiac output, and stroke volume both at rest and during stress testing made in a mission of extended duration would be used to follow the progress of cardiovascular dysfunction resulting from prolonged exposure to weightlessness. Experiments of this type require inflight observations by man at regular time intervals.

Equipment Requirements:

- o Large Primate Facility (Restrained) N=4
- o LBNPD
- o Pharmacological kit
- o Biotelemetry System
- o GPWS

Crewtime Requirements:

- o Daily maintenance of the animals is required
- o It is assumed that sacrifices for histological cardiac assessment is intended for postflight

Cardiovascular Experiment Concept 8: 02/2/08 (B002)

Rhesus monkeys will be instrumented with appropriate radiotelemetry monitoring devices prior to preflight experimentation. PREFLIGHT: Two Rhesus monkeys would be centrifuged at angular velocities equivalent to those necessary to produce 0.125, 0.25, 0.5, and 1.0 g. in space for seven days at each velocity. Physiologic data from these and two non-centrifuged control animals will be recorded during these periods by telemetry. INFLIGHT: The same animals will undergo centrifugation and data collection during flight for a comparable period of time at each rate.

Equipment Requirements:

- o Biotelemetry monitoring system - 12" high standard, 19" wide rack mounted panel
- o Primate Holding Facility (Restrainted) N=2
- o Primate centrifuge - dimensions estimated at 4'x4'x4' (0-1.0g)

Crewtime Requirements:

- o A Payload Specialist would be required to provide daily care (feeding, cleaning, etc.), of the animals, provide daily operational checks of the centrifuge, and periodic daily checks of telemetry operation.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

PROGRAM STATUS: The Cardiovascular/Cardiopulmonary subdiscipline would benefit from the inflight implementation of a computer-aided dynamic imaging system. Trade studies need to be performed to determine which system would satisfy most applications, and the feasibility of developing a flight system for the space station. Technology advancements in the next ten years may dictate which of the systems currently used for research will be ready for SS. Promising systems include nuclear magnetic resonance (NMR), positron emission tomography (PET), and the multi-wire proportional counter (MWPC). Several concepts currently exist for a Large Primate Holding Facility. The French (ESA) have developed a 2 rhesus system, with all environmental control and animal instrumentation incorporated into the floor mounted cylindrical facility. This system is to be flown in 1983 by the Russians on their Cosmos Biosatellite. The animals will not be man-tended for the flight's duration of 2 to 3 weeks. Another concept tested in SMD-III was developed by Nello Pace (UC-Berkeley). This monkey pod contained only one animal and the system was not designed for 0g operation. Another concept for the shuttle middeck has been developed, however it has incurred disfavor by the astronauts primarily because of the proposed middeck location. This system could be modified for use in the SS.

SYSTEM DESCRIPTION: The equipment requirements for the Cardiovascular/Cardiopulmonary experiment concepts are provided in Table 1. The human experiment operations will be performed in the Health Maintenance Facility. The non-human experiment concepts will require the vivarium for specimen support and the Life Sciences Laboratory Facility (LSLF) to accommodate any non-human experiment operations.

SYSTEM OPERATION: The human experiments operations will be performed by the medical crewmember. Some of these measurements can be obtained during the routine medical operations. The non-human experiments with primates should allow frequent man-tending of the animals to ensure the health and comfort of the specimens. Chronic instrumentation of the animals will allow most measurements to be obtained by biotelemetry.

The investigators prefer a video and voice link during the experiment operations. However, as these activities become increasingly routine on SS, the realtime downlink of data and video and voice communication with the principle investigator will not be as critical as in the early stages of experimentation.

The shuttle will provide consumables resupply, biological sample and data return, and specimen and equipment changeout at approximately 90 day intervals. Routine module/facility repair/maintenance is anticipated.

SYSTEM INTEGRATION: The human experiment instrumentation will be incorporated into the HMF which will be integrated and operational in 1990. The non-human experiments are to be implemented in the Life Sciences Research Module (LSRM) which will be operational in 1995.

Table 1 Cardiovascular Experiment Concept Requirements

EQUIPMENT REQTS / EXPERIMENT CONCEPTS	ANIMAL HOLDING FACILITY	GPWS	ANIMAL CENTRIFUGE	ECHOCARDIO-GRAPHY	BLOOD PRESSURE (PMS)	LBNPD	ECG (PMS)	LIMB PLETHYSMO-GRAPH	PHARMACO-LOGICAL KIT	RETINAL PHOTOGRAPHY	OCULAR TONOMETRY	RETINAL PRESSURE	SALINE INGESTION KIT	LRG. PRIM. RESTRAINT FACILITY	BTS	OSCILLO-SCOPE	STRIP CHART RECORDER
CONCEPT 1 02/1/01 (A001)				✓	✓	✓	✓	✓	✓								
CONCEPT 2 02/1/02 (A001)										✓	✓	✓					
CONCEPT 3 02/1/03 (A001)						✓							✓				
CONCEPT 4 02/2/04 (A002)														✓			
CONCEPT 5 02/1/05 (A004)				✓	✓	✓	✓	✓	✓	✓	✓	✓			BLOOD PROCESSING EQUIPMENT SEE HEMATOLOGY		
CONCEPT 6 02/1/06 (A004)				✓	✓		✓	✓	✓						COUNTERMEASURES DEVICES TBD		
CONCEPT 7 02/2/07 (A004)						✓			✓					✓ N = 4	✓	✓	✓
CONCEPT 8 02/2/08 (B002)			✓ LRG PRIMATE											✓ N = 2	✓	✓	✓

NOTE: It would be beneficial to implement advanced techniques of physiological imaging in the ultimate SS for CV research

SPACE STATION USERS CONCEPT

SUBSYSTEM SUPPORT: The experiment equipment items will be located in the pressurized modules, HMF and LSRM, and they will draw power from these facilities. Data management strategies will vary with the experiment. Realtime data and video downlink with two-way voice communication will be initially required during all experiment operations.

BENEFITS: The data derived from the Cardiovascular/Cardiopulmonary experiments will be directly relevant to earth-based disorders such as Barter's Syndrome (backward cardiac failure) and congestive heart failure. The Skylab data on the neural mechanisms of cardiac and circulatory function contributed significantly o the Handbook of Circulation currently in use in the USA medical communities. The physiological studies and technological advancement in support of this subdiscipline will find earth-based applications in the early detection of heart/circulatory problems and the identification of high-risk individuals.

The flight research will benefit from the SS by increased numbers of experimental subjects, both human and animal, and increased mission duration. The increased mission durations will allow greater time for complex experiment interactions and more frequent data collection sessions. The primate studies require manned presence for routine and contingency animal maintenance.

DIRECT BENEFITS:

REFERENCES:

Documents:

No.	Title
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SPACE STATION USERS CONCEPT

REFERENCES (Con't)

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APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Life/Biological/Medical Sciences

TITLE: Vestibular/Neurophysiology (MMCX-0603)

PRINCIPAL CONTACT: Manning J. Correia, Ph.D.

ORGANIZATION: University of Texas - Medical Branch, Galveston

MMC CONTRACT: A. K. Wildgen

PROGRAM OBJECTIVE: Past spaceflight missions have indicated that space sickness has a significant impact on the well-being and operational efficiency of crewmembers particularly during the first few days of a mission. It is anticipated by approximately half of the investigators contacted that an acceptable intervention will be developed by the SS era. The remaining investigators believe that a "bandaid" may be available at that time, however, the solution of the problem lies in the understanding of the underlying mechanisms. While the SS will provide the optimal setting within which the extensive study of vestibular physiology and function could be implemented, it is believed that the vestibular subdiscipline will assume a lower priority by the end of this decade. Space sickness is most disruptive in the first few days of a mission, during which adaptation occurs, therefore, it will not be perceived as such a detriment in light of the longer missions proposed for SS. None-the-less, vestibular function research remains to be of high priority within the investigator community. The vestibular-induced perceptual alterations may prove extremely hazardous in the re-entry and landing phases of shuttle operations. The issues which need to be addressed for SS include neurosensory and electrophysiological function over long periods of adaption, the chronic and/or progressive morphological and biochemical alterations due to long duration 0g exposure, and musculoskeletal deconditioning due to reduced neurovestibular inputs to postural muscles.

Vestibular/Neurophysiology Experiment Concept 1: 03/2/01 (A002)

Vestibular Function

Species: Rat, Small Primate, Rhesus, Cat, Pigeon, Frog, Goldfish, Gerbil

Procedures:

Two to four specimens will be maintained in-flight in weightlessness and at other (0.1-1.25 g) accelerations. At 10, 40, 180 days:

- o all specimens will be weighed
- o all specimens will be subjected to appropriate visual, rotational and linear stimuli and their responses recorded.

At conclusion, specimens will be returned alive for further studies.

SPACE STATION USERS CONCEPT

Experiment Concept 1 (con't)

Equipment Requirements:

- Animal holding facilities
  - Rodent (rat & gerbil)
  - Small primate
  - Large primate
  - Cat
  - Pigeon
  - Frog
  - Goldfish
- Animal Centrifuge (0.1 to 1.25 g)
  Acceleration systems (linear and rotational)
- Visual Field Motion System
- Electrophysiological recording system
  - See vestibular concept 03/2/02 (B011)

Crewtime Requirements:

- Periodic animal maintenance
- Heavy schedule on days 10, 40, 180

Vestibular/Neurophysiology Experiment Concept 2: 03/2/02 (B011)

"Anatomical and Electrophysiological Studies of the Effects of Weightlessness on the Vestibular Apparatus of the Gerbil".

A multiple-flight series of carefully controlled morphological and electrophysiological studies are proposed to investigate the effects of reduced gravity on the mammalian vestibular apparatus, the results of which will be directly relevant to a better understanding of the etiology and pathophysiology of space (motion) sickness. The overall objectives for this conceptual experiment are: 1) to investigate the effects of prolonged periods (90 days) of reduced gravity on the structural and neural elements of the gerbil's vestibular apparatus, more specifically, changes in otoconia, alterations in afferent, efferent, and autonomic neural structures, and changes in focal metabolic activity of the ampullae and reflecting "neural rearrangement" or neural plasticity; 2) To investigate the response of the semicircular canals and otoliths to reduced gravity within the SS by recording and analyzing primary afferent neural discharge, using computer-based, point process analytical techniques to detect subtle changes in the resting discharge of a motionless animal with its head and body mechanically coupled to the SS bulkhead (exposing the animal to SS vibration), or free-floated yet tethered to the SS bulkhead by a flexible instrument cable, 3) To determine threshold values for otolithic hair cells as reflected by afferent neural output and intensity (input-output) functions for macular and ampullar afferents in the reduced gravitational environment by delivering varying intensities of linear and angular acceleration with on- and off-axis rotation in an onboard, small animal, short arm centrifuge.

SPACE STATION USERS CONCEPT

Experiment Concept 2 (con't)

Typical inflight measurements include the following:

No.	Type	Units	Accuracy/ Tolerance	Description
01	Posture	N/A	N/A	Video recording
02	Motion	N/A	N/A	Video recording
03	Head bumping	No. per unit time	N/A	Video recording
04	AP train	uV	10	Downlinked
05	ECG	mV	0.1	Downlinked
06	EEG	uV	1	Downlinked
07	AP interspike intervals	usec	10	Downlinked
08	AHUT position status	N/A	N/A	Downlinked
09	AHUT accelerations	g	.001g	Downlinked
10	Gerbil Head position	degree	1	Downlinked
11	Microelectrode position	um	0.5	Downlinked
12	Microelectrode impedance	MOhm	1	Downlinked
13	Control unit switch status	N/A	N/A	Downlinked
14	Amplifier gain status	N/A	N/A	Downlinked

All measurements designated for downlinking could be recorded onboard and the magnetic tape or floppy disks returned by Shuttle for earth-based analyses.

Equipment Requirements

1. Rodent holding facility
2. GPWS
3. Electrophysiological kit
4. Microelectrode puller (horizontal)
5. Dissecting microscope
6. IR videocamera
7. Videocamera timer and mount
8. Videocamera shroud and mirrors
9. Video recorder
10. LSLE microcomputer
11. Power frame, Tektronics RTM506
12. Oscilloscope, Tektronics SC501
13. Oscilloscope, Tektronics SC502
14. Voice recorder
15. Experiment control unit
16. Microdrive, Burleigh PZ550
17. Microdrive controller, Burleigh PZ551
18. Animal holder and unit tester (AHUT)
19. AHUT tether
20. AHUT mount
21. Audio monitor
22. Headset (earphones and microphone)
23. PS "Perch"
24. Display microprocessor
25. Dynamic environment monitoring system
26. Video tape
27. Voice tape

SPACE STATION USERS CONCEPT

Vestibular/Neurophysiology Experiment Concept 3: 03/2/03 (A002)

Vestibular Physiology

Species: Rat

Procedures:

Specimens will be maintained inflight in weightlessness and at other (0.1-1 g) accelerations. At intervals;

- all specimens will be weighed
- six specimens from each group will be sacrificed and the otoconial membrane and related structures dissected and preserved
- six specimens from each group will be returned alive for further studies

Equipment Requirements

- Rodent holding facility (rats)
- Rodent centrifuge (0.1 to 1.0 g)
- SMMI
- GPWS
- Sacrifice/dissection kit (dissecting microscope)
- Tissue preservation kit
- Refrigerator/freezer tissue storage

Crewtime Requirement

- Periodic animal maintenance
- Heavy schedule on days of sacrifice

Vestibular/Neurophysiology Experiment Concept 4: 03/2/04 (A004)

A typical investigation could utilize rodents to study the nature and time course of any possible changes in vestibular physiology resulting from space flight. Groups of approximately 24 rats could be maintained inflight at different g-levels including zero-g, 0.1-g, 0.5-g, and 1.0-g. At intervals all specimens would be weighed and 6 specimens from each group would be sacrificed, the otoconial membrane and related structures dissected and preserved. Six members of each group would be returned alive for further studies.

Experiment Concept 4 (con't)

Equipment Requirements:

- o Rodent holding facility; rats N = 24
- o Rodent Centrifuge
  - 0.1g: N = 24
  - 0.5g: N = 24
  - 1.0g: N = 24
- o GPWS
- o SMMI
- o Sacrifice/Dissection Kit (Dissection microscope)
- o Tissue Preservation Kit
- o Tissue Storage

Crewtime Requirements:

- o Heavy schedule on days of sacrifice
- o Periodic animal maintenance

Vestibular/Neurophysiology Experiment Concept 5: 03/2/05 (A004)

Another typical, complimentary vestibular investigation could utilize a wide array of animals including rats, small primates, rhesus monkeys, cats, pigeons, frogs, and goldfish to study the changes and time course involved in adaptation and readaptation to zero-g, microgravity, and the provocative response could also be studied by utilizing appropriate provocative stimuli. Groups of approximately 4 specimens each (greater number of fish) would be maintained inflight in weightlessness and at four other (0.1, 0.5, 1.0, 1.25) g accelerations. At 10, 40, and 180 days the specimens would be weighed and all specimens would be subjected to appropriate visual, rotational, and linear stimuli and their responses recorded. At the conclusion of these inflight studies the specimens would be returned alive for postflight studies.

Equipment Requirements:

- o Animal holding facility (multiple species)
  - Rodent
  - Small primate
  - Large primate
  - Cat
  - Pigeon
  - Frog
  - Goldfish
- o Acceleration devices (TBD)
- o Animal centrifuges (0.1, 0.5, 1.0, 1.25g)
- o SMMI
- o GWPS
- o Electrophysiological equipment, see Concept 03/2/02 (B011)

SPACE STATION USERS CONCEPT

Experiment Concept 5 (con't)

Crewtime Requirements:

- o Heavy schedule on recording days 10, 40 and 180.
- o Periodic animal maintenance (species dependent).

PROGRAM STATUS: NASA has recently provided additional support to the ongoing vestibular activities in pursuit of countermeasures for the space sickness phenomenon. The Vestibular Function Research Program and the Vestibular Research Facility (VRF) development efforts are currently underway and it is anticipated that an acceptable means of inducing angular and linear accelerations and an animal centrifuge will be produced for Shuttle spacelab which can be easily modified for space station.

SYSTEM DESCRIPTION: The equipment requirements for the Vestibular/ Neurophysiology experiment concepts are provided in Table 1. The human experiment operations will be performed in the HMF as space and time allow. The non-human experiments will require the vivarium for specimen support and the Life Sciences Laboratory Facility (LSLF) to accommodate non-human experiment operations.

SYSTEM OPERATION: The human experiments will be performed in the HMF by a qualified payload specialist. The non-human experiments will require a crewmember operator preferably with electrophysiological experience. All non-human experiment activities will occur in the LSRM. The investigators prefer realtime video and voice downlink during the experiment operations. However, as these activities become routine on the SS, the realtime downlink of data and video and the voice communication with the investigators will not be as critical as in the early stages of experimentation.

The Shuttle will provide consumables resupply, biological sample and data return, and specimen and equipment changeout at approximately 90 day intervals. Routine module/facility repair/maintenance is anticipated.

SYSTEM INTEGRATION: The human experiment instrumentation will be incorporated into the HMF. Space for human linear/angular accelerator devices will probably not be available until after incorporation of the Category III HMF in 1995. It is suggested by some investigators that new means of vestibular stimulation be developed for SS. The non-human experiment instrumentation will be accommodated by the LSRM which will be operational in 1995.

SUBSYSTEM SUPPORT: The experiment equipment items will be located in the pressurized modules, HMF and LSRF, and they will draw power from these facilities. Data management strategies will vary with the experiment. Realtime data and video downlink with two-way voice communication will be initially required.

Table 1 Vestibular/Neurophysiology Experiment Concept Requirements

EQUIPMENT REQTS / EXPERIMENT CONCEPT	ANIMAL HOLDING FACILITY	GPWS	ANIMAL CENTRIFUGE	ACCELERA-TION DEVICE(S)	VISUAL FIELD MOTION SYSTEM	KIT, ELEC-TROPHYSIO-LOGY	MICROELEC-TRODE PULLER (HORIZ.)	DISSECTING MICRO-SCOPE	IR VIDEO-CAMERA	VIDEOCAMERA TIMER AND MOUNT	VIDEOCAMERA SHROUD AND MIRRORS	VIDEO RECORDER	LSLE MICRO-COMPUTER OR PDP 11/23	POWER FRAME, TEKTRONICS RTM506	OSCILLOSCOPE TEKTRONICS SC501	OSCILLOSCOPE TEKTRONICS SC502	
CONCEPT 1 03/2/01(A002)	MULTI. SPECIES	✓	MULTI. SPECIES	✓	✓	✓	✓					✓	✓	✓	✓	✓	
CONCEPT 2 03/2/02(B011)	✓ GERBIL	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
CONCEPT 3 03/2/03(A002)	RODENT	✓	RODENT					✓									
CONCEPT 4 03/2/04(A004)	RODENT	✓	✓					✓									
CONCEPT 5 03/2/05(A004)	MULTI-PLE	✓		✓	✓	✓	✓					✓	✓	✓	✓	✓	

Table 1 Vestibular/Neurophysiology Experiment Concept Requirements (Cont'd)

EXPERIMENT CONCEPT \ EQUIPMENT REQTS	VOICE RECORDER	EXPERIMENT CONTROL UNIT	MICRODRIVE BURLEIGH PZ550	MICRODRIVE CONTROLLER BURL. PZ551	ANIMAL HOLDER & UNIT TESTER (AHUT)	AHUT TETHER	AHUT MOUNT	AUDIO MONITOR	HEADSET (EARPHONES & MICROPHONE)	PS "PERCH"	DISPLAY MICRO-PROCESSOR	DYNAMIC ENVMT MONITORING PKG	STEREO-TAXIC	SMMI	SACRIFICE & DISSECTION KIT	TISSUE PREP. KIT	TISSUE STORAGE
CONCEPT 1 03/2/01(A002)	✓	✓	✓	✓				✓	✓		✓	✓	✓				
CONCEPT 2 03/2/02(B011)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
CONCEPT 3 03/2/03(A002)														✓	✓	✓	✓
CONCEPT 4 03/2/04(A004)														✓	✓	✓	✓
CONCEPT 5 03/2/05(A004)	✓	✓	✓	✓				✓	✓		✓	✓	✓	✓			

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

BENEFITS: The vestibular research efforts are primarily concerned with the elucidation of the etiological mechanisms of space sickness and ultimately the development of acceptable countermeasures. As such, the information derived will be directly applicable to the understanding of normal vestibular function and earth-based vestibular maladies such as otitis media, Meniere's Syndrome, and endolymphatic hydrops. The vestibular function research is also of great interest to the military since perceptual alterations occur in very high altitude flying and in precision aircraft at high speeds. The safety of these pilots as well as the Shuttle pilots is of extreme importance.

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SPACE STATION USERS CONCEPT

REFERENCES: (Con't)

A009 National Research Council Space Science Board, Life Beyond The Earth's Environment: The Biology of Living Organisms in Space (The Bricker Report), 1979.

Contributors

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APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Life/Biological/Medical Sciences

TITLE: Osteology (MMCX-0604)

PRINCIPAL CONTACT: Christopher Cann, Ph.D.

ORGANIZATION: University of California - San Francisco

MMC CONTACT: A. K. Wildgen

PROGRAM OBJECTIVE: Classical balance studies in Gemini, Apollo and Skylab missions have indicated a serious negative calcium balance. If the daily negative calcium loss recorded in Skylab crewmembers were to continue at the rates measured, a 10% loss in skeletal calcium was predicted for each year of weightless flight. (A004) This could pose a serious danger to astronauts, especially during the stress of reentry following a long mission. The possibility of a vertebral compression fracture during reentry increases with the age and gender (more predominant in females) of the astronauts. It is critical to determine whether the calcium losses continue indefinitely or whether a new equilibrium level is eventually established.

It should be determined if induced g fields reverse the deleterious effects of 0g on bone loss and progressive increases in urinary calcium concentration and excretion rates. These experiments should be designed for both human subjects and species (such as rats) which also respond to weightlessness with bone mobilization and calciuria. Until this question is answered, the potential remains for recurrent renal calculi (stones) and skeletal fractures during prolonged exposure to decreased gravitational forces. Suggested areas of investigation include analysis of bone strength as a function of time of exposure to weightlessness, pharmacological or other interventions that slow bone resorption, the measurement of calcium precipitation, and design of interventions that prevent bone loss and/or precipitation.

Currently, countermeasures have been focusing upon skeletal loading, pharmacologic intervention and induced electrical events in bone. It is possible that treatment of future crewmembers with medications prior to flight will permit long duration flights to be undertaken without adverse effects on the skeletal system.

Osteology Experiment Concept 1: 04/2/01 (A002)

Species: Rat, and Small Primate
Procedures:

Specimens will be maintained in flight, in weightlessness, and at 1-g.

Urine and feces will be collected continuously for analysis upon return.
At intervals:

SPACE STATION USERS CONCEPT

Experiment Concept 1 (con't)

- All specimens will be weighed (i.e. their masses will be measured)
- Six specimens from each group will be sacrificed, dissected, and parts of the skeletal system and internal organs will be preserved for analysis upon return
- Blood samples will be taken and preserved for analyses upon return

At conclusion, 15 specimens from each group will be returned alive for further studies.

Equipment Requirements:

- Rodent holding facility
- Rodent centrifuge (1g)
- Primate holding facility
- Primate centrifuge (1g)
- Urine and feces collection and storage
- SMMI
- GPWS
- Sacrifice and dissection kits (Rodent and Primate)
- Blood collection kit
- Blood storage (-20°C plasma; +4°C hematocrit)
- Tissue storage (-50° to -70°C)
- Blood centrifuge (+4°C)

Crewtime Requirements:

- Scheduling of data collection periods is TBD-heavy crewtime requirement on days of sacrifice.

Osteology Experiment Concept 2: 04/1/02 (A001)

Direct measurement of skeletal calcium or mineral content changes should be obtained during the proposed mission, e.g., photon absorption, activation analysis, or computerized tomography pre- and post-mission.

Classical balance methods treat the subjects as a black box in which the contents of the box are unknown but inferred by measuring the differences between input and output. The classical densitometry methods popularized by Cameron are generally capable of measuring mineral changes of specific osseous sites in the extremity. Evidence from clinical conditions and other evidence available from crewmembers suggests that a greater percentage loss of calcium would be expected in the spine and upper femur. Newer methods which measure mineral content in the spine are just now becoming available, but have not yet been tested adequately in clinical settings. Just as promising, but also untried in crewmembers, are the activation analysis techniques which quantitate calcium content directly, either as total body calcium or as regional calcium content. Proposed methodology must be accompanied by sufficient clinically oriented background data.

SPACE STATION USERS CONCEPT

Experiment Concept 2 (con't)

Equipment Requirements:

No inflight equipment requirements, all measurements are pre- and post.

Crewtime Requirements

None

Osteology Experiment Concept 3: 04/1/03 (A001)

Another analytic method to be considered would be an early post-flight direct biopsy of the iliac crest (e.g., a standard cylindrical biopsy is 8 x 25 mm after oral tetracycline).

Bone biopsy should be considered among the possible concepts if animal studies indicate that adequately housed and fed animals do not show a propensity for calcium loss, and if the state of bone remodeling becomes critical to the understanding of this phenomena. It is expected that ongoing Soviet missions and Shuttle flights will help determine if there is any justification for using this classical research approach in the operational setting of the space station mission.

Equipment Requirements:

No inflight equipment requirements, all measurements are pre- and post-flight.

Crewtime Requirements:

- None

Osteology Experiment Concept 4: 04/2/04 (A004)

Typical investigations could include the use of the rodent to elucidate the mechanisms which cause calcium to be lost from the skeleton. The animals (approximately 39 rats) would be maintained in weightlessness and a second group (of about the same number) would be maintained inflight at one-g in a rodent centrifuge to act as a control. Urine and feces would be collected continuously for analysis upon return. At intervals, all specimens would be weighed and six selected numbers of each group would be sacrificed and dissected. Parts of the skeletal system and internal organs would be removed, blood samples would be taken, and all would be preserved for analyses upon return to Earth. At the conclusion of the flight, 15 specimens from each group would be returned alive for further studies. A typical experiment could last 360 days with four sacrifices being performed at 90, 180, 270, and 360 days after launch.

Experiment Concept 4 (con't)

Equipment Requirements:

- Rodent holding facility, N=39
- Rodent centrifuge (1g) N=39
- Urine/feces storage
- SMMI
- GPWS
- Sacrifice/dissection kit
- Blood collection kit
- Blood storage (-20°C and +4°C)
- Tissue storage
- Blood centrifuge (+4°C)

Crewtime Requirements:

- Heavy on sacrifice days 90, 180, 270 and 360.
- Periodic animal maintenance

Osteology Experiment Concept 5: 04/2/05 (A004)

The primate should be studied to elucidate the mechanisms which cause calcium to be lost from the skeleton inflight. The animals (approximately 16 squirrel monkeys) would be maintained in weightlessness and a second group (of about the same number) would be maintained inflight at one-g, in a primate centrifuge, to act as a control. Urine and feces would be collected continuously for analysis upon return. At intervals, all specimens would be weighed and one of each group would be sacrificed and dissected. Parts of the skeletal system and internal organs would be removed, blood samples would be taken, and all would be preserved for analyses upon return to Earth. At the conclusion of the flight, 8 specimens from each group would be returned alive for further studies. A typical experiment could last 360 days with four sacrifices being performed at 90, 180, 270, and 360 days after launch.

Equipment Requirements:

- Primate holding facility N=16
- Primate centrifuge (1g) N=16
- Urine/feces storage
- SMMI
- GPWS
- Sacrifice/dissection kit
- Blood collection kit
- Blood storage (-20°C and +4°C)
- Tissue storage (-50° to -70°C)
- Blood centrifuge (+4°C)

Experiment Concept 5 (con't)

Crewtime Requirements:

- Heavy on days of sacrifice
- Periodic mass measurements and animal maintenance

Osteology Experiment Concept 6: 04/1/06 (A004)

Direct measurement could be obtained on all crewmembers of skeletal calcium or mineral content changes occurring during the proposed mission by photon absorption, activation analysis, or computerized tomography pre-and post-mission. The classical densitometry methods popularized by Cameron are generally capable of measuring mineral changes of specific osseous sites in the extremities. Certain evidence suggests that a greater percentage loss of calcium would be expected in the spine and upper femur and methods which measure mineral content in the spine are just now becoming available and offer promise for future development.

In addition, carefully obtained and timed blood samples should be obtained and analyzed. These analyses may be crucial to the understanding of the mechanism by which calcium loss occurs during space flight. Biochemical measurements and hormonal measurements, (for hydroxyproline, parathormone and vitamin D metabolities, etc.) in plasma or urine will be performed on specimens drawn at selected times before, during, and following the missions. The inflight specimens would be returned to Earth by the STS or stored on board the space station.

Supplementary information could be obtained by an iliac crest biopsy performance early postflight. Bone biopsies should be considered only if animal studies indicate that adequately housed and fed animals do not show a propensity for calcium loss, and if the state of bone remodeling becomes critical to the understanding of this phenomenon.

Equipment Requirements:

- Blood collection kit (human)
- Blood storage (plasma -20^{o}C, hematocrit +4^{o}C)
- Urine collection (UMS)
- Urine storage (-10^{o}C)
- Blood centrifuge (+4^{o}C)

Experiment Concept 6 (con't)

Crewtime Requirements:

Periodic blood draws on all crewmembers.

Osteology Experiment Concept 7: 04/1/07 (A004)

Countermeasure programs should be evaluated directly in the space station environment. NASA has studied countermeasures using multiple bed rest studies, but to date, no operationally practical countermeasures have been developed. Because of the new knowledge now available, we can expect new approaches to developing effective countermeasures and that ongoing bed rest studies should be able to designate a practical countermeasure to calcium loss by the time of the space station occupancy. Evaluation of the contermeasures could be by the same methods employed in the human experiment concept 04/1/06 (A004).

Equipment Requirements

- Blood collection kit
- Blood storage (-20°C and +4°C)
- Urine collection (UMS)
- Urine storage (-10°C)
- Blood centrifuge (+4°C)

Crewtime Requirements:

- Periodic blood draws on all crewmembers.

Osteology Experiment Concept 8: 04/1/08 (B006)

Blood draws will be taken from all crewmembers following oral administration of labeled tetracycline 2 draws/wk. the first month of the mission and 1 draw/wk. thereafter throughout the mission. Ground based analysis of these samples will include as a minimum: parathyroid hormone, vitamin D metabolites, calcium, phosphorous, proteins, calcitonin, $^{46}Ca/Ca$ and $^{48}Ca/Ca$ ratios. Supplementary information which should be available from other biomedical experiments include: renal plasma filtration rates, circulating antidiuretic hormone, plasma volume, plasma proteins, dietary intake (Ca and P), fluid intake, urine volume and composition, and body mass.

Equipment Requirements:

- Blood collection Kit
- Blood centrifuge (+4°C)
- Blood storage (+4°C hematocrit and -20°C plasma fractions)
- Radiological container

Experiment Concept 8 (con't)

Crewtime Requirements:

- Extensive for medical crewmember on days of blood draws, all crewmembers must participate.

PROGRAM STATUS: All equipment items except the animal centrifuge and a long duration animal holding facility are currently available for spaceflight. It is anticipated that development activities for these items will be initiated in time for implementation on SS. The animal centrifuge is planned for Shuttle spacelab and it should be easily modified for use in the SS. Future activities in this subdiscipline would benefit from an inflight bone densitometry technique and an automated means of blood and urine analysis.

SYSTEM DESCRIPTION: The equipment requirements for the Osteology experiment concepts are provided in Table 1. Any human data collection sessions will be conducted in the HMF as time and space allow. The nonhuman experiments will require the vivarium and LSLF.

SYSTEM OPERATION: All human data collection will occur in the HFM with operations performed by the medical crewmember. Most of these measurements can be obtained during the routine medical status checks. The nonhuman experiment activities will occur in the Life Sciences Research Module.

The Shuttle will provide consumables resupply, biological sample and data return, and specimen and equipment changeout at approximate 90 day intervals. Routine module/facility repair/maintenance is anticipated.

SYSTEM INTEGRATION: The human experiment instrumentation will be incorporated into the HMF which will be integrated and operational in 1990. The nonhuman experiment instrumentation is to be integrated into the Life Sciences Research Module which is to be operational in 1995. The early integration of the automated blood and urine analyses system would greatly reduce the storage space required for biological samples. The bone densitometry system will probably not be integrated until late in the SS era and only if warranted by the pre- and post-flight densitometry data and the hormonal and metabolic measurements.

SUBSYSTEM SUPPORT: The experiment equipment items will be located in the pressurized modules, HMF and LSRF, and they will draw power from these facilities. Data management strategies will vary with the experiment. However, most osteology experiment concepts require only inflight blood and urine sample collection with pre- and post-flight analyses. These, in addition to the non-human biological samples, will be returned via the Shuttle. The only data to be downlinked will be the vivarium and animal status information.

Table 1 *Osteology Experiment Concept Requirements*

EQUIPMENT REQTS / EXPERIMENT CONCEPTS	ANIMAL HOLDING FACILITY	GPWS	ANIMAL CENTRIFUGE	STORAGE +4°C	SMMI	SACRIFICE DISSECTION KITS	TISSUE-20°C STORAGE	BLOOD CENTRIFUGE +4°C	UMS	BLOOD COLLECTION KIT	BLOOD -20°C STORAGE			ULTIMATE SS
CONCEPT 1 04/2/01(A001)	RODENT & PRIMATE	✓	RODENT & PRIMATE	URINE FECES	✓	RODENT & PRIMATE	✓	✓		✓	✓			• BONE DENSITOMETRY
CONCEPT 2 04/1/02(A001)			NONE: (NO INFLIGHT DATA COLLECTION)											TECHNIQUE INFLIGHT • AUTOMATED BLOOD
CONCEPT 3 04/1/03(A001)			NONE: (NO INFLIGHT DATA COLLECTION)											ANALYSIS SYSTEM
CONCEPT 4 04/2/04(A004)	RODENT N=39	✓	RODENT N=39	URINE FECES	✓	RODENT	✓	✓		✓	✓			
CONCEPT 5 04/2/05(A004)	PRIMATE N=16	✓	PRIMATE N=16	URINE FECES	✓	PRIMATE	✓	✓		✓	✓			
CONCEPT 6 04/1/06(A004)				URINE				✓	✓	HUMAN	✓			
CONCEPT 7 04/1/07(A004)				URINE				✓	✓	HUMAN	✓			
CONCEPT 8 04/1/08(B006)								✓		HUMAN	✓			

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

BENEFITS: The information to be obtained in the Osteology subdiscipline is directed toward defining inflight operational capabilities and constraints, establishing the limits of human space habitation and to develop countermeasures for the bone and calcium loss induced by prolonged exposure to hypogravity. The data obtained in this area will greatly enhance ongoing earth-based research in osteoporosis, particularly in post-menopausal women, and calcium-metabolic disorders.

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APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

REFERENES: (Con't)

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SPACE STATION USERS CONCEPT

DISCIPLINE: Life/Biological/Medical Sciences

TITLE: Musculoskeletal Physiology (MMCX-0605)

PRINCIPAL CONTACT: Kenneth N. Baldwin, Ph.D.

ORGANIZATION: University of California-Irvine

MMC CONTACT: A. K. Wildgen

PROGRAM OBJECTIVE: Previous space flight data have shown significant decreases in muscle strength and volume and total body mass. In Skylab missions 1 and 3, a 25% reduction in muscle strength occurred with an approximate 5% decrease in muscle volume and total body mass. Skylab 4 (84 days) initiated a rigorous exercise regimen with an improved nutritional program, in spite of which a 10% decrease in muscle strength was exhibited with 2% reduction in muscle volume and body mass. The measured increase of excreted 3-methylhistidine indicated that the losses were due to muscle protein catabolism. The Russian Cosmos data confirmed these results and provided evidence that the losses continued to occur throughout a 175 day mission. (A005)

It has been suggested that the exposure to hypogravity removes the chronic muscle tension necessary to maintain normal muscle tonicity and metabolism. It is necessary to determine the extent of this hypogravity-induced muscle atrophy in order to establish safe limitations on human space habitation. The reduced muscle strength will seriously impact inflight work schedules and operational efficiency of long-duration missions. Countermeasures should be explored to limit the extent of musculoskeletal deconditioning on SS. Additional studies with animals will allow a greater amount of information to be obtained on the morphological, biochemical and subcellular changes in all muscle groups with prolonged exposure to hypogravity. The electrophysiological (EMG) correlates of these changes should also be explored in conjunction with the study of neural inputs to the various muscle groups.

Musculoskeletal Experiment Concept 1: 05/2/01 (A005)

This Musculoskeletal experiment concept proposes the use of the rodent to elucidate the mechanisms of muscle mass loss and the influence of caloric intake and hormonal changes. The animals (approximately 39 rats) would be maintained in weightlessness, and a control group (of about the same number) would be maintained in-flight, at one-g, using a centrifuge. Urine and feces would be collected continuously for analysis upon return to Earth. At intervals, all specimens would be weighed, and six specimens from each group would be sacrificed and dissected. Parts of the muscle system, endocrine glands, and blood would be sampled and preserved for analyses upon return to Earth. At the conclusion of the flight, 15 specimens from each group would be returned alive for further studies. A typical experiment could last 360 days with four sacrifices being performed at 90, 180, 270, and 360 days after launch.

SPACE STATION USERS CONCEPT

Experiment Concept 1 (Con't)

Equipment Requirements:

- Rodent Holding Facility (Rats; N=39)
- Rodent 1g Centrifuge (Rats; N=39)
- Urine (-10°C) & Feces (+4°C) Storage
- SMMI
- GPWS
- Rodent Sacrifice/Dissection Kit
- Tissue Storage (-50°C to -70°C)
- Blood Storage (plasma -20°C; hematocrit +4°C)

Crewtime Requirements:

- Heavy on mission days 90, 180, 270 and 360
- Approximately 1 day/wk for holding facility maintenance and animal mass measurements

Musculoskeletal Experiment Concept 2:05/2/02 (A005)

This experiment concept proposes the use of the primate to elucidate the mechanisms of muscle mass loss and the influence of caloric intake and hormonal changes. Their investigation would be identical to the investigation described in 05/2/01 (A005) except for the total number of specimens in each group (16 instead of 39) and the number of specimens which would be sacrificed (1 instead of 6).

Equipment Requirements:

- Primate Holding Facility N=16
- Primate 1g Centrifuge N=16
- Urine and feces storage (Refrigerated)
- SMMI
- GPWS
- Primate Sacrifice/Dissection Kit
- Tissue Storage (-50°C to -70°C)
- Blood Storage (plasma -20°C and hematocrit +4°C)

Crewtime Requirements:

- Heavy on mission days 90, 180, 270 and 360
- 1 day/wk for holding facility maintenance and animal mass measurements

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

Musculoskeletal Experiment Concept 3:05/2/03 (BO16)

The objective of this experiment conceptualized for SS is to characterize the morphological, biochemical and subcellular changes which occur in the anti-gravity muscles of rats with long-term exposure to hypogravity. One hundred and eight rats will be maintained in a RAHF-like environment with continuous monitoring of both environmental parameters and normal physiological parameters. The environmental parameters should include ambient temperature, relative humidity and photoperiod. The health status of each animal should be continuously assessed by monitoring of activity level, urine/feces output and composition, gas analysis, water and food consumption, blood pressure, and deep body temperature. The last two measurements will require chronic instrumentation of the animals preflight and a biotelemetary system. Such data would most likely be downlinked to relieve the crewmembers of the continuous data monitoring duty. In case of death of an animal, or other contingency situation the appropriate crewmember will be notified (voice uplink) to employ appropriate contingency procedures. Periodic animal holding facility maintenance will be required and animal weights (SMMI) assessed periodically.

The experimental design will consist of a 3 x 6 paradigm with each group comprised of 5 animals. Thirty five animals will be exposed to near null gravity in the normal space station environment. An additional 35 animals will be exposed to 0.5g continuously throughout the mission and the last group of 35 rats will be continuously centrifuged at 1.0g. Five rats from each group will be sacrificed at mission days 30, 60, 90, 180, and 360. The remaining animals will be returned for postflight assessment of exercise capacity, stress tolerance or other such treatments.

The means of inflight sacrifice must be anesthetization (eg. sodium pentobarbital) with immediate dissection of the gastrocneminus and soleus. These tissues will be stored at cryogenic temperatures (-50 to -70) and returned via Shuttle for ground-based analysis. Postflight tissue analyses will include histological and biochemical characterization.

It is anticipated that this study will be conducted in conjunction with the cardiovascular, endocrinology and metabolic studies to maximize the information derived. Such supplementary information would include nutrient and mineral balances, muscle tissue circulation, cardiovascular status, cardiac muscle characterization, endocrinological, hematological and osteological data.

It would not be necessary to fly all groups simultaneously provided that care is taken to minimize the introduction of confounding variables.

Experiment Concept 3 (con't)

Ultimately, it is hoped that an entire physiological and biochemistry laboratory be available onboard space station to study muscle contractile properties (in vivo and in vitro) inflight following long-duration null gravity exposure. It would also be beneficial to have a means of inducing exercise inflight. Currently a rat treadmill is employed in ground-based laboratories, but this hardware concept would be incompatible with 0g conditions. Future studies should also include study of muscle development from embryos throughout adulthood and in 0g conceived and reared animals.

Equipment Requirements:

- o Rodent Holding Facility N=35
- o Rodent Centrifuge (0-1g capability) N=35(minimum)
- o Urine/Feces Storage
- o Gas Analysis
- o Biotelemetry System (BTS)
- o SMMI
- o Rodent Sacrifice/Dissection Kit
- o Tissue Storage (-50 to -70 C)
- o GPWS

Crewtime Requirements:

- o heavy on mission days 30, 60, 90, 180 and 360
- o 1 day/wk for holding facility maintenance and animal mass measurements

Ultimate Requirements:

- o Animal exercise system
- o Fully equipped electrophysiological and biochemistry laboratory

Musculoskeletal Experiment Concept 4: 05/2/04 (B016)

The objective of this SS experiment is to characterize the morphological, biochemical and subcellular changes which occur in the anti-gravity muscles of squirrel monkeys followng long duration exposure to hypogravity.

Four squirrel monkeys will be maintained in a RAHF-like environment with continuous monitoring of both environmental parameters (ie. relative humidity, temperature, photoperiod) and physiological status parameters (ie. activity levels, heart rate, blood pressure, body temperature, urine/feces output and composition, food and water consumption, and gas analysis). Weights should be assessed periodically (SMMI). Chronic instrumentation of the animals will be required preflight for biotelemetry. It would be desired to have EMG assessments obtained periodically throughout the mission. One animal will be sacrificed on each of mission days 30, 90 and 180. The remaining animal will be returned on mission day 360 for postflight assessment.

SPACE STATION USERS CONCEPT

Experiment Concept 4 (con't)

Inflight procedures will include periodic animal holding facility maintenance, animal mass measurements, animal sacrifices, dissection and tissue storage. Sacrifice must be by anesthetization. Tissues will be stored at cryogenic temperatures (-50 to -70 C) and returned via Shuttle for postflight histological and biochemical characterization. The EMG measurements could be obtained, periodically from the animal to be returned alive on mission day 360. The frequency and scheduling of these measurements are not critical. The suggested schedule is daily the first week and monthly thereafter throughout the mission.

It is anticipated that the data obtained in this study will be supplemented by data from other disciplines such as metabolism, hematology, cardiovascular etc. Great care should be taken to eliminate confounding variables induced by over-instrumenting the animals and/or by subjecting the animals to incompatible experimental manipulations.

Equipment Requirements:

- Small primate holding facility N=4
- Biotelemetry system
- Urine/feces storage (-10^{o}C and -20^{o}C respectively)
- Gas analysis
- SMMI
- GPWS
- Primate sacrifice/dissection kit
- Physiograph (EMG) with computerized data storage (such as DEC PDP 11/23)
- Tissue Storage (-50 to -70 C)
- EMG kit (electrodes, etc.)
- Primate Restraint System

Crewtime Requirements:

- Heavy on days 30, 90 and 180
- 1 day/wk for animal maintenance
- 3 hours daily wk 1 and 3 hours 1 day/week thereafter for EMG assessment.

SPACE STATION USERS CONCEPT

Musculoskeletal Experiment Concept 5: 05/2/05 (A002)

Muscle loss
Species: Rat and Small Primate
Procedures:

Specimens will be maintained inflight in weightlessness and at 1-g. Urine and feces will be collected continuously for analyses upon return. At intervals:

- o all specimens will be weighed
- o six specimens from each group will be sacrificed, dissected and parts of the muscle system and the endocrine glands will be preserved for analyses upon return
- o blood samples will be taken and preserved for analyses upon return

At conclusion, 15 specimens from each group will be returned for further studies.

Equipment Requirements:

- o Rodent holding facility
- o Primate holding facility
- o Animal centrifuge (lg)
- o Urine and feces storage
- o Animal dissection kits (rodent and primate)
- o GPWS
- o Tissue storage
- o Blood sample storage
- o SMMI

Crewtime Requirements:

- o Heavy on days of sacrifice
- o Periodic animal maintenance

Musculoskeletal Experiment Concept 6: 05/1/06 (A006)

Experiments should be designed to determine whether decreases in skeletal muscle mass will adversely affect work performance in space and whether these changes are reversible by small increases in artificial g-forces or by other interventions. In man, and other species, nitrogen balance protocols would be coupled to measurements of urinary 3-methylhistidine, the latter reflecting muscle catabolic processes. Specific areas of investigation include: long-term optimization of exercise strategies to minimize muscle loss; interventions to specifically maintain anti-gravity muscles during periods of disuse; and evaluation of the role of substrates, metaboltites, and humoral factors on the maintenance of muscle mass and function.

SPACE STATION USERS CONCEPT

Experiment Concept 6 (con't)

Equipment Requirements:

- o Urine & feces collection & storage
- o Blood collection kit (human)
- o Blood centrifuge (refrigerated +4 C)
- o Refrigerated blood storage
- o Exercise equipment (eg. ergometer, whole body work system)
- o Means of inducing artificial g-forces (ultimate SS)

Crewtime Requirements:

- o All crewmembers will be involved with some daily measurements and more extensive weekly measurements.

SYSTEM DESCRIPTION: The equipment requirements for the musculoskeletal experiment concepts are provided in Table 1. The human data collection activities will occur in the HMF. The non-human experiments will require the Vivarium and the Life Sciences Laboratory Facility (LSLF).

SYSTEM STATUS: A long duration animal holding facility will require development for space station. The animal centrifuge is currently planned shuttle spacelab, so it is assumed that the system can be easily adapted for SS. Electrophysiological studies on spacelab will allow assessment of actual instrumentation requirements for a SS electrophysiological laboratory setup.

SYSTEM OPERATION: The human data collection and exercise activities will occur in the HMF under the jurisdiction of the medical crewmember. Most human measurements can be obtained in conjunction with routine medical status checks. The nonhuman research will be performed in the Life Sciences Research Module (LSRM).

The shuttle will provide consumables resupply, biological sample and data return, and specimen and equipment changeout as required. Shuttle visitation will occur at approximate 90 day intervals. Routine module/facility repair/maintenance is anticipated.

SYSTEM INTEGRATION: The human experiment instrumentation and exercise equipment will be incorporated into the HMF. The Category II HMF (1990) can accommodate most of the blood and urine sample collection and storage. Exercise devices will be made available in Category II with increasing space devoted to research and exercise with the Category III (1995) HMF. The animal experimentation requirements will be met with the integration of the LSRM in 1995. The ultimate SS (2000+) will allow space for the incorporation of complete physiology, electrophysiology and biochemistry laboratories for both human and non-human experimentation. A rodent exercise system was requested for the mature SS and a means of inducing artificial-g should be explored for later incorporation.

Table 1 Musculoskeletal Experiment Concept Requirements

EXPERIMENT CONCEPTS \ EQUIPMENT REQTS	ANIMAL HOLDING FACILITY	GPWS	ANIMAL CENTRIFUGE	REFRIG. +4°C	SMMI	SACRIFICE DISSECTION KIT	FREEZER -20°C	FREEZER -50° -70°C	GAS ANALYSIS	BTS	PHYSIOGRAPH & COMPUTER	EMG KIT	PRIMATE RESTRAINT	UMS	HUMAN BCK	BLOOD CENTRIFUGE (REFRIG. +4°C)	EXERCISE EQPT.
CONCEPT 1 05/2/01(A005)	N=39 RAT	✓	1g N=39 RAT	URINE FECES	✓	RAT	BLOOD	TISSUE								✓	
CONCEPT 2 05/2/02(A005)	SMALL N=16 PRIMATE	✓	1g N=16 PRIMATE	URINE FECES	✓	PRIMATE	BLOOD	TISSUE								✓	
CONCEPT 3 05/2/03(B016)	N=35 RAT	✓	0.5 g 1.0 g	URINE FECES	✓	RAT		TISSUE	✓	✓							
CONCEPT 4 05/2/04(B016)	N=4 PRIMATE	✓		URINE FECES	✓	PRIMATE		TISSUE	✓	✓	✓	✓	✓				
CONCEPT 5 05/2/05/(A002)	RAT & PRIMATE	✓	1g	URINE FECES	✓	RODENT PRIMATE	BLOOD	TISSUE								✓	
CONCEPT 6 05/1/06(A006)				URINE FECES			BLOOD							✓	✓	✓	✓

NOTES:

ADDITIONAL ITEMS REQUESTED FOR THE ULTIMATE SS INCLUDE:

- A COMPLETE PHYSIOLOGY, ELECTROPHYSIOLOGY, AND BIOCHEMISTRY LABORATORY;
- A RODENT EXERCISE SYSTEM;
- A MEANS OF INDUCING ARTIFICAL G.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

SUBSYSTEM SUPPORT: The experiment equipment items will be located in the pressurized modules, HMF and LSRM, and they will draw power from these facilities. Data management strategies will vary with the experiment. Electrophysiological data will probably be recorded onboard and the data on disks or tapes will be returned via shuttle. The biological samples will also be returned on the shuttle for postflight analyses. The vivarium and animal status data should be continuously downlinked.

BENEFITS: The musculoskeletal physiology data will aid in the definition of inflight human capabilities in order to maximize operational efficiency and establish maximium mission durations. In addition, the data will contribute to an understanding of musculoskeletal disorders such as disuse atrophy and musculodistrophy.

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APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

REFERENCES: (Con't)

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APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Life/Biological/Medical Sciences

TITLE: Hematology/Immunology (MMCX-0606)

PRINCIPAL CONTACT: Christopher Dunn, Ph.D.

ORGANIZATION: Baylor School of Medicine; Northrop Services, Inc.

MMC CONTACT: A. K. Wildgen

PROGRAM OBJECTIVE: Past spaceflight data have shown that a decrease in red blood cell (RBC) mass occurs with a relative increase in deformed RBCs. In addition, plasma volume decreases, some immune protein fractions increase, a relative leukocytosis occurs and phytohemagglutinin-induced T-lymphocyte transformation is suppressed. During Skylab 4 (84 days) the measurements obtained indicated that the hematological changes were not as sever as in previous flights. However, it has been suggested that the exercise regimen and the improved nutrition on this flight contributed to the reduced severity of the response rather than any adaptive normalization of hematological dynamics. The dynamics of these changes over long durations and the repercussions on crew health should be studied in space station in order to establish the limitations on human habitation in space and operational impacts.

Hematology/Immunology Experiment Concept 1: 06/1/01 (A004)

Typical investigations could include confirmation of the red cell mass decreases and red cell shape changes found postflight in Skylab. In the 84-day Skylab mission, reasonably good data were obtained that suggest a stabilization and/or normalization of the red cell mass changes, which had been repeatedly shown to occur during the Apollo and the earlier Skylab flights. A refined experimental model with increased measurement precision and sophistication would verify the red cell shape changes and apparent normalization of red cell mass that take place during long-term space flight. Such an investigation would also help elucidate the mechanisms of the red cell mass decrease and red cell shape changes.

Equipment Requirements;

- o Blood collection kit (human)
- o Hematocrit centrifuge
- o Blood centrifuge (Refrigerated +4 C)
- o Blood storage (freezer)

Crewtime Requirements:

- o All crewmembers should participate as subjects. One medically trained crewmember should obtain the blood collections.

Hematology/Immunology Experiment Concept 2: 06/1/02 (A004)

Non-red blood cell studies should be performed since little is known about the kinetics or functions of other blood cells in the space environment, e.g., platelets and leukocytes. Similarly, little is known about kinetic or quantitative changes in plasma proteins of all types. However, these high priority and sophisticated types of studies should not be initiated on long duration missions in the absence of preliminary and pilot observations from crewmembers of missions of short duration. Typical investigations in this area would verify changes and study causitive mechanisms with improved techniques.

Equipment Requirements;

- o Blood collection kit (human)
- o Blood centrifuge (Refrigerated +4 C)
- o Blood storage (freezer)

Crewtime Requirements:

- o All crewmembers should participate as subjects. One medically trained crewmember should obtain the blood collections.

Hematology/Immunology Experiment Concept 3: 06/1/03 (A004)

It is suggested to bank plasma samples to await improved methodologies. The data suggesting changes in immunological function following space flights are sketchy and of uncertain validity and significance. In this regard, unless experimental concepts and techniques show considerable advance, plasma samples from space station crews would be collected and preserved until such a time that new techniques and experiments are developed.

Equipment Requirements;

- o Blood collection kit (human)
- o Blood centrifuge (Refrigerated +4 C)
- o Blood storage (freezer: plasma -20 C))
  (refrigerator: +4 C hematocrit)

Crewtime Requirements:

- o All crewmembers should participate as subjects. One medically trained crewmember should obtain the blood collections.

Hematology/Immunology Experiment Concept 4: 06/1/04 (A001)

Confirmation of the red cell mass decreases and red cell shape changes found post-flight in Skylab.

If the primary experimental capability relates to the long duration of the space station missions, we must address this capability in relation to what has been accomplished in the 84 days of the longest Skylab mission, in which reasonably good data were obtained. These data suggest stabilization and/or normalization or the red cell mass changes which had been repeatedly shown during the Apollo and the early Skylab series. What is needed now is a refined experimental model with increased measurement precision and sophistication which would help elucidate the mechanisms of the red cell mass decrease and red cell shape changes in flights of up to 60 days. A "look-see" type of study to verify the apparent normalization or the red cell mass which was seen in the longest Skylab mission and to verify the red cell shape changes would appear to be a flexible space station mission study.

Typical measurements include red cell mass; red cell shape by scanning electron microscopy; and red cell mean life span. These measurements require drawing blood samples and processing the specimens obtained.

Equipment Requirements:

- Blood collection kit (human)
- Hematocrit centrifuge
- Blood centrifuge (Refrigerated +4 C)
- Blood storage (freezer: plasma -20 C)
  (refrigerator: hematocrit +4 C)

Crewtime Requirements:

- All crewmembers should participate as subjects. One medically trained crewmember should obtain the blood collections

Hematology/Immunology Experiment Concept 5: 06/1/05 (A001)

Non-red blood studies:

Little is known about the kinetics or functions of other blood cells in the space environment, e.g., platelets and leukocytes. Similarly, little is known about kinetic or quantitative changes in plasma proteins of all types. However, these high priority and sophisticated types of studies should not be initiated on long duration missions in the absence of preliminary and pilot observations from crew members of missions of short duration. Investigations in these areas are recommended as experiments only in the form of the simplest types of studies which would verify changes rather than elucidate mechanisms.

Typical measurements include: white cell and platelet mean life span, ability of cultured lymphocytes to respond to mitogenic stimuli, thymus and bone marrow cell classification by monoclonal antibody techniques, etc. These measurements require drawing blood samples and processing the specimens obtained.

Equipment Requirements:

- Blood collection kit (human)
- Blood centrifuge (Refrigerated +4 C)
- Blood storage (freezer: plasma -20 C)
  (refrigerator: hematocrit +4 C)

Crewtime Requirements:

- o All crewmembers should participate as subjects. One medically trained crewmember should obtain the blood collections.

Hematology/Immunology Experiment Concept 6: 06/1/06 (A001)

Banking of plasma samples to await improved methodologies.

Many of the same comments applicable to blood studies are pertinent in this area. The data suggesting changes in immunological function following space flights are sketchy and of uncertain validity and significance. What is needed are refined experiments carried out initially using crewmembers of short duration missions to guide development of appropriate experiments on a space station. In this regard unless experimental concepts and techniques show considerable advance, Shuttle flights seem to offer a better opportunity to initiate this line of investigation.

Equipment Requirements:

- o Blood collection kit (human)
- o Hematocrit centrifuge
- o Blood centrifuge (Refrigerated +4 C)
- o Blood storage (plasma -20 C, hematocrit +4 C)

Crewtime Requirements:

- o All crewmembers should participate as subjects. One medically trained crewmember should obtain the blood collections.

Hematology/Immunology Experiment Concept 7: 16/1/07 (B017)

It would be beneficial to do a complete hematological/immunological evaluation of SS crewmembers daily the first week of their mission and weekly thereafter (in combination with their routine biomedical assessment) for the remainder of their stay. The measurements which should be obtained include hemoglobin, hematocrit,, various RBC indices (e.g. count, survival, shape, metabolic capacity), plasma volume, 2,3-DPG, adenosine triphosphate, iron binding proteins, erythropoietin and erythropoietin inhibitors. Additional information which may be beneficial to the interpretation of the hematology data include: body mass, fluid and dietary intake, ACTH, cortisol, PAH, insulin, prostaglandins, angiotension, antiduretic hormone, creatinine, sodium, potassium and calcium.

Equipment Requirements:

- o Blood collection kit (human)
- o Hematocrit centrifuge
- o Refrigerated centrifuge (+4 C)
- o Blood storage (plasma -20 C, hematocrit +4 C)
- 0 LMMI

SPACE STATION USERS CONCEPT

Crewtime Requirements:

- o All crewmembers should participate as subjects. One medically trained PS will obtain the blood draws.

Hematology/Immunology Experiment Concept 8: 06/2/08 (B017)

Blood draws from animals will be obtained daily the first week of the mission and once or twice weekly thereafter throughout the mission. Mice are the preferred species since most hematological background work has been accomplished with mice. Blood samples will be obtained from the animals following sacrifice by decapitation. Bone marrow and spleen samples will be obtained for inflight cultures. Follow-up studies should be performed with rats and small primates.

Equipment Requirements:

- o Blood Collection Kit (mouse)
- o Hematocrit Centrifuge
- o Centrifuge - refrigerated + 4 C
- o Culture Centrifuge (gas and temperature regulation)
- o Tissue culture kit (petri dishes and culture medium)
- o Blood storage - plasma -20 C
  - hematocrit +4 C
- o Sacrifice/Dissection Kit
- o SMMI
- o GPWS
- o Rodent Holding Facility
- o Animal Centrifuge

Crewtime Requirements:

- o Intensive crew activity the first week and 1 day/week thereafter.
- o Periodic animal maintenance.

PROGRAM STATUS: The conceptual blood studies for humans discussed for this subdiscipline could easily be accommodated by instrumentation currently available for Shuttle or previously flown on Skylab. The nonhuman conceptual experiment will require a long-duration animal holding facility and an animal centrifuge. Since an animal centrifuge is planned for Shuttle Spacelab, it is assumed that the system will be easily modified for implementation on SS.

SYSTEM DESCRIPTION: The equipment requirements for the Hematology/Immunology experiment concepts are provided in Table 1. The human data collection operations will occur in the HMF. The nonhuman experiment activities will be accommodated by the Life Sciences Research Module (LSRM).

SYSTEM OPERATION: The human data collection activities will occur in the HMF under jurisdiction of the medical crewmember in conjunction with the routine medical status checks. The nonhuman research will be conducted in the Life Sciences Research Module.

Table 1 Hematology/Immunology Experiment Concept Requirements

EXPERIMENT CONCEPTS \ EQUIPMENT REQTS	ANIMAL HOLDING FACILITY	GPWS	ANIMAL CENTRIFUGE	BLOOD COLLECTION KIT	SMMI	LMMI	SACRIFICE &DISSECTION KIT	PLASMA -20^{o}C STORAGE	BLOOD $+4^{o}$C STORAGE	TISSUE CULTURE KIT	BLOOD CENTRIFUGE	HEMATOCRIT CENTRIFUGE	CULTURE CENTRIFUGE	ULTIMATE SS
CONCEPT 1 16/1/01 (A004)				✓ HUMAN				✓	✓		✓	✓		• BLOOD PROCESSING EQUIPMENT • CARDIAC MONITORS • BIOPSY INSTRUMENTATION • EXERCISE PERFORMANCE MONITORS • VESTIBULAR FUNCTION EQUIPMENT (B017)
CONCEPT 2 16/1/02 (A004)				✓ HUMAN				✓	✓		✓			
CONCEPT 3 16/1/03 (A004)				✓ HUMAN				✓	✓		✓			
CONCEPT 4 16/1/04 (A001)				✓ HUMAN				✓	✓		✓	✓		
CONCEPT 5 16/1/05 (A001)				✓ HUMAN				✓	✓		✓			
CONCEPT 6 16/1/06 (A001)				✓ HUMAN				✓	✓		✓	✓		
CONCEPT 7 16/1/07 (B017)				✓ HUMAN		✓		✓	✓		✓	✓	✓	
CONCEPT 8 16/2/08 (B017)	✓ RODENT	✓	✓ RODENT	✓ RODENT	✓		✓	✓	✓	✓	✓	✓	✓	FOLLOWUP STUDIES WITH RATS AND SMALL PRIMATES

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

The Shuttle will provide consumables resupply, biological sample return, and subject and equipment changeout as required. Routine module/facility repair/maintenance is anticipated.

SYSTEM INTEGRATION: The human experiment instrumentation can be easily accommodated by the Category I medical support capability provided by the Shuttle. However, data collection will not be required for these conceptual experiments until the crewmembers are inhabiting the SS for periods longer than the Shuttle missions. It is anticipated that these longer missions will necessarily include a Category II level of medical support which will be available in 1990. The non-human experiment can be easily performed in the LSRM which is to be implemented in 1995.

It is hoped that an automated means of blood analysis will be available for SS which will reduce the amount of refrigerated and freezer storage required for blood sample storage and it will also reduce the need for sample return by Shuttle.

SUBSYSTEM SUPPORT: The experiment equipment items will be located in the pressurized modules, HMF and LSRM, and they will draw power from these facilities. Data management strategies will vary with the experiment, however it is anticipated that most analyses will be performed postflight. The vivarium and animal status data should be downlinked continuously.

BENEFITS: The Hematology/Immunology data will aid in the definition of mission duration limitations. In addition, the flight data will contribute to an understanding of earth-based blood disorders such as leukemia, anemic syndromes and immunological stressor mechanisms.

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SPACE STATION USERS CONCEPT

REFERENCES: (Con't)

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APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Life/Biological/Medical Sciences

TITLE: Fluids/Electrolyte Imbalances (MMCX-0607)

PRINCIPAL CONTACT: Carolyn Leach-Huntoon, Ph.D.

ORGANIZATION: NASA Johnson Space Center

MMC CONTACT: A. K. Wildgen

PROGRAM OBJECTIVE: Body fluid shifts followed by a reduction in fluid volume occurs during the first 48 hours of weightlessness. In addition, these changes are accompanied by the concurrent loss of electrolytes (sodium and potassium) continuing throughout the duration of the mission (Skylab data). Hormonal responses to counteract these changes were shown to occur, but they were ineffective in preventing the fluid/electrolyte losses. Part of the fluid loss is in the form of a decreased plasma volume which appears to persist throughout flights lasting up to 84 days. This reduction in volume may be expected to reduce $+G_z$ tolerance of astronauts upon their return to Earth, thereby impairing crew performance during the critical reentry and landing phases of the flight. The excessive sodium and potassium excretion continues throughout the mission despite aldosterone secretion.

The extent of the electrolyte losses in longer flights are unknown and difficult to predict. Prolonged electrolyte loss could result in dehydration and cardiac malfunction. The ability of individuals to cope with normal as well as emergency procedures may be severely comprised by the reduction in plasma sodium and potassium levels (A004). Space Station studies should address such issues as the Gauer-Henry reflex renal hemodynamics in zero-g, renal response to water/salt loads and dehydration in zero-g, and the humoral mechanisms involved in the above processes.

Fluid/Electrolyte Experiment Concept 1: 07/2/01 (A002)

Species: Rat, Small Primate

Procedures:

Specimens will be maintained inflight in weightlessness, and in individual metabolism cages. Urine and feces will be collected continuously for analyses upon return. At intervals:

- all specimens will be weighed
- blood samples will be taken and preserved for analyses upon return
- balance studies will be made for 14 days, fresh urine and feces will be collected daily and preserved, and food/water consumption will be measured accurately
- six specimens will be sacrificed, dissected, and blood, kidneys, hypothalmus, pituitary, and adrenal glands preserved

SPACE STATION USERS CONCEPT

Experiment Concept 1 (Con't)

Equipment Requirements:

- Rodent holding facility - metabolic cages
- Primate holding facility - metabolic cages
- Urine/feces storage
- GPWS
- SMMI
- Sacrifice/dissection kits (Rodent and primate)
- Tissue storage
- Blood collection kit
- Blood centrifuge
- Blood storage

Crewtime Requirements:

- Heavy on days of sacrifice
- Periodic animal mass measurements and holding facility maintenance

Fluid/Electrolyte Experiment Concept 2: 07/2/02 (A004)

Typical investigations could include the use of rodents under carefully controlled conditions of nutrition and water consumption to study the effects of long-term space flight on the various fluid compartments and electrolytes. The animals (approximately 24) would be maintained in weightlessness, and a second group (of about the same size) would be maintained at one-g to act as a control group. Specimens from both groups would be maintained in individual metabolic cages and urine and feces would be collected continuously and stored for postflight analyses. At intervals, all specimens would be weighed; blood samples taken and preserved for analysis upon return; and 14-day balance studies performed. A typical study would be performed on 12 rats (6 from each group) and would include the daily collection of all urine and fecal samples as well as the accurate measurement of food and water consumption. At the end of each balance study all 12 animals would be sacrificed, dissected and blood, kidneys, hypothalmus, pituitary and adrenal glands preserved for analysis upon return to Earth. A typical experiment could last 360 days with four sacrifices being performed at 90, 180, 270, and 360 days after launch.

Equipment Requirements:

- Rodent holding facility - metabolic cages N=24
- Rodent centrifuge (1g) - metabolic cages N=24
- Urine/feces storage
- SMMI
- Blood collection kit (rodent)
- Blood centrifuge
- Blood storage
- Sacrifice/dissection kit (rodent)
- Tissue storage
- GPWS

SPACE STATION USERS CONCEPT

Experiment Concept 2: (cont)

Crewtime Requirements:

- o Periodic animal maintenance, blood draws and mass measurements
- o Heavy on days of sacrifice 90, 180, 270 and 360

Fluid/Electrolyte Experiment Concept 3: 07/2/03 (A004)

Typical investigations could include the use of small primates under carefully controlled conditions of nutrition and water consumption to study the effects of long-term space flight on the various fluid compartments and electrolytes. The animals (approximately 8) would be maintained in weightlessness, and a second group (of about the same size) would be maintained at one-g to act as a control group. Specimens from both groups would be maintained in individual metabolic cages and urine and feces would be collected continuously and stored for postflight analyses. At intervals, all specimens would be weighed; blood samples taken and preserved for analysis upon return; and 14-day balance studies performed. A typical study would be performed on 4 animals (2 from each group) and would include the daily collection of all urine and fecal samples as well as the accurate measurement of food and water consumption. At the end of each balance study, all 4 animals would be sacrificed, dissected and blood, kidneys, hypothalmus, pituitary and adrenal glands preserved for analysis upon return to Earth. A typical experiment could last 360 days with four sacrifices being performed at 90, 180, 270, and 360 days after launch.

Equipment Requirements:

- o Primate holding facility - metabolic cages N=8
- o Primate centrifuge (1g) - metabolic cages N=8
- o Urine/feces storage
- o SMMI
- o Blood collection kit (primate)
- o Blood centrifuge
- o Blood storage
- o Sacrifice/dissection kit (primate)
- o Tissue storage
- o GPWS

Crewtime Requirements:

- o Periodic animal maintenance, blood draws and mass measurements
- o Heavy on days of sacrifice 90, 180, 270 and 360

PROGRAM STATUS: The metabolic cages and long-duration holding facility will require development for SS. The animal centrifuge is planned for Shuttle Spacelab, so it is assumed that this system can be easily modified for use in the SS. The remaining items are acceptable as planned for spacelab or as utilized previously in Skylab or Shuttle.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

SYSTEM DESCRIPTION: The equipment requirements for the fluid/electrolyte studies are provided in Table 1. All experiment operations will be performed in the Life Sciences Research Module (LSRM). No human experiments were proposed in this subdiscipline to date.

SYSTEM OPERATION: The nonhuman data collection activities will occur in the Life Sciences Laboratory Facility (LSLF). Animal support will be provided in the vivarium. The Shuttle will provide consumables resupply, biological sample return, and specimen and equipment changeout as required. Routine module/facility repair/maintenance is anticipated.

SYSTEM INTEGRATION: The vivarium and the LSLF are both part of the Life Sciences Research Module (LSRM) which is to be integrated in 1995. The metabolic cages should be designed for simple module changeout, and interchangeable with the standard holding facility cage modules. Additional experiment-specific instrumentation will be changed out as required.

SUBSYSTEM SUPPORT: The equipment items will be located in the pressurized LSRM and they will draw power from this facility. Biological sample analysis will be performed postflight. The animal status data and vivarium parameters will be downlinked continuously.

BENEFITS: It is uncertain at this time whether fluid/electrolyte changes in spaceflight are directly caused by gravity-unloading or whether they are secondary effects. It is hoped that experiments performed on STS will determine the nature of these changes, and establish whether the alterations are hazardous or benign. If determined to be serious, the studies should be implemented aboard SS at the earliest opportunity in conjunction with the metabolic and cardiovascular studies, in order to define appropriate countermeasures. Data derived from these studies will be applicable to ground-based medicine by further elucidation of homeostatic mechanisms.

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Documents:

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Table 1 Fluid/Electrolyte Experiment Concept Requirements

EXPERIMENT CONCEPTS \ EQUIPMENT REQTS	ANIMAL HOLDING FACILITY	GPWS	ANIMAL CENTRIFUGE	METABOLIC CAGES	SMMI	STORAGE $-10^{o}C/+4^{o}C$	SACRIFICE DISSECTION KITS	TISSUE STORAGE	BLOOD COLLECTION KIT	BLOOD $(+4^{o}C)$ CENTRIFUGE	BLOOD STORAGE $(-10^{o}C/+4^{o}C)$			ULTIMATE SS
CONCEPT 1 07/2/01(A002)	RODENT & PRIMATE	✓		✓	✓	URINE FECES	RODENT & PRIMATE	✓	✓	✓	✓			IMPLEMENTATION OF
CONCEPT 2 07/2/02(A004)	RODENT	✓	RODENT	N=48	✓	URINE FECES	RODENT	✓	✓	✓	✓			WHOLE BODY FLUID COMPARTMENT IMAGING
CONCEPT 3 07/2/03(A004)	PRIMATE	✓	PRIMATE	N=16	✓	URINE FECES	PRIMATE	✓	✓	✓	✓			WITH DIGITAL ENHANCEMENT TECHNIQUES - HUMAN & PRIMATES

SPACE STATION USERS CONCEPT

REFERENCES: (Con't)

A005	Johnston, R.S., Richard S. Johnston & Associates, Inc., Review of Present and Future Trends of Materials Science and Life Sciences Flight Experiments: Part I: Life Sciences, February, 1981.
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A017	Johnston, R.S., Dietline, L.F., Biomedical Results from Skylab, NASA/JSC, 1977.
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A021	Simmonds, R.C., Bourne, G.H., The Use of Non-Human Primates in Space, NASA Conference Publication 005, December, 1974.
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APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Life/Biological/Medical Sciences

TITLE: Metabolism (MMCX-0608)

PRINCIPAL CONTACT: Christopher Cann, Ph.D.

ORGANIZATION: University of California, San Francisco

MMC CONTACT: A. K. Wildgen

PROGRAM OBJECTIVE: The Skylab data indicates that a negative nitrogen balance persists throughout flight without evidence of adaptation even in the longest flight of 84 days. In addition to nitrogen, there was excessive excretion of sodium, potassium, calcium, and phosphorous. Classical metabolic balance studies should be performed over longer duration missions to determine whether changes in these and other important nutrients reach significant negative balance levels as to pose potential hazards to crew health and operational efficiency. The balance studies should be supplemented with determinations of Standard Metabolic Rates. While measurements can be obtained on the crewmembers, animal studies provide greater capability for diet, environment and activity controls and a greater amount of information can be obtained with postflight body composition studies performed on larger numbers of experimental subjects.

Metabolism Experiment Concept 1: 08/1/01 (A001)

Classical balance studies should be performed before flight and periodically during the planned missions. Although desirable, it is not operationally practical to perform a continuous balance study throughout a space station mission. Such studies are feasible from a dietary standpoint since there is a reasonably constant intake of the major mineral and organic nutrients. The very nature of a continuous long duration space station mission suggests that the food will not vary significantly from day to day or month to month in the nutrient content provided. It also seems likely that the crewmembers will eat a similar amount of flight food each day. This will give a prolonged equilibration period which should make shorter collection periods practical, e.g., 7 days. The relatively large 300 mg/day calcium loss predicted from the Skylab data would allow a simpler, less structured study than a classic balance study, since even moderate variations in the intake and excretion rates would not preclude a negative balance of this magnitude from being detected.

Crewmember food will be pre-analyzed and some dietary restrictions may need to be imposed. Urine and fecal samples would be collected over each 7-day period for all crewmembers and they will be returned via Shuttle for analysis.

Equipment Requirements:

- UMS
- Urine and feces storage

Experiment Concept 1 (con't)

Crewtime:

- o Moderate crewtime of all crewmembers to log food and water consumption and to collect and store urine/feces output.

Metabolism Experiment Concept 2: 08/1/02 (A001)

Biochemical and hormonal measurements, e.g., hydroxproline, parathormone and vitamin D metabolites, etc. in plasma or urine will be performed on specimens drawn at selected times before, during, and following the missions. The inflight specimens would be returned to Earth by the STS or stored onboard the space station. Carefully obtained and timed blood samples may be crucial to the understanding of the mechanisms by which calcium loss occurs during space flight. For example, the demonstration of lowered plasma levels of 1,25-$(OH)_2D_3$ at selected times, before, during and after the mission might eliminate or diminish the need to prove calcium loss by balance study. The crewmembers diet will require monitoring and some restrictions imposed. Blood sampling is required on a day prior to Shuttle return. Refrigeration and blood separation as in Skylab might be needed, e.g., the Skylab blood centrifugation system displaced .05 and m^3 and weighed 13.5 kg. A passive freezer box of about .2 m^2 and 50 kg would be practical. Blood samples would need refrigeration at -20 C in a passive freezer. Equipment is already available and various assays are known.

Equipment Requirements:

- o Blood Collection Kit
- o Blood Centrifuge
- o Blood Storage (Passive freezer -20 C)
- o UMS

Crewtime Requirements:

- o Minimal crewtime to log diet and one day to obtain blood samples from all crewmembers (blood draws repeated at TBD intervals).

Metabolism Experiment Concept 3: 08/1/03 (A001)

Countermeasure programs should be evaluated using any of the previous concepts to test utility. NASA has studied countermeasures using multiple bedrest studies. To date, no operationally practical countermeasure has been developed. Because of the new knowledge now available, we can expect new bedrest studies to make therapeutic use of the vitamin D derived substances and even high calcium intakes as potential countermeasures. These approaches have been ruled out for the present because of lack of understanding concerning potential renal stone formation which makes this type of therapy seemingly unacceptable. Until ground-based studies are completed, it would not seem practical to designate a countermeasure for a space station mission. However, this should not preclude accepting experiments which include study of a countermeasure. We can expect that ongoing bedrest studies should be able to designate a practical countermeasure for calcium loss by the time of the space station occupancy.

Experiment Concept 3 (con't)

No new instruments are required unless indicated by a new countermeasure technique.

Equipment Requirements:

- o TBD

Crewtime Requirements:

- o TBD

Metabolism Experiment Concept 4: 08/2/04 (A002)

Species: Rat, Small Primate

Procedures:

Specimens will be maintained inflight in weightlessness and at 1-g in individual metabolism cages. At intervals:

- All specimens will be weighed
- Balance studies will be conducted for 7 days, oxygen, food, and water consumption and urine, feces and carbon dioxide production will be measured, the feces and fresh urine will be collected and preserved, mass measurements of the specimens will be obtained daily, and physical activity recorded continuously.

Equipment Requirements:

- o Rodent holding facility - Metabolic cages
- o Small primate holding facility - Metabolic cages
- o SMMI
- o Animal centrifuge - 1g
- o Gas analysis
- o Fresh feces and urine collection and storage
- o Activity monitoring (continuous)

Crewtime Requirements:

- o Periodic animal maintenance and mass measurements

Metabolism Experiment Concept 5: 08/2/05 (A004)

Typical investigations could include the use of rodents under carefully controlled nutritional conditions to study how metabolic balance is altered during exposure to long-term space flight. The animals (approximately 24) would be maintained in weightlessness, and a second group (of about the same size) would be maintained at one-g (using a centrifuge) to act as a control group. Specimens from both groups would be maintained in individual metabolic cages. At intervals, all specimens would be weighed and 7-day balance studies performed. A typical 7-day balance study would be performed on 12 rats (6 from each group) and include the measurement of oxygen, food, and water

Experiment Concept 5 (con't)

consumption, as well as urine, and carbon dioxide production. The feces and fresh urine would be collected and preserved. The body mass of each specimen would be determined daily during the balance study and physical activity recorded continuously. A typical experiment could last 360 days with four balance studies being performed at 90, 180, 270, and 360 days after launch.

Equipment Requirements:

- o Rodent holding facility - Metabolic cages N=24
- o Animal centrifuge (1g) N=24
- o Gas analysis
- o Fresh feces and urine collection and storage
- o SMMI (daily) N=48

Crewtime Requirements:

- o Minimum of 4 hrs/day each week (4 weeks) of data collection
- o Periodic animal maintenance

Metabolism Experiment Concept 6: 08/2/06 (A004)

A typical metabolic experiment would use primates to study the effects of long-term spaceflight on metabolic balance. The animals (approximately 8) would be maintained in weightlessness, and a second group (of about the same size) would be maintained at one-g (using a centrifuge) to act as a control group. Specimens from both groups would be maintained in individual metabolic cages. At intervals, all specimens would be weighed and 7-day balance studies performed. A typical 7-day balance study would be performed on 4 animals (2 from each group) and include the measurement of oxygen, food, and water consumption, as well as urine, feces, and carbon dioxide production. The feces and fresh urine would be collected and preserved. The body mass of each specimen would be determined daily during the balance study and physical activity recorded continuously. A typical experiment could last 360 days with four balance studies being performed at 90, 180, 270, and 360 days after launch.

Equipment Requirements:

- o Primate holding facility - Metabolic cages N=8
- o Primate centrifuge (1g) - Metabolic cages N=8
- o Gas analysis
- o Urine and feces collection and storage
- o SMMI

Crewtime Requirements

- o Minimum of 2 hrs/day each week of data collection for mass measurements
- o Periodic animal maintenance

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

PROGRAM STATUS: The human metabolic studies can be easily accommodated by the equipment items currently available for shuttle. The nonhuman experiments will require development of a long-duration holding facility and metabolic cages for both rodents and primates. It is assumed that the animal centrifuge will be available for SS since development efforts are currently underway for its implementation on spacelab.

SYSTEM DESCRIPTION: The equipment items required for the metabolic experiments are listed in Table 1. Human data collection activities will occur in the HMF. The nonhuman experiments will be performed in the Life Sciences Research Module (LSRM).

SYSTEM OPERATION: The human data collection activities will occur in the habitability module HMF. Blood draws will be performed by the medical crewmember in conjunction with the routine medical status checks.

The vivarium will be required to support the animal specimens. It is hoped that all non-human data collection will be automated by the metabolic cages and downlinked continuously. Frequent urine/feces collection and storage activities will be required of the crewmember operator.

The shuttle will provide consumables resupply, biological sample return, and subject and equipment changeout as required. Routine facility/module repair/maintenance is anticipated.

SYSTEM INTEGRATION: The human studies can be performed as soon as long-duration missions are initiated with the integration of the HMF in 1990. The non-human studies can be initiated as soon as the LSRM is integrated in 1995. The metabolic cage changeout will occur inflight in the vivarium.

SUBSYSTEM SUPPORT: The experiment equipment items will be located in the pressurized modules, HMF and LSRM, and they will draw power from these facilities. The human data will most probably be in the form of written or voice cassette logs and postflight analyses of biological samples. The nonhuman data will be the animal status and vivarium and cage parameters downlinked continuously.

Table 1 Metabolic Experiment Concept Requirements

EQUIPMENT REQTS / EXPERIMENT CONCEPTS	ANIMAL HOLDING FACILITY	GPWS	ANIMAL CENTRIFUGE	HUMAN BCK	BLOOD CENTRIF. (REFIG.)	FREEZER $-20^{o}C$	STORAGE (AMBIENT TEMP)	METABOLIC CAGES	SMMI	GAS ANALYSIS	REFIG. $+4^{o}C$ STORAGE			
CONCEPT 1 08/1/01(A001)							URINE FECES							
CONCEPT 2 08/1/02(A001)				✓	✓	✓								
CONCEPT 3 08/1/03(A001)					TBD									
CONCEPT 4 08/2/04(A002)	✓		✓					RAT & PRIMATE	✓	✓	URINE FECES			
CONCEPT 5 08/2/05(A004)	RAT		✓ N=24					RAT	✓	✓	URINE FECES			
CONCEPT 6 08/2/06(A004)	PRIMATE		✓ N=8					PRIMATE	✓	✓	URINE FECES			

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

BENEFITS: The primary benefit derived from the metabolic studies will be the definition of human limitations in the space environment and the development of countermeasures to prolong the time man can effectively work in space. Other benefits to the scientific community include elucidation of the role gravity plays in normal metabolic mechanisms on earth to further understand pathologies and their treatment.

The long duration of the SS missions would allow more realistic estimations of metabolic activity following a period of prolonged "adaptation" to the space environment. Currently 7 to 10 day shuttle missions will provide data only on the initial period of adaptation.

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APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

REFERENCES: (Con't)

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APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Life/Biological/Medical Sciences

TITLE: Embryology/Developmental Physiology (MMCX-0610)

PRINCIPAL CONTACT: P. Jackie Duke, Ph.D.

ORGANIZATION: University of Texas - Dental Science Institute

MARTIN MARIETTA CONTACT: A. K. Wildgen

PROGRAM OBJECTIVE: Experiments utilizing amphibian eggs have shown the importance of the gravity vector and acceleration force levels in the normal first cleavage division and in subsequent development. To date, the factors determining the plane of first cleavage division and subsequent bilateral symmetrical development in mammals are unknown. The mechanisms underlying the process of axis formation are basic to the entire process of development. Earth-based studies have shown that critical periods exist for the normal development of each organ system which can be easily disrupted by relatively small environmental changes. In light of such evidence, it is of very high priority within this subdiscipline to study the effects of spaceflight conditions, particularly hypogravity, on the fertilization, development and maturation processes in various animal species. Of particular emphasis will be the study of mammalian development in 0g, since the long range goal is to determine the ultimate feasibility of space colonization. Short-range objectives include the determination of whether animals (single and multiple generations) reared in hypogravity exhibit anatomical, physiological and behavioral patterns adaptive to the new environment. The studies envisioned for space station will require the capability to support large animal colonies and 1g controls inflight for the full duration of each generation's life cycle and ultimately multiple generations.

Embryology/Developmental Physiology Experiment Concept 1: 10/2/01 (A002)

Animal Development

Species: Mouse (20 males, 120 females)

Male and female mice will be maintained inflight in weightlessness and at 1-g. Activity data and video images will be recorded. Females will be weighed and blood samples taken every 3 days. Females will be sacrificed and embryos and fetuses dissected and preserved (approximately every 3 days). Surviving adults and new borns will be returned alive after 60 days for further studies.

Equipment Requirements:

- o Rodent holding facility N=140
- o Rodent centrifuge N=140
- o Video recording system

Experiment Concept 1 (con't)

- o Blood collection kit
- o Blood centrifuge
- o Blood storage (plasma -10 to -20 C, hematocrit +4°C)
- o SMMI
- o Sacrifice/dissection kit
- o GPWS
- o Tissue storage (-50 C to -70 C)

Crewtime Requirements:

- o Crewmember support required every 3 days throughout 60 day mission
- o Periodic animal maintenance

Embryology/Developmental Physiology Experiment Concept 2: 10/2/02 (A004)

Typical investigations could include the use of rodents (mice) to examine questions related to embryological and fetal development as well as to examine questions related to maturation. Male and female mice (approximately 10 male and 60 female) will be maintained inflight in a weightless state. A second group of animals of about the same number will be maintained inflight at one-g using a centrifuge. Activity data and video images will be recorded. Animals from both groups will be mated. Females will be weighed and blood samples taken every 3 days. Approximately every 3 days, females will be sacrificed and embryos and fetuses will be dissected and preserved. Surviving adults and newborns will be returned alive after 60 days for further studies.

Equipment Requirements:

- o Rodent holding facility (mice N=70)
- o Rodent centrifuge (1g; N=70)
- o Video recording system
- o SMMI
- o GPWS
- o Blood collection kit
- o Blood centrifuge
- o Sacrifice/dissection kit
- o Blood storage (plasma -20 C; hematocrit +4 C)
- o Tissue storage (-50 to-70 C)

Crewtime Requirements:

- o Crewmember support required every 3 days throughout a 60 day mission.
- o Periodic animal maintenance

Embryology/Developmental Physiology Experiment Concept 3: 10/2/03 (A004)

This study proposes the use of several species of vertebrates in order to determine how embryological development in the absence of gravity differs in sensitivity among the various species. Approximately 60 tubes of frog eggs, 60 chicken eggs, and 24 pregnant mice will be maintained inflight in weightlessness, and a similar number of each will be maintained inflight at one-g. At 5-day intervals for 30 days, embryos from each group will be sacrificed and preserved. At 30 days survivors will be returned to Earth alive for further studies.

Experiment Concept 3 (con't)

Equipment Requirements:

- Amphibian egg facility
- Fowl egg facility
- Rodent (maternal cage) holding facility
- Animal centrifuges (lg)
  - amphibian eggs (frog)
  - fowl eggs (chicken)
  - rodents (mice)
- GPWS
- Sacrifice/dissection kits
- Tissue storage

Crewtime Requirements:

- A crewperson is required to support experiment operations 1 out of every 5 days throughout the 30 day mission.
- Periodic animal maintenance

Embryology/Developmental Physiology Experiment Concept 4: 10/2/04 (A004)

A typical investigation could include the use of a rodent to examine the successive development of several generations. The animals (approximately 3 male and 18 female rats) would be maintained in weightlessness, and a second group (of about the same number) would be maintained in flight at one-g to act as a control group. Video images of behavior and activity monitoring would be obtained continuously. Upon achieving orbit, selected individuals from each group would be mated. At intervals, all specimens would be weighed, and selected members of the population produced by the previous mating inflight would be mated. Progeny not selected for mating would be sacrificed and preserved. At 270 days, selected members of the first and second generation would also be mated. At 360 days, selected members of the first, second, third, and fourth generation of mating inflight would be returned alive for further studies.

Equipment Requirements:

- Rodent holding facility; (Rats; initial N=21)
- Rodent centrifuge (N=21)
- Video recording
- Maternal cages
- Sacrifice/dissection kit
- GPWS
- Tissue storage

Crewtime Requirements:

- Crewmember support at TBD intervals
- Periodic animal maintenance

SPACE STATION USERS CONCEPT

Embryology/Developmental Physiology Experiment Concept 5: 10/2/05 (B003)

Each experimental group should consist of 1 to 5 male mice and 3 to 5 females. One group will be maintained in normal 0g housing and the second group will be chronically centrifuged at 1g. Mice for null and 1g experiments should be allowed a period of adaptation prior to breeding to obviate stress effects (approximately 30 days). Weights and blood samples can be taken during this time to provide baseline data on hormonal levels and estrus cycles and to accustom the animals to being handled. Animals for these studies must be proven breeders. Since gravitational effects seem to be on developmental timing, timed matings are essential to this project. Every phase of development needs to be investigated, including spermatogenesis and oogenesis. Rather than sacrificing mice rather arbitrarily at three day intervals, selected stages known to be teratogensensitive should be studied. Whole embryos will have to be sectioned and examined, and additional studies need to be carried out on specific tissues such as the limb and the palate. Detailed procedures descriptions are available.

Equipment Requirements:

- Rodent holding facilities (mice N=10+)
- Rodent centrifuge (N=10+)
- Maternal cages
- GPWS
- SMMI
- Tissue storage
- Sacrifice/dissection kit (Dissecting microscope)
- Cell culture centrifuge (optional)
- Tissue preservation kit
- TEM automated tissue processing hardware
- Microscope

Crewtime Requirements:

- Intermittent (TBD) crewmember support, heavy on days of sacrifice
- Periodic animal maintenance

<u>PROGRAM STATUS</u>: The conceptual experiments will require the development of long duration animal holding facilities and cage modules modified to allow some form of nesting behavior (maternal cages). Amphibian egg facilities have already been flown, however, a fowl egg facility will require development. (The Russians are currently developing a quail farm facility to be accommodated on their space station.) It is assumed that the animal centrifuge will be ready for SS since it is currently in development for Shuttle Spacelab.

<u>SYSTEM DESCRIPTION</u>: The equipment requirements for the Embryology/Developmental Physiology experiment concepts are listed in Table 1. All potential studies proposed involve animal subjects, therefore, implementation will require the Life Sciences Research Module (LSRM).

Table 1 Embryological/Developmental Physiology Experiment Concept Requirements

EQUIPMENT REQTS / EXPERIMENT CONCEPTS	ANIMAL HOLDING FACILITY	GPWS	ANIMAL CENTRIFUGE	VIDEO RECORD.	BCK	BLOOD STORAGE	SMMI	SACRIFICE DISSECTION KIT	TISSUE STORAGE	AMPHIB. EGG FACILITY	FOWL EGG FACILITY	MATERNAL CAGES	CULTURE CENTRIFUGE	TISSUE PRESERV. KIT	TEM PROC H/W	MICROSCOPE
CONCEPT 1 10/2/01 (A002)	MICE N=140	✓	✓	✓	✓	✓	✓	✓	✓			✓				
CONCEPT 2 10/2/02 (A004)	MICE N=70	✓	1 g N=70	✓	✓	✓	✓	✓	✓			✓				
CONCEPT 3 10/2/03 (A004)	MICE N=24	✓	✓					✓	✓	✓	✓ N=60	✓ N=60				
CONCEPT 4 10/2/04 (A004)	RAT N=21+	✓	1 g N=21+	✓				✓	✓			✓				
CONCEPT 5 10/2/05 (B003)	MICE N=10	✓	MICE N=10				✓	✓	✓			✓	✓	✓	✓	✓

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

SYSTEM OPERATION: All experiment activities in this subdiscipline will be performed in the Life Sciences Research Module (LSRM). It would be beneficial to have an experienced animal researcher or DVM assigned to the animal care and experiment operations. Most animal status data collection will be automated and downlinked. Biological samples will be obtained for postflight analyses.

The Shuttle will provide consumables resupply, biological sample return, specimen and equipment changeout as required. Routine module/facility repair/maintenance is anticipated.

SYSTEM INTEGRATION: The LSRM is to be integrated in 1995. The studies proposed in this subdiscipline could conceivably be implemented anytime thereafter.

BENEFITS: This subdiscipline requires a space station facility. Animals need time to adapt to 0g (about one month), the gestational period requires another twenty days, and additional time is needed if one wants to investigate maturation at 0g. To investigate changes caused by phenotypic selection pressures of zero gravity, generations of animals need to be raised in the weightless state. Measurements of the animals, as well as surgical and experimental procedures (labeling, drug injection) require attendance by personnel, thereby necessitating a manned facility (B003).

Initially, this program will provide basic information on the relationship of gravity to embryogenesis and evolution. The influence of altered gravity on cellular structure and processes will be detailed. The earth disease osteoporosis is mimicked by 0g effects, and it is likely that other diseases will find comparable models appearing under null gravity conditions. Already, improper hydroxyapatite crystal growth and cross-linking in collagen have been noted. Studies of bone formation in null gravity could enhance understanding, prevention and/or cure of various skeletal problems, such as chondystrophies, nonunioned bone fractures, cleft lip and palate, and bone and collagen diseases such as osteoporosis, osteopetrosis, osteogenesis imperfecta and Paget's disease. Since division and differentiation seem to be altered by altered gravity, a number of processes may be affected including wound healing hematopoiesis, growth of malignancies and aging.

REFERENCES:

No.	Title
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SPACE STATION USERS CONCEPT

REFERENCES: (Con't)

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CONTRIBUTORS:

No.	Name	Organization
B003	P. Jackie Duke, Ph.D.	UT-Houston
B005	Lizabeth Kraft, DVM	NASA/ARC
B013	Muriel D. Ross, Ph.D.	UM-Ann Arbor
B028	Greg Harris, Ph.D.	CU-Denver

SPACE STATION USERS CONCEPT

DISCIPLINE: Life/Biological/Medical Sciences

TITLE: Psychology/Behavior (MMCX-0611)

PRINCIPAL CONTACT: TBD

ORGANIZATION: TBD

MARTIN MARIETTA CONTACT: A. K. Wildgen

PROGRAM OBJECTIVE: The Space Station itself should be designed to maximize the operational efficiency of the crewmenbers. Preliminary efforts are underway to address basic habitability requirements for the SS inhabitants. Relatively little work has been done since the 1950's (army research) and the 1960's (NASA manned systems research) in the definition of the optimal human work and habitation environments. Now that a great deal more information is available with regard to the physiological changes in space flight, it is time to reassess the crew systems support requirements in light of these physiological changes. The health and sense of well-being of the crewmember necessarily affects the work performance of the individual. Ground-based research should be performed prior to the design of the station itself to further define "optimal" work and living environments. However, the study of crew interactions, and inflight capabilities over the long-term may not be possible until actual implementation of long-duration SS missions. The types of issues which require study include changes in perception due to weightlessness; stresses of high density living quarters, isolation, changes in environment and schedules, and high work loads; and the normal everyday group dynamics and personality conflicts. Research in this area will aid in developing optimal group composition (skill and personality mixes), work schedules, tools and crew support systems, and recreational provisions in order to achieve high performance levels inflight. Preliminary data (unpublished, personal communication) have shown promising results in the search for a solution of space sickness by preflight behavioral modification training. Continued work in these areas seems warranted.

Psychology Experiment Concept 1: 11/1-2/01 (A006)

Specifically, it must be determined how a range of g fields which could be realistically implemented with the SS (e.g. 0, 0.2, 0.5, and 1.0) affect performance levels over extended time periods. These experiments would be carried out with both human subjects and animals using a variety of learned (e.g. classical and instrumental conditioning techniques) and unlearned (e.g. activity level measures) behavioral assessment procedures. In addition, technologically advanced psychophysical methodologies would be employed to determine changes in levels of sensory-motor function. The validity, reliability, sensitivity, and comparability of such performance assessment procedures have been convincingly demonstrated in behavioral pharmacology and behavioral physiology laboratories over the last decade.

SPACE STATION USERS CONCEPT

Equipment Requirements:

- Animal holding facility
- Animal centrifuge (0 to 1.0g)
- TBD

Crewtime Requirements:

- TBD

Psychology Experiment Concept 2: 11/1/02 (A006)

An issue which requires consideration is how basic behavioral assessment procedures and other life sciences studies can be integrated within the frame work of a comprehensive programmed environment concept approach to a dedicated habitability module which could be realistically implemented with the SS configuration. In addition to the standardized learned and unlearned performance evaluation and psychophysical assessment procedures, these experiments would explore the application of a total and continuous "life space" program within the context of an integrated work and habitability model. This approach would provide for objective measurement and quantification of individual and social adjustment patterns (e.g. frequency and duration of social episodes, social distance measures, etc.) which have been developed in recent ground-based studies with small human groups under confined micro-society conditions.

Equipment Requirements:

- TBD

Crewtime Requirements:

- TBD

PROGRAM STATUS: Relatively little work has been done on the psychological and operational impacts of the environment on the human since the 1950's. Currently a mass perception experiment is planned for Spacelab 1 and some behavioral modification work is being conducted by the military - USAF (G. West) and NASA/JSC (P. Cowings) to attempt to alleviate the space sickness problem. A great deal of preliminary work remains to be done regarding:

1) The optimization of crew size and composition for maximal SS operational efficiency and social harmony.

2) Alleviation of psychological/morale problems associated with cramped living conditions, close and continuous work interactions, heavy and stressful work schedules, biomedical problems, long duration isolation from loved ones and friends, unfamiliar diet, etc.

3) Optimization of habitability and work areas for maximal efficiency.

4) Human-factors engineering of support systems and tools.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

SYSTEM DESCRIPTION: No special needs are anticipated for this discipline which would require expanded SS capabilities. If adequate preliminary research is conducted, the evolution of the SS itself can be optimized to fulfill the needs of its human inhabitants.

Any psychological/behavioral testing on humans would best be performed in the HMF under supervision of the medical crewmember. All non-human experiments must be accommodated by the Life Sciences Research Module (LSRM). The suggested equipment items for this subdiscipline are listed in Table 1.

SYSTEM OPERATION: Since the techniques to be employed in this subdiscipline are not yet defined, operational requirements cannot be fully discussed here. Perceptual or performance experiments may require experiment-specific instrumentation with possible downlink of video/voice/data. All nonhuman activities will occur in the Life Sciences Research Module.

The crewmembers will serve as both operators and subjects for the human experiments and a trained payload specialist will be required to perform the animal experimentation.

The Shuttle will serve to resupply consumables and to return data for earth-based analyses. Routine repair/maintenance of the HMF and LSRM are anticipated.

SYSTEM INTEGRATION: As soon as the HMF is operational in 1990 and all crewmembers are assigned to long duration stay times, the psychological testing should begin. The animal experimentation can begin as soon as the LSRM is integrated in 1995.

SUBSYSTEM SUPPORT: All equipment items will be located in the pressurized modules, HMF or LSRM, and they will draw power from these facilities. Data management strategies will be dependent upon the experiment-specific requirements.

BENEFITS: A great number of benefits will be derived from the early implementation of a psychological research program both in support of SS and aboard SS. Optimization of crews for maximal efficiency of SS operation is a readily apparent goal. In addition, the use of behavioral modification techniques appears to provide a viable alternative to pharmaceutical intervention for space sickness. The subsequent study of SS crewmembers in the constrained and isolated conditions of SS will be directly relevant to earth-based situations such as isolated research bases, oil rigs, military bases and submarine and naval ship crew selection. The technology derived from the SS design for optimal efficiency and human compatibility will also be relevant to the design of the above work places.

Table 1 Psychology Experiment Concept Requirements

EXPERIMENT CONCEPTS \ EQUIPMENT REQTS	ANIMAL HOLDING FACILITY	GPWS	ANIMAL CENTRIFUGE												
CONCEPT 1 11/1-2/01(A006)	✓		✓	--	TBD	--									
CONCEPT 2 11/1/02 (A006)	--	TBD	--												

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

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CONTRIBUTORS:

No.	Name	Organization
B001	Richard Johnston	Texas Medical Ctr., Inc.
B004	C. Herb Ward, Ph.D.	Rice University
B021	W. Carter Alexander, Ph.D.	USRA - Brooks AFB

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Life/Biological/Medical Sciences

TITLE: Radiation Biology (MMCX-0612)

PRINCIPAL CONTACT: Lisabeth Kraft, DVM

ORGANIZATION: NASA/ARC

MMC CONTACT: A. K. Wildgen

PROGRAM OBJECTIVE: Cosmic radiation is a serious concern for long-duration space flight missions. Preliminary data (unpublished, personnel communication) have shown that primates exposed to 55 MeV levels have had a higher mortality rate from gliomas approximately twenty years after the time of exposure. Those exposed to 2000+ MeV levels did not exhibit the same propensity for tumor development. The ambient radiation levels during solar flare activity is in the range of 35 to 50 MeV. The risk to space station inhabitants should be addressed by first characterizing the cosmic radiation environment of the space station, determining the actual risk to living systems, and assessing the effective levels of shielding. The suggested means of assessing the radiation risks include the use of animal systems to determine tumor development, cataracts incidence, mutogenic or transformation effects, life span deviations, and cell loss of non-dividing cells. The research is of very high priority, and a great deal of the work can be performed on earth. The conceptual experiments proposed could be implemented on space station to verify the earth-based research findings.

Radiation Experiment Concept 1: 12/2/01 (A004)

Typical investigations could include an examination of the effect of radiation exposure, during long duration space flight, upon the rodent. The animals (approximately 100 mice per treatment) will be maintained in weightlessness with nominal shielding, 2 x nominal shielding, and 4 x nominal shielding. A second group (of the same number of specimens and treatments) will also be maintained inflight at one-g using a centrifuge. Active dosimeters will record HZE particle flux. At 180 days, all specimens will be returned alive for further studies.

This study should be flown at 28.5° to 57° inclination and again at 75° to 90°.

Equipment Requirements:

o Rodent holding facility	N=300 mice
- nominal shielding	n=100
- 2x nominal shielding	n=100
- 4x nominal shielding	n=100
o Animal centrifuge (1g)	N=300 mice
- nominal shielding	n=100
- 2x nominal shielding	n=100
- 4x nominal shielding	n=100
o Active dosimeters	

Experiment Concept 1: (cont)

Crewtime Requirements:

- o Periodic maintenance of animal facilities.

Radiation Biology Experiment Concept 2: 12/2/02 (A002)

This conceptual experiment proposes examination of the effect of radiation exposure, during varying durations of space flight, upon nondividing cells (such as nerve cells and photoreceptors) of the rodent. The animals (approximately 100 mice per treatment) will be maintained in weightlessness with nominal shielding, 2 x nominal shielding, and 4 x nominal shielding. A second group (of the same number of specimens and treatments) will also be maintained inflight, at one-g, using a centrifuge. Active dosimeters will record HZE particle flux. At 730 days, all specimens will be returned alive for further studies.

This study should be flown at 28.5° to 57° inclination and again at 75° to 90°.

Equipment Requirements:

o Rodent holding facility	N=300 mice
- nominal shielding	n=100
- 2x nominal shielding	n=100
- 4x nominal shielding	n=100
o Animal centrifuge (1g)	N-300 mice
- nominal shielding	n=100
- 2x nominal shielding	n=100
- 4x nominal shielding	n=100
o Active dosimeters	

Crewtime Requirements:

- o Periodic maintenance of animal facilities.

SYSTEM DESCRIPTION: The animals will be maintained in the vivarium located in the Life Sciences Research Module (LSRM). Equipment requirements are minimal for the conceptual studies in this subdiscipline. A listing of instrumentation is provided in Table 1.

SYSTEM OPERATION: Animals will be maintained in the vivarium for long duration missions (suggested 180 days and 730 days) and returned via shuttle for postflight testing and analyses. It is anticipated that the holding facility will be automated, requiring little crewmember interaction. A DVM or experienced animal researcher should be assigned to the animal care operations. The shuttle will supply consumables at periodic intervals and specimen return at the conclusion of the experiments.

SYSTEM INTEGRATION: This study could be implemented as soon as the LSRM is operational in 1995. It was suggested by the external reviewers to postpone the implementation of the proposed studies to later in the SS era following extensive ground-based research.

Table 1 Radiation Biology Experiment Concept Requirements

EQUIPMENT REQTS / EXPERIMENT CONCEPTS	ANIMAL HOLDING FACILITY	GPWS	ANIMAL CENTRIFUGE	ACTIVE DOSIMETERS										
CONCEPT 1 12/2/01 (A004/ A002)	N=300 MOUSE		N=300 ✓	✓	SHIELDING OF HOLDING CAGES NOMINAL, 2X AND 4X									
CONCEPT 2 12/2/02 (A004/ A002)	N=300 MOUSE		N=300 ✓	✓	" " " " " "									

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

SUBSYSTEM SUPPORT: The animal holding facility will require power support from the Life Sciences Research Module. The vivarium parameters and animal status data should be downlinked continuously.

BENEFITS: The primary benefit of this study is the establishment of hazards/limitations to crewmembers due to the radiation environment of the SS. If appropriately designed and implemented, this study program will provide guidelines as to adequate shielding levels for spaceflight. The information will be a valuable contribution to earth-based research programs concerned with the environmental factors associated with cancer. The primary benefit the SS provides to this study is the long duration (180 and 730 days) missions which cannot be accommodated by the Spacelab.

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Documents

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A005	Johnston, R. S., Richard S. Johnston & Associates, Inc., Review of Present and Future Trends of Materials Science and Life Sciences Flight Experiments: Part I: Life Sciences Considerations for Space Station, September 14, 1982.

Contributors

No.	Name	Organization
B005	Lisabeth Kraft, DVM	NASA/ARC
B020	Bill Williams, Ph.D.	NASA/ARC
B021	W. Carter Alexander, Ph.D.	USRA-Brooks AFB

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Life/Biological/Medical Sciences

TITLE: Basic Space Biology (MMCX-0614)

PRINCIPAL CONTACT: Richard S. Johnston

ORGANIZATION: Texas Medical Center, Inc. - Houston

MMC CONTACT: A. K. Wildgen

PROGRAM OBJECTIVE: The Basic Space Biology subdiscipline is concerned with the role of gravity in shaping the form and function of living systems. The three major areas of concern are: (1) the role of gravity in development, (2) the study of gravity receptor mechanisms in both plants and animals, and (3) the physiological effects of gravity. The unique conditions of space flight are utilized for basic research concerning the effects of hypogravity on growth, reproduction, behavior, morphology, biochemistry and genetics of a wide variety of organisms. Information is sought concerning the role of gravity in microscopic organisms' life processes, tissue cultures, genetics at the subcellular and molecular levels, and interspecies differences in their adaptive capabilities to the space flight environment. The basic space biology activities will allow the probing of interesting phenomena which will result in more knowledge and additional questions to be posed concerning the role of gravity in the evolution of life as we know it on earth.

Basic Space Biology Experiment Concept 1: 14/2/01 (A006)

Gravity and body size interact strongly. Experiments are needed on groups of animals representing a considerable range of mass, and comparisons should be made between quadrupeds and bipeds, as well as between birds and mammals (the two types of homeotherms). For example: mouse (0.03 kg), hamster and coturnix (0.11 kg), rat (0.30 kg), rabbit and chicken (2-4 kg), and dog and monkey (10 kg) represent the range of specimens needed. Results will establish scale factors in gravitational physiology of homeotherms necessary for relating results of animal experiments to human data.

Experiments are needed at several g-levels. In addition to those at 1 g, there should be studies at 1.5 g and 2.0 g on centrifuges on Earth, at 0.2 g, 0.5 g, and 1.0 g on centrifuges in space, and the all important control, nominal "zero g". Typical observations and measurements to be made in hypogravity include:

1) Body mass determinations and nutritional balances at weekly intervals.

2) Urinary concentrations of creatine, creatinine, hydroxyproline, 3-methylhistidine.

3) Respiratory metabolism, heart rate and body temperature as indicators of circadian rhythms.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

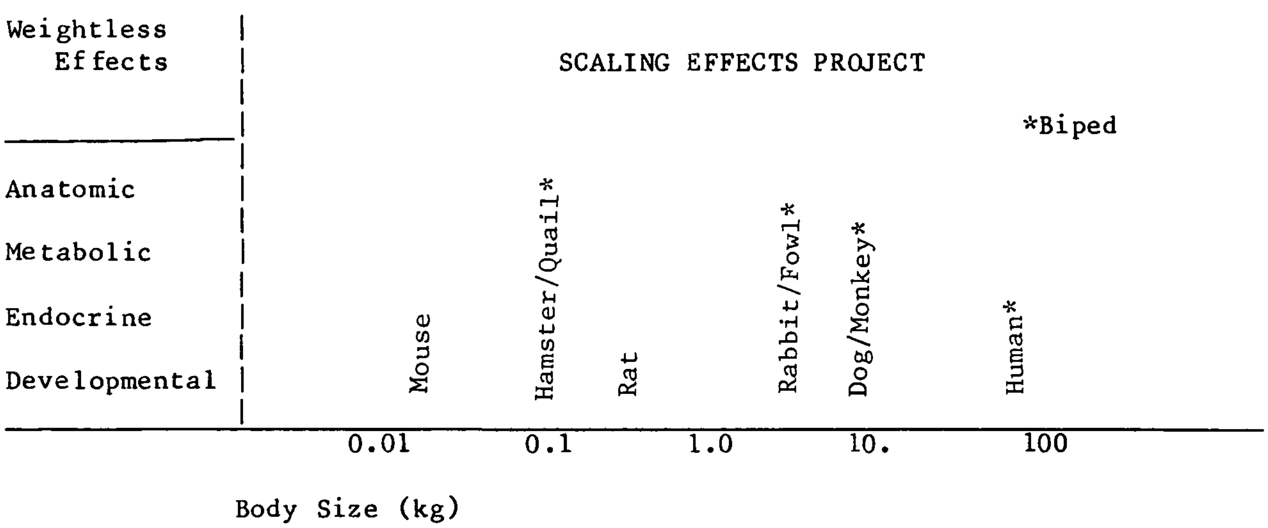
Experiment Concept 1 (con't)

4) On animals sacrificed at intervals: Hematology, plasma composition, and bone histology.

5) Fluid and electrolyte shifts to reveal redistribution of body fluid to the thoracic and head regions as occurs in animals and humans.

After space flight, the remaining animals will be returned to the 1 g laboratory for intensive study of deadaptive and/or readaptive changes.

These measurements of progressive changes under weightlessness or at different levels of hypogravity (0 to 1g) need not be done on all animals simultaneously. Changes induced by weightlessness would indicate perturbations of processes or organismic components that probably could be identified specifically. Subsequent experiments would follow-up such leads and allow investigators to evaluate and understand the mechanisms responsible for the adaptive and important pathological effects of spaceflight.



Equipment Requirements:

- o Rodent holding facility
- o Fowl holding facility
- o Canine holding facility
- o Primate holding facility
- o Animal centrifuge
  - multiple species
  - multiple g (0.2, 0.5, 1.0g)
- o SMMI
- o Urine collection
- o Urine storage
- o Biotelemetry system
- o Blood collection kit
- o Blood centrifuge
- o Blood storage

SPACE STATION USERS CONCEPT

Experiment Concept 1 (con't)

- o Sacrifice/dissection kit (multiple species)
- o Tissue storage
- o GPWS

Crewtime Requirements:

- o Periodic mass measurements, blood draws and holding facility maintenance
- o Heavy on days of sacrifice.

Basic Space Biology Experiment Concept 2: 14/2/02 (A006)

Basic questions on the role of gravity in evolution and physiology could be answered by animal experimentation (e.g. g effects on the complete life cycle of one or more typical homeotherm species, viz. sperm and egg production, fertilization, embryogenesis, birth, rearing of neonates (maternal and litter behavior), growth and development, and reproduction).

Equipment Requirements:

- o Holding facilities
  - Multiple species (rodents, primates, fowl)
  - Maternal cages
- o GPWS
- o SMMI
- o Incubators
- o Tissue extraction & preservation kits
- o Sacrifice/dissection kits
- o Centrifuge - animal
- o Centrifuge - blood
- o Tissue storage
- o Blood storage
- o Blood collection kit
- o Blood centrifuge

Crewtime Requirements:

- o TBD

PROGRAM STATUS: The long-duration holding facility for multiple species will require development. Holding facilities for canine and fowl specimens are not currently planned and they will require development. The animal centrifuge is planned for Shuttle Spacelab and its assumed that the system will be easily modified for SS.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

SYSTEM DESCRIPTION: The equipment items required to support the Basic Space Biology conceptual experiments are listed in Table 1. These non-human experiments proposed will be supported by the vivarium and Life Sciences Laboratory Facility (LSLF) on the Life Sciences Research Module (LSRM).

SYSTEM OPERATION: All experiment activities will occur in the LSRM. It is preferred by the investigators to assign a crewmember with extensive animal research experience (PhD or DVM) to the experiment operations. All animal status and vivarium information should be downlinked continuously.

The shuttle will provide consumables resupply, biological sample and data return, and equipment and specimen changeout as required. Routine module/facility repair/maintenance is anticipated.

SYSTEM INTEGRATION: These conceptual experiments could conceivably be implemented when the LSRM is integrated and operational in 1995. The suggested integration time for the experiment-specific equipment items is the later "evolutionary" to the early "mature" phase of the SS since holding facilities for canine and fowl specimens are not currently planned, and the long-duration animal support capability for these species will require development.

SUBSYSTEM SUPPORT: The equipment items and holding facility will require power support from the Life Sciences Research Module. The vivarium parameters and animal status data should be downlinked continuously.

BENEFITS: The basic research questions posed within this discipline are too numerous to address individually here. In general, basic research, while answering a number of challenging and interesting hypotheses, will generate more questions than those answered. By pursuing such lines of inquiry, our understanding of the space environment, and thus the Earth environment, will be increased and possible solutions as to our origins and evolution generated. In exploring the possible influences of the space environment on biological organisms, the potential for exploitation of that environment in commercial ventures is increased in such areas as electrophoretic separation, genetic engineering and pharmaceutical manufacturing.

Table 1 Basic Space Biology Experiment Concept Requirements

EQUIPMENT REQTS / EXPERIMENT CONCEPTS	ANIMAL HOLDING FACILITY	GPWS	ANIMAL CENTRIFUGE	SMMI	STORAGE	BTS	BCK	BLOOD STORAGE	SACRIFICE DISSECTION	TISSUE STORAGE	INCUBATORS	MATERNAL CAGES	BLOOD CENTRIFUGE	
CONCEPT 1 14/2/01 (A006)	*	✓	*	✓	URINE	✓	✓	✓	✓	✓			✓	*RODENT, PRIMATE, FOWL
CONCEPT 2 14/2/02 (A006)	*	✓	*	✓			✓	✓	✓	✓	✓	✓	✓	AND CANINE FACILITIES

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

REFERENCES:

Documents

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Contributors

No.	Name	Organization
B001	Richard S. Johnston	Texas Medical Ctr, Inc.
B005	Lisabeth Kraft, DVM	NASA/ARC
B023	Richard Radmer	Martin Marietta Laboratories

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Life/Biological/Medical Sciences

TITLE: Controlled Environment Life Support Systems - CELSS (MMCX-0615)

PRINICPAL CONTRACT: Richard Radmer, Ph.D.

ORGANIZATION: Martin Marietta Laboratories - Baltimore

MMC CONTACT: A. K. Wildgen

PROGRAM OBJECTIVES: The ultimate goal of the Controlled Environment Life Support System (CELSS) research program is the development of a closed (or semi-closed) ecological life support system to be implemented aboard a future space station. Current research in this subdiscipline has been focusing upon several areas: (1) Control Systems technology, (2) Waste Processing including regeneration of atmospheric gases and potable water, and (3) conventional (plants) and unconventional (algae) Food Production.

1) Control Systems: (CELSS Workshop Chairman - Auslander)

In the area of Control Systems, development research is focused upon: (a) data systems for state estimation, and (b) control and data systems and systems analysis technology for a space-based operational CELSS.

The development efforts for state estimation are oriented toward acquisition of knowledge and understanding of each of the individual systems components. This development scheme involves the study of various models at various aggregate levels and control designs assessed to select the most suitable aggregate level for implementation. The driving payload for space station will be a fully operational CELSS (not fully closed) for a minimum of 2 people with an "escape hatch" feature for contingency system failures. The SS will serve as a test bed for the development of technologies to achieve this test system. Activities required to meet this goal will be the development of: (1) general purpose instruments for the most economical means of changeout and repair as required; (2) automated techniques of organic and inorganic chemical analyses of liquids and gases to evaluate, on a very high speed feedback control loop, trace chemical buildups; (3) new instrumentation concepts to quantitatively characterize the state of the biological system (particularly the human) for model optimization; and (4) control systems testing to define CELSS design and evolution. These activities will necessarily include extensive plant experimentation such as 0g effects on growth and physiology, light requirements, batching effects on system stability, weight and volume cost effectiveness, etc. (see Space Station User's Concept - Botany). Assessments of system size and storage requirements will include determination of consumables resupply requirements in light of probablistic parametric studies of contingency failures and system reliability. The sizing of the system also requires study and demonstration since the control system design changes with the biological system occupancy.

PROGRAM OBJECTIVES: (cont)

2) Microbes and Unconventional Food Sources: (CELSS Workshop Chairman - Dave White)

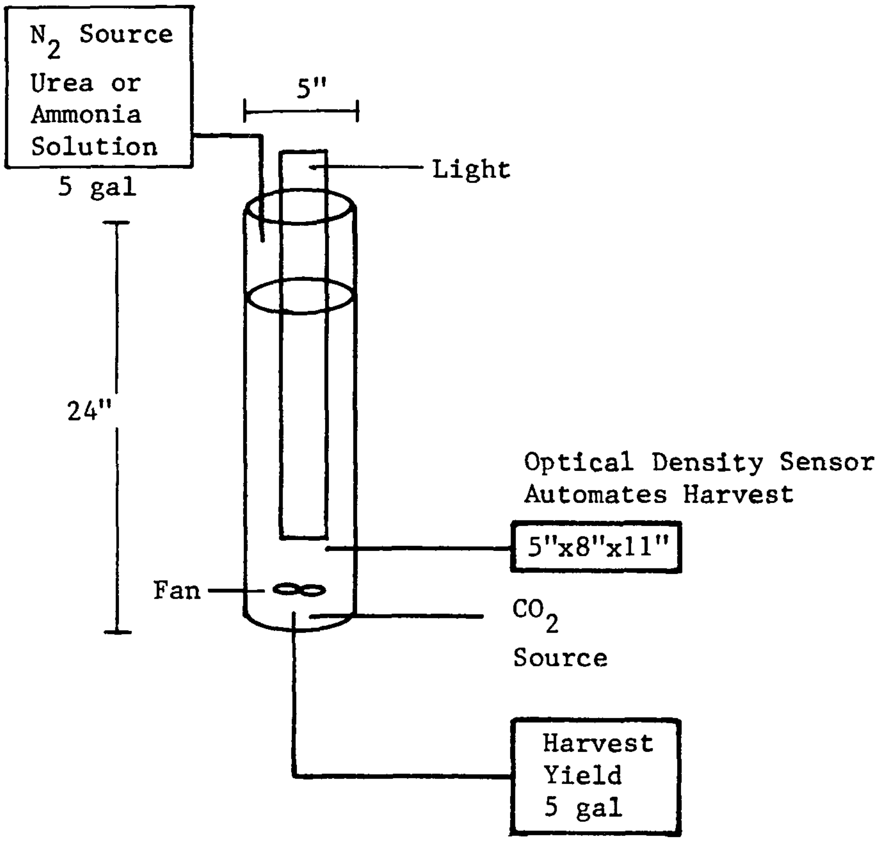
The working group on microbes and unconventional food sources addressed: (a) the problems of biological waste processing (anaerobic and aerobic systems), (b) alternative means of short-circuiting the waste-to-food cycle, and (c) the relation of microbes to plants. A number of alternative means of producing food directly from waste were suggested for testing on SS, including biological systems such as goats, fungi, termites and fish. Plants and algae currently appear to be the most reasonable alternative. However, the waste will require processing prior to introduction to the plant/algae system since sodium tends to accumulate in closed systems and plants are sensitive to excessive sodium. Heavy metals will also require removal from the system.

Botany investigators anticipate using the normal flora found here on earth, however problems may exist with that level of contamination inflight. The flora on one hand could be used as indicators of culture problems, yet the microbes could in turn wipe out the entire plant colony and upset the system balance. Research in this area should address microbial contamination of nutrient solutions, modifications of the edible portion of plant(s), environment sterility requirements, and rapid monitoring methods.

The driving SS payload suggested by this group was the concept verification of a pilot waste processing system designed to support three crewmembers. In order to achieve this "pilot plant," earth-based development systems must be tested in the space environment on shuttle or in the SS, plant experiments must establish optimal species for incorporation, and the staged verification of the fermentation process should be accommodated on the SS with systems from one liter to one-hundred liters. Pigs could be used for the verification testing since their gastrointestinal systems are similar to humans.

3) Algae Research: (CELSS Workshop Chairman - Richard Radmer)

The algae research activities are oriented toward the study of the organisms themselves and the support hardware development. The organism research will establish the optimal species for SS CELSS incorporation based upon its nutritional composition, productivity and yield, palatability and processing requirements. The hardware development activities are directed toward establishing system requirements (light sources, photoperiod, wavelength, gas control and monitoring), fluid handling and system operation in 0g, component testing and staged integration, resulting in a concept feasibility demonstration of a full-scale SS operational algae culture system.



Dick Radmer's Current Algae Setup (MML)

- System 0g Incompatible-Flow Gravity Dependent and CO_2 Bubbles Won't Rise.
- System Limited by Engine Life & Not the Biological System.
- Genetic Engineering - Protein Content & Lipid & Carbohydrate Content of Algae.

Figure 1 Algae System Setup

PROGRAM OBJECTIVES: (cont)

4) Plant Growth: (CELSS Workshop Chairman - Huffaker)

The plant system survivability is totally dependent upon the ability to control and monitor the environment. Inorganic and organic chemical analyses techniques and instrumentation will require development, as will the aeroponics technology. The driver facilities for SS will be plant growth module(s), a manned propagation facility, and a plant harvesting and processing laboratory.

CELSS Experiment Concept 1: 15/2/01 (A004)

Typical investigations could include the assessment of any morphological and nutritional variations of higher edible plants grown in weightlessness by measuring plant biomass, nutritional composition, and by microscopic characterization of the structural anatomy of plant organs, tissues, and cells. This investigation should be coordinated with independent plant biology investigations. Seeds of two edible species (lettuce and radish) will be planted and maintained dry in flight. At intervals, some seeds of each species will be automatically wet with a nutrient solution. These seeds will be maintained in an automated, lm growth chamber, at zero-g, for the duration of the flight. All plants will be returned to earth after 90 days, for further studies. Various developmental stages would thus be available to ascertain whether any morphological changes occur in zero-g and whether nutrient compositions of these higher plants differ in zero-g as compared to one-g.

Equipment Requirements:

Plant Growth Chamber (automated) lm

Crewtime Requirements:

None

CELSS Experiment Concept 2: 15/2/02 (A004)

The testing of interactions of biological systems with the spacecraft environment is proposed by measuring plant harvest biomass, dissecting and preserving plant specimens for microscopic analysis of development, and monitoring gas and nutrient recycling. Two or more species of edible plants (bean, sweet potato, others) will be grown from seed in an automated, lm growth chamber, for 90 to 120 days, depending on the species. The growth chamber environment will be monitored to allow a control system to maintain homeostasis, a process that will simultaneously permit continuous monitoring of the fundamental metabolism of the plants. The environment will be purposefully altered from time to time, to determine the characteristics of the biological responses observed. Plants will be thinned, oriented, harvested, dissected, and preserved at various stages of development. The

CELSS Experiment Concept 2: (cont)

water transpired by the plants will be collected, purified, and used to make nutrient solutions. Gas exchange phenomena, pH, and conductance of the nutrient solution will be measured continuously. Samples of the nutrient solution will be obtained twice daily and frozen for later analysis. Seeds from plants grown in flight will be planted to obtain second-generation plants. The investigation should thus provide information or answers to several questions concerning whether recycling-process techniques require alterations to zero-g, whether any morphological variations occur and to what extent these variations will affect harvesting techniques in zero-g, whether the nutrient compositions of these plants will be altered, and whether the capability to control plant development will be any different in zero-g as compared to one-g.

Equipment Requirements:

- o Plant Growth Unit - Continuously monitored, automated
- o GPWS
- o Dissection/tissue preparation kit
- o Nutrient sample storage (-10 to -20 C)
- o Harvesting and storage system
- o Planting/repotting supplies

Crewtime Requirements:

TBD

CELSS Experiment Concept 3: 15/2/03 (A004)

The assessment of algal growth physiology in zero-g is proposed by measuring the chemical characteristics of these single-celled organisms and their nutrient solution. A one-liter, sterile liquid culture medium will be inoculated with Chlorella cells inflight. The culture will be purged continuously with an air-CO_2 mixture. Light will be provided to permit photosynthetic growth. A continuous or intermittent addition of fresh nutrient medium will be balanced by the removal and preservation of medium and cells for later analyses. Cell number and chlorophyll content will be monitored continuously. Volatile organic compounds will be trapped for subsequent analyses. After 30 days the experiment will be terminated. The investigation will provide a means to assess whether algal culture and harvesting techniques appropriate on Earth will be applicable in space, and whether the nutritional composition of the algae differs or remains similar to that found on Earth.

Equipment Requirements:

- o Algae growth chamber
- o Biochemical analysis system/kits
  - algal analysis (nutritional composition)
  - medium analysis
  - volatile organic compounds analysis

CELSS Experiment Concept 3: (cont)

Crewtime Requirements:

- TBD
- Organic/inorganic chemist preferred

CELSS Experiment Concept 4: 15/2/04 (A007)

The CELSS Control System working group, chaired by Dr. D. M. Auslander (UC - Berkeley), has proposed the need for research in two areas (1) Control/Data Systems and (2) State Estimation Data Systems. Most work will be ground-based with occasional STS flights to verify 0g operation of systems at various system aggregate levels. The control systems technology verification missions will be implemented on SS prior to and in conjunction with CELSS experiment concepts 15/2/05, 06, and 07.

Equipment Requirements:

TBD

Crewtime Requirements:

TBD

CELSS Experiment Concept 5: 15/2/05 (A007)

The CELSS Plant Working Group, chaired by Dr. R. C. Huffaker (UC - Davis), proposed a $6m^2$ modular plant growth facility as the driving payload for space station. The modules will be adaptable to the plant species selected and totally automated. Preliminary shuttle experiments will define the system for ultimate implementation aboard SS. The system will control and monitor light levels, photoperiods, gas composition, temperature, relative humidity, nutrient solution composition and pH. Plant monitoring will also be automated to measure respiration, photosynthesis, and transpiration rates. The laboratory facility will provide the means for manned implementation of the propagation, harvesting and plant processing operations.

Equipment Requirements:

- Plant growth facility - $6m^2$
- GPWS (multiple)
- Propagation and processing system/kits
- Harvest storage

Crewtime Requirements:

- 1 day wk for experiment operations
- Heavier on harvest, propagation days which will be dependent upon the selected plant species.

SPACE STATION USERS CONCEPT

CELSS Experiment Concept 6: 15/2/06 (A007/B023)

The CELSS Unconventional Food Source working group, chaired by Dr. Richard Radmer (Martin Marietta Laboratories) have proposed multiple flights to test the feasibility of zero-g algae culture systems. The current ground-based laboratory system is zero-g incompatible.

The zero-g concept will be demonstrated with a man-tended facility (60-100 l) aboard the mature SS. Beyond the year 2000 it is anticipated that an algae culture system will be incorporated in a semi-closed environmental life support system aboard SS to maintain 2 to 3 crewmembers. This facility will be a feasibility demonstration for implementation in the design of future (year 2000+) space stations.

Equipment requirements:

Algae culture system: fan, light, optical density sensor, CO_2 source, N_2 source, harvest storage, automated chemical analyses.

Crewtime Requirements:

If the chemical analyses are not automated, a chemist (organic and inorganic) will be required for periodic analyses of algae, nutrient solution, and gas output compositions.

CELSS Experiment Concept 7: 15/1-2/07 (A007)

The CELSS Workshop Waste Processing working group, chaired by Dr. David White (Florida State University), has suggested a technology feasibility demonstration of a pilot waste processing plant designed for three crew members. The system would consist of a 100 liter anaerobic fermenter into which water, feces and urine would be input, and a 50 liter aerobic fermenter with a membrane ultrafilter. The aerobic fermenter would require an oxygen source and an outlet for methane. Continuous monitoring of O_2 and pH would be required.

Equipment Requirements:

- Waste Processing Plant (automated control/monitoring)
- Support computer and display station

Crewtime Requirements:

- Operation and monitoring will be primarily automated.

Table 1 CELSS Experiment Concept Requirements

EXPT Concepts \ Equipment	Plant Growth Chamber	GPWS	Plant Centrifuge	Dissection and Tissue Prep Kit	Nutrient Sample Storage -10 to -20°C	Harvest Storage	Planting and Repotting System	Algal Culture System	Chemical Analysis	Waste Processing System
Concept 1 15/2/01 (A004)	1 m^2 Automated					All Analysis Postflight				
Concept 2 15/2/02 (A004)	1 m Automated	√		√	√	√	√			
Concept 3 15/2/03 (A004)		√						√	√	
Concept 4 15/2/04 (A007)	TBD (Control & Data Systems)									
Concept 5 15/2/05 (A007)	6 m^2	√		√		√	√		√	
Concept 6 15/2/06 (A007) (B023)								√		
Concept 7 15/2/07 (A007)										√

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

SYSTEM DESCRIPTION: Individual components and simple model demonstrations will be implemented onboard Shuttle and the early (evolutionary) SS to test techniques and concepts feasibility. In the evolutionary phase of SS various levels of aggregate control systems and alternative control system designs will be tested. On the mature SS a pilot waste processing plant will be tested in addition to a larger plant growth facility (1m to 6m) and an algae culture system. The driving payload for implementation on the "ultimate" SS (beyond the year 2000) is the 2 to 3 crewmember CELSS feasibility demonstration. This facility will incorporate an "escape hatch" feature for emergency contingencies.

PROGRAM STATUS: Research is currently funded by NASA/HQ in four major areas: (1) controls and data processing, (2) plant physiology and development in controlled environmental systems, (3) algae, and (4) bacteria. Boeing Company (J. Olson) has been funded to perform ongoing "Breakeven Analyses" as the systems become better defined.

SYSTEM OPERATION: The plant growth systems will initially be accommodated in the Life Sciences Research Module vivarium. Any manned interaction (plant manipulations and/or biochemical analyses) will be performed in the Life Sciences Laboratory Facility. As the larger plant growth modules ($6m^2$) are developed, additional pressurized modules may be required to support growth, harvesting and processing which will require manned interaction.

The pilot waste processing plant and the CELSS test system will operate continuously throughout each test/mission. Fulltime monitoring may be required initially by either the crewmembers or the ground support crew. The crewmembers will serve as system operators of the CELSS demonstration.

The Shuttle will provide consumables resupply as required until the CELSS is fully operational (ultimate SS) at which time resupply visits will diminish in frequency. Routine equipment repair/maintenance/changeout is anticipated.

SYSTEM INTEGRATION: Staged integration of test systems will be scheduled. Most experimentation will occur in the Life Sciences Research Module which will be integrated in SS in 1995. The large plant growth modules (6 m^2) and the 2-3 crewmember CELSS will be integrated in the mature SS after the year 2000.

SUBSYSTEM SUPPORT: Research efforts will attempt to minimize the size and power requirements of the CELSS demonstration payload which are yet TBD. The data management strategies for the control systems are also yet to be determined and estimates will be derived with continued research. At this time, it is suggested that the data be downlinked continuously for the principal investigators.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

BENEFITS: The desire for a long-duration manned space facility is the driver for a closed environment life support system. Potential benefits derived from the technology development efforts include commercial production of agricultural products in earth-based controlled environment facilities. (An environmentally controlled lettuce facility is currently operational in Austria.) By optimizing food production, the earth-based applications in agriculture are self-evident. The study of closed micro-environments will allow better understanding of the earth's ecosystem and thus motivate more intelligent management of the earth's resources.

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Contributors:

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B004	Calvin H. Ward, Ph.D.	Rice University
B024	Clayton Huber, Ph.D.	BYU
B025	David White, Ph.D.	Florida State University

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Life/Biological/Medical Sciences

TITLE: Botany (MMCX-0616)

PRINCIPAL CONTACT: Calvin H. Ward, Ph.D.

ORGANIZATION: Rice University

MMC CONTACT: A. K. Wildgen

PROGRAM OBJECTIVE: The botany research falls into two classes: 1) basic biological questions ceonerning the role of gravity in plant physiology and 2) development efforts oriented toward inflight food production for future incorporation into a closed, or semi-closed, ecological life support system in a future space station.

The basic plant physiology issues include the mechanisms of gravity perception, the dynamics of gravitrophic responses, the role gravity plays in normal differentiation and organogenesis. Such questions will require long duration missions (in excess of four weeks) and acceleration profiles not exceeding 10^{-4}g, preferably 10^{-5} to 10^{-6}. The low acceleration profiles may require implementation of these experiments on a free-floating platform.

The studies of plant systems for future incorporation into the CELSS demonstration payload include addressing issues such as gravity and transient vibration and acceleration effects; batching systems; microbial load; light sources, wavelengths and, photoperiods; nutrient compositions and delivery systems; environmental control and monitoring systems; harvest and processing techniques; and edible yield.

Botany Experiment Concept 1: 16/2/01 (A002)

Plant Development
Species: Arabidopsis, Carrot, Pine, Bean
Procedures:

Seeds of the selected plants will be initially maintained inflight planted in a dry condition. At selected intervals, depending upon the species, groups of seeds will be automatically wetted with a nutrient solution. The plants will then be maintained in a plant growth chamber using automated procedures. At 90 days, the plants will be returned alive for further studies.

Equipment Requirements:

- Plant growth unit

Crewtime Requirements:

None - all operations automated

SPACE STATION USERS CONCEPT

Botany Experiment Concept 2: 16/2/02 (A002)

Plant Physiology
Species: Wheat, Oats, Peas, Corn
Procedures:

Seeds will be wetted in flight. Seeds and seedlings will be incubated in weightlessness and at various accelerations between 0-g and 1-g for periods up to 30 days. The video images of the seedlings will be recorded. Seeds and seedlings will be moved and/or reoriented to various acceleration vectors. Seedlings will be dissected and preserved for further studies.

Equipment Requirements:

- o Plant growth unit
- o Plant centrifuge (0 to 1.0 g)
- o Video recording system
- o Fixative kit
- o Tissue storage
- o GPWS

Crewtime Requirements:

- o Moderate crewtime for seedling dissection and preservation and plant reorientations periodically

Botany Experiment Concept 3: 16/2/03 (A006)

What is the threshold for g-force detection by a plant? This measurement was attempted on earth using clinostats for hypogravity simulation. The possible inadequacy of the simulation was recognized by the investigators, but the tests were done before space vehicles became practically available for botanical research. Initial results indicated that using clinostats the plant bioaccelerometers were sensitive to as little as 10^{-7}g. That fantastic sensitivity measurement was distrusted, and the apparatus was redesigned to reduce, as much as possible, low level vibrational inputs. The tests were then repeated and the limit was found to be about 10^{-3}g. In spite of the experimenters' caution, the different values obtained warn us that we cannot be sure the hypogravity simulation method is valid. Obviously the measurements should be made under real, not simulated hypogravity. When the sensitivity threshold is measured in space, the results should be unambiguous, but tests will require a space platform/station on which the "background" g-level will be no greater than 10^{-4}g. We are not confident that a Shuttle payload could achieve this with crewmembers' activities and other sources of accelerations with which to contend.

Special SS Requirement:

10^{-4}g level

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Life/Biological/Medical Sciences

TITLE: Botany (MMCX-0616)

PRINCIPAL CONTACT: Calvin H. Ward, Ph.D.

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The basic plant physiology issues include the mechanisms of gravity perception, the dynamics of gravitrophic responses, the role gravity plays in normal differentiation and organogenesis. Such questions will require long duration missions (in excess of four weeks) and acceleration profiles not exceeding 10^{-4}g, preferably 10^{-5} to 10^{-6}. The low acceleration profiles may require implementation of these experiments on a free-floating platform.

The studies of plant systems for future incorporation into the CELSS demonstration payload include addressing issues such as gravity and transient vibration and acceleration effects; batching systems; microbial load; light sources, wavelengths and, photoperiods; nutrient compositions and delivery systems; environmental control and monitoring systems; harvest and processing techniques; and edible yield.

Botany Experiment Concept 1: 16/2/01 (A002)

Plant Development
Species: Arabidopsis, Carrot, Pine, Bean
Procedures:

Seeds of the selected plants will be initially maintained inflight planted in a dry condition. At selected intervals, depending upon the species, groups of seeds will be automatically wetted with a nutrient solution. The plants will then be maintained in a plant growth chamber using automated procedures. At 90 days, the plants will be returned alive for further studies.

Equipment Requirements:

- Plant growth unit

Crewtime Requirements:

None - all operations automated

SPACE STATION USERS CONCEPT

Botany Experiment Concept 2: 16/2/02 (A002)

Plant Physiology
Species: Wheat, Oats, Peas, Corn
Procedures:

Seeds will be wetted in flight. Seeds and seedlings will be incubated in weightlessness and at various accelerations between 0-g and 1-g for periods up to 30 days. The video images of the seedlings will be recorded. Seeds and seedlings will be moved and/or reoriented to various acceleration vectors. Seedlings will be dissected and preserved for further studies.

Equipment Requirements:

- o Plant growth unit
- o Plant centrifuge (0 to 1.0 g)
- o Video recording system
- o Fixative kit
- o Tissue storage
- o GPWS

Crewtime Requirements:

- o Moderate crewtime for seedling dissection and preservation and plant reorientations periodically

Botany Experiment Concept 3: 16/2/03 (A006)

What is the threshold for g-force detection by a plant? This measurement was attempted on earth using clinostats for hypogravity simulation. The possible inadequacy of the simulation was recognized by the investigators, but the tests were done before space vehicles became practically available for botanical research. Initial results indicated that using clinostats the plant bioaccelerometers were sensitive to as little as 10^{-7}g. That fantastic sensitivity measurement was distrusted, and the apparatus was redesigned to reduce, as much as possible, low level vibrational inputs. The tests were then repeated and the limit was found to be about 10^{-3}g. In spite of the experimenters' caution, the different values obtained warn us that we cannot be sure the hypogravity simulation method is valid. Obviously the measurements should be made under real, not simulated hypogravity. When the sensitivity threshold is measured in space, the results should be unambiguous, but tests will require a space platform/station on which the "background" g-level will be no greater than 10^{-4}g. We are not confident that a Shuttle payload could achieve this with crewmembers' activities and other sources of accelerations with which to contend.

Special SS Requirement:

10^{-4}g level

SPACE STATION USERS CONCEPT

Experiment Concept 3 (con't)

Equipment Requirements:

- o Plant growth unit
- o Centrifuge (0 to 1.0 g)
- o Fixative kit
- o Tissue storage
- o GPWS

Crewtime Requirements:

- o Periodic plant fixation

Botany Experiment Concept 4: 16/2/04 (A006)

To answer the question, "How does gravity determine the course of plant morphological development?", it will be necessary to grow a population of plants which experience no detectable g-signals through at least one complete life cycle. The minimum duration will be about 4 weeks which exceeds what Spacelab can accommodate. Moreover, if, as has been suggested, a g-pulse can determine whether or not a particular developmental sequence will ensue, the test environment must not include even brief episodes of g-force applications above a threshold now estimated to be no higher than 10^{-3}g. The Shuttle Spacelab cannot meet this requirement.

S/S Special Requirement:

10^{-3}g

Equipment Requirements:

- o Plant growth unit

Crewmember Requirements:

TBD

Botany Experiment Concept 5: 16/2/05 (A004)

Typical investigations could include: The assessment of plant development in weightlessness by measuring plant biomass and by a microscopic description of the anatomy of plant organs, tissues, and cells. For example, seeds of four species of plants, water cress (Arabidopsis), carrot, pine, and bean, will be maintained inflight from an initially dry condition. At selected intervals, depending on the species, groups of seeds will be automatically wetted with a nutrient solution. The plants will be maintained in an automated, $1m^3$ plant growth chamber, at zero-g, and at 90 days, all plants will be returned to Earth for sampling of wet and dry weight and further studies. Various ages and stages of differentiation and organogenesis would

Experiment Concept 5 (con't)

thus be available for some conclusions to be made as to whether plants require the ability to detect and respond to accelerations in order to develop normally.

Equipment Requirements:

- o Plant growth chamber - $1m^3$, automated

Crewtime Requirements:

- o None - fully automated system and measurements obtained pre- and post-flight.

Botany Experiment Concept 6: 16/2/06 (A004)

Plants physiological responses to various accelerations will be assessed by procuring automatic video image recordings of seedling orientation. Seeds of four plant species (wheat, oats, corn, and peas) will be automatically wetted in flight, and subsets of each species will be incubated for periods up to 30 days, in automated $1m^3$ plant growth chambers, at various accelerations between zero-g and one-g. A sequence of various accelerations will be applied to some seeds and seedlings, in order to measure their reorientation, if any. After certain periods of time, seedlings will be sampled for wet and dry weight, and will be dissected and preserved for further studies. The degree of sensitivity of plant sensors can thus be tested, giving an understanding of whether fluid and mechanical movements resulting from growth are controlling the threshold of sensitivity.

Equipment Requirements:

- o Plant growth unit
- o Video recording system
- o Tissue fixative kit
- o Plant centrifuge (0 to 1.0 g)
- o GPWS
- o Tissue storage

Crewtime Requiremnts:

- o Crewmember support is required to perform fixation procedures

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

PROGRAM STATUS: Efforts are currently progressing with funding from NASA in several universities and Ames Research Center. Some plant experiments have flown and are planned for future STS missions. A great deal of work remains in the study of various species, environmental control and monitoring systems, and the integration of plants into CELSS concepts.

SYSTEM DESCRIPTION: The Whole Plant Cuvet system is currently under development for Spacelab by Dr. Schwartzkopf at the University of New Hampshire. As development efforts proceed, the Plant Growth Unit concept is anticipated to increase to 6 m^3 modules, and ultimately modified for implementation in the CELSS demonstration payload (after the year 2000). The equipment items required to support the conceptual experiments proposed in the Botany subdiscipline are listed in Table 1.

SYSTEM OPERATION: Most plant growth systems concepts require totally automated control and monitoring. Some experiments will require manned interaction for biological sample collection and processing for postflight analysis. The activities will be performed in the Life Sciences Research Module.

Some experiments will require manned interaction for biological sample collection and processing for postflight analysis. These activities will be performed in the Life Sciences Research Module.

SYSTEM INTEGRATION: The plant experiments will be performed in the Life Sciences Research Module which will be integrated and operational in 1995. The expanded plant modules ($6m^3$) will be implemented after the year 2000.

SUBSYSTEM SUPPORT: Power for the plant experiments will be drawn from the Life Sciences Research Modules. Continuous data downlink will be required, and some experiments will require video downlink, as well.

BENEFITS: The Botany experiments will provide knowledge concerning the role gravity plays in the development of form and function of living organisms. The information derived will be applicable to ground-based agricultural research, particularly in the assessment of microbial loads and optimization of environmental parameters.

Table 1 Botany Experiment Concept Requirements

Equipment Reqts / Experiment Concepts	Plant Growth Fac	GPWS	Plant Centrifuge	Video Record	Fixative Kit	Tissue Storage								Special SS Requirements
Concept 1 16/2/01 (A002)	✓													
Concept 2 16/2/02 (A002)	✓	✓	✓	✓	✓	✓								
Concept 3 16/2/03 (A006)	✓	✓	✓		✓	✓								$<10^{-4}$g
Concept 4 16/2/01 (A006)	✓													$< 10^{-3}$g
Concept 5 16/2/05 (A004)	✓ $1m^3$													
Concept 6 16/2/06 (A004)	✓	✓	✓	✓	✓	✓								

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

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CONTRIBUTORS:

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B024	Clayton Huber, Ph.D.	BYU
B025	Dave White, Ph.D.	Florida State University

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APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Materials Processing in Space

TITLE: Space Station Materials Processing Laboratory

PRINCIPAL CONTACT: K. Demel

ORGANIZATION: NASA/JSC

MMC CONTACT: D. Wenger

PROGRAM OBJECTIVE: Provide a low-gravity laboratory environment to optimize man-in-the-loop interaction for performing basic materials processing research and for transferring these phenomena into commercially viable product lines.

PROGRAM STATUS: No formal plan has been generated.

SYSTEM DESCRIPTION: A Spacelab-type module dedicated to MPS research facilities. The following types of experiment hardware will be mounted in the module: Acoustic Containerless Furnace, Electrostatic Containerless Furnace, Electromagnetic Containerless Furnace, Vapor Crystal Growth Facility, Crystals from Solution Facility, Floating Zone Furnace, Directional Solidification Furnace, Fluids/Chemical Process Facility, Fluid Experiment System, Gradient Furnace, Isothermal Furnace, Electrophoresis Separation, and a Combustion Research Furnace. Analysis and sample preparation hardware such as a Stereo Microscope and a Vapor Phase Reactor will also be included.

SYSTEM OPERATION: Experiment materials and inserts will be supplied by industry, universities, NASA, or research groups, and delivered to SS in the mid-deck lockers of Shuttle. Individual Laboratory facilities may be periodically changed out or upgraded as improved technology becomes available.

Additional utility outlets shall be provided for Single Purpose Experiments, Commercial Development Hardware, and low power/space applications of Commercial Production Hardware.

SYSTEM INTEGRATION: The Laboratory Module will be 4.6 meters in diameter and 8 meters long. Its total weight will be about 8,000 kilograms. Instantaneous acceleration disturbances shall be minimized, particularly during sensitive experiment operations.

SUBSYSTEM SUPPORT:

POWER: 6,000 watts typical operating power, 8,000 watts peak.

DATA MANAGEMENT AND COMMUNICATION: Low rate status data from most facilities. The Laboratory probably has its own recording system.

THERMAL SYSTEM: Significant power and thermal dissipation required from the furnaces, 8,000 watts and potentially 3,000°C.

POINTING STABILITY: N/A

SPACE STATION USERS CONCEPT

BENEFITS:

SPACE STATION UTILIZATION: SS provides a permanent research facility to be used for developing an understanding of processing phenomena in the space environment and developing new or improved commercial products. An existing versatile research facility will significantly reduce individual experiment costs by simplifying hardware fabrication and reducing design/test times. Simple concept feasibility experiments will become economically affordable.

MAN'S ROLE: SS crew participation is essential to supply, activate, and monitor the experiment hardware.

SYNERGISTIC ADVANTAGES: N/A

DIRECT BENEFITS: The knowledge base of MPS phenomena will be greatly expanded, allowing more realistic predictions for types of processes that may prove successful. This, in turn, leads to a continually more purposeful research program, with liklihood of successful commercialization ideas. Individual experiment cost and time requirements will be reduced to the extent of encouraging additional MPS concepts for commercial product lines. MPS feasibility experiments will become a realistic option for commercialization ventures.

SPACE STATION USERS CONCEPT

DISCIPLINE: Materials Processing in Space

TITLE: Acoustic Containerless Furnace

PRINCIPAL CONTACT: Dr. T. Wang

ORGANIZATION: NASA/JPL

MMC CONTACT: D. Wenger

PROGRAM OBJECTIVE: Utilize acoustic waves as a technique for manipulation of molten materials with no physical contact to container walls or holding devices.

PROGRAM STATUS: Both a single-axis and a three-axis system are scheduled for STS flights in 1983 and 1984.

SYSTEM DESCRIPTION: This furnace will be contained within the SS MPS Research Laboratory. The furnace chamber is filled with an inert gaseous environment while levitating pressure waves are established with acoustic drivers. Material samples are melted and manipulated in a purified state since there are no container walls or holding devices to contaminate the samples. It is desirable to provide an elongated chamber to allow sample undercooling. Ceramics/glass experimenters would prefer to extend the temperature range to 3000°C. The furnace should be capable of handling samples weighing more than one kilogram.

SYSTEM OPERATION: SS crewman would be required to exchange experiment samples, operate the furnace, and monitor experiment progress. Experiments could last as long as 2-3 hours.

SYSTEM INTEGRATION: Furnace dimensions will be about 1.0 x 0.6 x 0.6 meters, with a weight of 45 kilograms. Toxic vapors may be produced during processing, requiring external vent capability. Thermal dissipation could be a maximum temperature design constraint.

SUBSYSTEM SUPPORT:

POWER: 5,000 watts

DATA MANAGEMENT & COMMUNICATION: Low rate status data.

THERMAL SYSTEM: State of the art.

POINTING ACCURACY: N/A

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

BENEFITS:

SPACE STATION UTILIZATION: The SS laboratory concept will allow higher power, higher temperature, and better thermal dissipation capabilities than any STS-based concept. The manned interface capability allows a simpler hardware design.

MAN'S ROLE: The SS crew is essential for sample resupply, experiment initiation, and process monitoring.

SYNERGISTIC ADVANTAGES: Any material may be melted in a containerless manner by at least one of the SS Laboratory levitation facilities; acoustic, electrostatic, or electromagnetic.

DIRECT BENEFITS: The extended furnace capabilities will allow processing of totally new materials.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Materials Processing in Space

TITLE: Electrostatic Containerless Processing

PRINCIPAL CONTACT: Dr. T. Wang

ORGANIZATION: NASA/JPL

MMC CONTACT: D. Wenger

PROGRAM OBJECTIVE: Manipulate a dielectric molten material within an electrostatic field with no physical contact to container walls or holding devices.

PROGRAM STATUS: A JPL system has flown on SPAR and KC-135 flights. No STS flights are scheduled.

SYSTEM DESCRIPTION: This furnace will be contained within the SS MPS Research Laboratory. The furnace operates with its chamber in a vacuum environment, as the dielectric sample is controlled by an electrostatic field. A CCD camera feedback system is required to monitor the sample position and adjust electrode charging. Sample control is not as good, nor furnace design as advanced as Acoustic Containerless Furnaces. Various types and shapes of electrostatic levitators could be tested. The maximum temperature capability should be 1700°C.

SYSTEM OPERATION: SS crewman would be required to exchange experiment samples, operate the furnace, and monitor experiment progress. Experiments could last as long as 2-3 hours.

SYSTEM INTEGRATION: Furnace dimensions will be about 1.0 x 0.6 x 0.6 meters, with a weight of 45 kilograms. Toxic vapors may be produced during processing, requiring external vent capability. Thermal dissipation could be a maximum temperature design constraint.

SUBSYSTEM SUPPORT:

POWER: 3,000 watts.

DATA MANAGEMENT & COMMUNICATION: Low rate status data.

THERMAL SYSTEM: Dissipation capability required.

POINTING STABILITY: N/A

SPACE STATION USERS CONCEPT

BENEFITS:

SPACE STATION UTILIZATION: The SS Laboratory concept will allow higher power, higher temperature, and better thermal dissipation capabilities than any STS-based concept. The manned interface capability provides a simpler hardware design.

MAN'S ROLE: The SS crew is essential for sample resupply, experiment initiation, and process monitoring.

SYNERGISTIC ADVANTAGES: Any material may be melted in a containerless manner by at least one of the SS Laboratory levitation furnaces; acoustic, electrostatic, or electromagnetic.

DIRECT BENEFITS: The SS laboratory implementation of this furnace will allow the processing of new materials.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Materials Processing in Space

TITLE: Electromagnetic Containerless Processing

PRINCIPAL CONTACT: Dr. P. Curreri

ORGANIZATION: NASA/MSFC

MMC CONTACT: D. Wenger

PROGRAM OBJECTIVE: Utilize an electromagnetic field as a technique for manipulation and control of electrically conductive materials with no physical contact to container walls or holding devices.

PROGRAM STATUS: No STS flights are scheduled.

SYSTEM DESCRIPTION: This furnace will be contained within the SS MPS Research Laboratory. The furnace operates with its chamber in a vacuum environment, as an electrically conductive sample is manipulated by an electromagnetic field. Material samples are melted and controlled in purified condition since there are no container walls or holding devices to contaminate the samples. Various shapes and types of magnetic levitators could be tested. The maximum temperature capability should be 1200°C.

SYSTEM OPERATION: SS crewman would be required to exchange experiment samples, operate the furnace, and monitor experiment progress. Experiments could last as long as 2-3 hours.

SYSTEM INTEGRATION: Furnace dimensions will be about 1.0 x 0.6 x 0.6 meters, with a weight of 45 kilograms. Toxic vapors may be produced during processing, requiring external vent capability.

SUBSYSTEM SUPPORT:

POWER: 2,500 watts.

DATA MANAGEMENT & COMMUNICATION: Low rate status data.

THERMAL SYSTEM: Dissipation capability required.

POINTING STABILITY: N/A

BENEFITS:

SPACE STATION UTILIZATION: The SS laboratory concept will allow higher power, higher temperature, and better thermal dissipation capabilities than any STS-based concept. The manned interface capability provides a simpler hardware design.

BENEFITS (continued):

MAN'S ROLE: The SS crew is essential for sample resupply, experiment initiation, and process monitoring.

SYNERGISTIC ADVANTAGES: Any material may be melted in a containerless manner by at least one of the SS Laboratory levitation furnaces; acoustic, electrostatic, or electromagnetic.

DIRECT BENEFITS: The SS Laboratory implementation of this furnace will allow the processing of new materials.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Materials Processing in Space

TITLE: Vapor Crystal Growth Facility

PRINCIPAL CONTACT: J. Zweiner

ORGANIZATION: NASA/MSFC

MMC CONTACT: D. Wenger

PROGRAM OBJECTIVE: Grow uniform, low defect, semiconductor crystals and enhance the basic understanding of chemical vapor transport mechanisms.

PROGRAM STATUS: Vapor growth experiments were performed on Skylab.

SYSTEM DESCRIPTION: This facility will be contained within the SS MPS Research Lab. The sample material and a transport agent will be heated to their vaporization point in the furnace while the crystal seed is maintained at a lower temperature. The vaporized material is deposited upon the crystalline seed in even epitaxial layers. The maximum temperature will be about 1100°C.

SYSTEM OPERATION: The SS crewman will be required to exchange experiment samples, operate the facility, and photograph the crystal growth. Experiment durations will vary between several minutes to many hours.

SYSTEM INTEGRATION: Facility dimensions will be about 2.0 x 2.0 x 1.0 meters, and it will weigh 275 kilograms. Toxic vapors may be produced, requiring an external vent.

SUBSYSTEM SUPPORT:

Power: 1000 watts

Data Management & Communication: Low rate status data

Thermal System: Dissipation capability required

Pointing Stability: N/A

BENEFITS:

Space Station Utilization: The SS Laboratory concept will allow more experiment flexibility than any STS-based concept.

Man's Role: The SS crew is essential for sample resupply, experiment initiation, and process photography.

DIRECT BENEFITS: This facility will provide the capability to grow more perfect crystals faster than possible on earth.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Materials Processing in Space

TITLE: Crystals From Solution Facility

PRINCIPAL CONTACT: Dr. R. Kroes

ORGANIZATION: NASA/MSFC

MMC CONTACT: D. Wenger

PROGRAM OBJECTIVE: Grow large compound crystals.

PROGRAM STATUS: Solution crystal growth experiments were performed on Skylab.

SYSTEM DESCRIPTION: This facility will be contained within the SS MPS Research Lab. Aqueous solutions will be heated until they became saturated, whereupon a seed crystal is immersed into the solution. The system is slowly allowed to cool as the solution supersaturates around the seed.

SYSTEM OPERATION: The SS crewman will be required to exchange crystals/solutions, operate the facility, and photograph crystal growth. The experiments may last up to 6 weeks.

SYSTEM INTEGRATION: Facility dimensions will be about 0.6 x 0.6 x 0.6 meters, and it will weigh 35 kilograms.

SUBSYSTEM SUPPORT:

Power: 75 watts

Data Management & Communication: Low rate status data

Thermal System: Very accurate temperature control

Pointing Stability: N/A

BENEFITS:

Space Station Utilization: STS flights do no provide adequate time for many types of crystal growth.

Man's Role: The SS crew is essential for solution resupply, experiment control, and process photography.

Synergistic Effects: N/A

DIRECT BENEFITS: This facility will provide the capability to grow much larger crystals than possible on earth.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Materials Processing in Space

TITLE: Floating Zone Furnace

PRINCIPAL CONTACT: J. Williams

ORGANIZATION: NASA/MSFC

MMC CONTACT: D. Wenger

PROGRAM OBJECTIVE: Formation of large, contaminant-free crystals.

PROGRAM STATUS: A Floating Zone Furnace (the Mirror Heating Facility) is planned for the ESA Spacelab and EURECA programs.

SYSTEM DESCRIPTION: This furnace will be contained within the SS MPS Research Laboratory. A rod of polycrystalline material is translated through the furnace focal point, creating a narrow molten zone of the material. As the material resolidifies behind the molten zone, a purified, single crystal is formed. The material effectively provides its own holding fixture and any material impurities move along the rod, remaining within the melt zone.

The maximum temperature of this furnace should be about 2100°C.

SYSTEM OPERATION: The SS crewman will be required to exchange experiment samples, operate the furnace, and monitor experiment progress. Experiments could last as long as two hours.

SYSTEM INTEGRATION: Furnace dimensions will be about 0.6 x 1.0 x 1.0 meters, and it will weigh 100 kilograms. Toxic vapors may be produced during processing requiring external vent capability.

SUBSYSTEM SUPPORT:

POWER: 1500 watts

DATA MANAGEMENT & COMMUNICATION: Low rate status data

THERMAL SYSTEM: Dissipation capability required

POINTING STABILITY: N/A

BENEFITS:

SPACE STATION UTILIZATION: The SS Laboratory concept will allow more experiment flexibility than any STS-based concept.

MAN'S ROLE: The SS crew is essential for sample resupply, experiment initiation, and process monitoring.

SYNERGISTIC ADVANTAGES: N/A

SPACE STATION USERS CONCEPT

DIRECT BENEFITS: This furnace provides the capability of processing new materials in workable quantities.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Materials Processing in Space

TITLE: Directional Solidification Furnace

PRINCIPAL CONTACT: Dr. A. Lehocsky

ORGANIZATION: NASA/MSFC

MMC CONTACT: D. Wenger

PROGRAM OBJECTIVE: Produce consistently aligned microstructure in alloys.

PROGRAM STATUS: Directional Solidification furnaces have flown on Skylab and on SPAR flights.

SYSTEM DESCRIPTION: This furnace will be contained within the SS MPS Research Laboratory. The furnace directionally cools heated alloys to produce an anisotropic microstructure. This morphology quite often provides the material with different thermal and magnetic properties. The furnace also has applications for producing large, single crystals. The maximum furnace temperature should be about 1700°C.

SYSTEM OPERATION: The sample materials will be contained within cylindrical, sealed cartridges. The SS crewman will be required to exchange experiment samples, operate the furnace, and monitor experiment progress. Experiments could last as long as several days.

SYSTEM INTEGRATION: Furnace dimensions will be about 1.2 x 0.6 x 0.6 meters, and it will weight 70 kilograms. Toxic vapors may be produced during processing requiring external vent capability.

SUBSYSTEM SUPPORT:

POWER: 1250 watts

DATA MANAGEMENT & COMMUNICATION: Low rate status data

THERMAL SYSTEM: Dissipation capability required

POINTING STABILITY: N/A

BENEFITS:

SPACE STATION UTILIZATION: The SS Laboratory concept will allow more experiment flexibility than any STS-based concept.

MAN'S ROLE: The SS crew is essential for sample resupply, experiment initiation, and process monitoring.

SYNERGISTIC ADVANTAGES: The Directional Solidification and Gradient Furnace functions may be combined into one facility if sample movement capability is incorporated.

SPACE STATION USERS CONCEPT

DIRECT BENEFITS: This furnace provides the capability of processing new materials in workable quantities.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Materials Processing in Space

TITLE: Fluids/Chemical Process Facility

PRINCIPAL CONTACT: Dr. D. Frazier

ORGANIZATION: NASA/MSFC

MMC CONTACT: D. Wenger

PROGRAM OBJECTIVE: Basic fluids and chemical processes research in the low-gravity environment.

SYSTEM DESCRIPTION: This facility will be contained within the SS MPS Research Lab. The facility will consist of a standard chemical laboratory work area with hardware modified for low-gravity applications.

SYSTEM OPERATION: The SS crewman will manually perform standard laboratory experiments.

SYSTEM INTEGRATION: Facility dimensions will be a work area of 0.6 x 1.6 meters and it will weigh about 25 kilograms.

SUBSYSTEM SUPPORT:

Power: 20 watts

Data Management & Communication: None

Thermal System: N/A

Pointing Stability: N/A

BENEFITS:

Man's Role: The SS crew is essential for experiment performance.

Synergistic Advantages: N/A

DIRECT BENEFITS: This facility allows simple demonstration of low-gravity fluid phenomena.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Materials Processing in Space

TITLE: Fluid Experiment System (FES)

PRINCIPAL CONTACT: J. Williams

ORGANIZATION: NASA/MSFC

MMC CONTACT: D. Wenger

PROGRAM OBJECTIVE: Conduct fluid phenomena investigations using optical observation techniques to increase the knowledge of fluid behavior relative to MPS.

PROGRAM STATUS: The FES is scheduled for STS missions.

SYSTEM DESCRIPTION: This facility will be contained within the SS MPS Research Laboratory. The FES consists of a Support Module (SM) and an Experiment Module (EM). The SM contains an optical train to provide Holographic and Schlieren recordings, a thermal control system, and command/data control system. The EM is specifically designed for a particular experiment and fits into the Laboratory SM. It is desirable to modify the STS FES configuration for SS to allow Holographic photography of solidified crystals made in the other facilities.

SYSTEM OPERATION: The SS crewman will be required to insert the Experiment Modules into the SM and initiate the experiment operation. Typical experiment areas include crystal solidification, fluid and bubble behavior, and chemical/biological studies. Experiments could last as long as two hours.

The maximum operating temperature will be 60^{o}C.

SYSTEM INTEGRATION: The facility dimensions will be about 1.0 x 0.7 x 2.0 meters, and it will weight 135 kilograms. A vent will be required.

SUBSYSTEM SUPPORT:

POWER: 2000 watts

DATA MANAGEMENT & COMMUNICATION: Low rate status data

THERMAL SYSTEM: Dissipation capability required

POINTING STABILITY: N/A

SPACE STATION USERS CONCEPT

BENEFITS:

SPACE STATION UTILIZATION: The SS Laboratory concept will allow extended experiment capabilities compared to STS configuration.

MAN'S ROLE: The SS crew is essential for module changeout, experiment initiation, and process monitoring.

SYNERGISTIC ADVANTAGES: The FES will be capable of providing Holographic photography of solid crystals manufactured in other Laboratory facilities.

DIRECT BENEFITS: The FES contributes to our understanding of fluid behavior and process phenomena in the space environment.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Materials Processing in Space

TITLE: Gradient Furnace

PRINCIPAL CONTACT: J. Williams

ORGANIZATION: NASA/MSFC

MMC CONTACT: D. Wenger

PROGRAM OBJECTIVE: Perform solidification and diffusion experiments with metal castings, composites, and glasses as cartridges are heated to differential temperatures.

PROGRAM STATUS: A Gradient furnace has flown on Skylab and is planned for the ESA Spacelab and EURECA programs.

SYSTEM DESCRIPTION: This furnace will be contained within the SS MPS research laboratory. The furnace utilizes high and low temperature zones to differentially heat sample cartridges. The sealed sample cartridges may be either evacuated or filled with inert gas.

The maximum furnace temperature should be about 1700°C and it will be able to provide a differential heating capability of 100°C per centimeter along a length of 8 centimeters.

SYSTEM OPERATION: The SS crewman will be required to exchange experiment samples, operate the furnace, and monitor experiment progress. Experiments could last as long as one day.

SYSTEM INTEGRATION: Furnace dimensions will be about 1.2 x 0.6 x 0.6 meters, and it will weigh 70 kilograms. Toxic vapors may be produced during processing, requiring external vent capability.

SUBSYSTEM SUPPORT:

POWER: 1250 watts

DATA MANAGEMENT & COMMUNICATION: Low rate status data

THERMAL SYSTEM: Dissipation capability required

POINTING STABILITY: N/A

BENEFITS:

SPACE STATION UTILIZATION: The SS Laboratory concept will allow more experiment flexibility than any STS-based concept.

BENEFITS (continued):

MAN'S ROLE: The SS crew is essential for sample resupply, experiment initiation, and process monitoring.

SYNERGISTIC ADVANTAGES: The Directional Solidification and Gradient Furnace functions may be combined into one facility if sample movement capability is incorporated.

DIRECT BENEFITS: This furnace provides the capability of processing new materials in workable quantities.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Materials Processing in Space

TITLE: Isothermal Furnace

PRINCIPAL CONTACT: J. Williams

ORGANIZATION: NASA/MSFC

MMC CONTACT: D. Wenger

PROGRAM OBJECTIVE: Perform solidification and diffusion experiments with metal castings, composites, and glasses as cartridges are uniformly heated and cooled.

PROGRAM STATUS: An Isothermal Furnace has flown on Skylab and is planned for the ESA Spacelab and EURECA programs.

SYSTEM DESCRIPTION: This furnace will be contained within the SS MPS Research Laboratory and provides uniform heating and rapid cooling capabilities. The material samples are contained within sealed cartridges that are either evacuated or filled with inert gas.

The maximum furnace temperature should be about 2100°C.

SYSTEM OPERATION: The SS crewman will be required to exchange experiment samples, operate the furnace, and monitor experiment progress. Experiments could last as long as two hours.

SYSTEM INTEGRATION: Furnace dimensions will be about 1.2 x 0.6 x 0.6 meters, and it will weigh 45 kilograms. Toxic vapors may be produced during processing requiring external vent capability.

SUBSYSTEM SUPPORT:

POWER: 1000 watts

DATA MANAGEMENT & COMMUNICATION: Low rate status data

THERMAL SYSTEM: Dissipation capability required

POINTING STABILITY: N/A

BENEFITS:

SPACE STATION UTILIZATION: The SS Laboratory concept will allow more experiment flexibility than any STS-based concept.

MAN'S ROLE: The SS crew is essential for sample resupply, experiment initiation, and process monitoring.

SYNERGISTIC ADVANTAGES: N/A

SPACE STATION USERS CONCEPT

DIRECT BENEFITS: This furnace provides the capability of processing new materials in workable quantities.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Materials Processing in Space

TITLE: Electrophoresis Separation

PRINCIPAL CONTACT: D. Suddeth

ORGANIZATION: NASA/GSFC

MMC CONTACT: D. Wenger

PROGRAM OBJECTIVE: Develop and demonstrate improved methods of separating and purifying biological, medical, and other types of materials.

PROGRAM STATUS: Electrophoresis separation experiments have flown on Skylab and early STS missions.

SYSTEM DESCRIPTION: This facility will be contained within the SS MPS Research Laboratory. This will be a universal facility also incorporating isoelectric focusing capabilities. The facility will allow modification of the following parameters: electrode shapes, electrode separation distances, electrode voltages, separation chamber size and shape, and the medium injection and removal techniques.

SYSTEM OPERATION: The process consists of injecting a medium into a confined chamber with parallel electrodes located at each end. A large voltage differential is applied across the electrode, causing the medium constituents to migrate to different locations along the chamber because of their varying charges and mobilities.

Experiment performance time is about three hours.

SYSTEM INTEGRATION: The facility dimensions will be 2.0 x 2.0 x 1.7 meters, and it will weigh 450 kilograms. The facility will require an external vent and experiment samples will require refrigeration.

SUBSYSTEM SUPPORT:

POWER: 1000 watts

DATA MANAGEMENT & COMMUNICATION: Low rate status data

THERMAL SYSTEM: Samples remain chilled at 0-10^{o}C, while 1000 watts is dissipated.

POINTING STABILITY: N/A

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

BENEFITS:

SPACE STATION UTILIZATION: This SS laboratory concept allows more experiment flexibility than any STS-based approach.

MAN'S ROLE: The SS crew is essential for facility modifications, experiment initiation, and process monitoring.

SYNERGISTIC ADVANTAGES: N/A

DIRECT BENEFITS: This facility provides the flexibility of testing different separation techniques and configurations in the space environment.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Materials Processing in Space

TITLE: Combustion Research Chamber

PRINCIPAL CONTACT: T. Labus

ORGANIZATION: NASA/LeRC

MMC CONTACT: D. Wenger

PROGRAM OBJECTIVE: Basic research of combustion processes and extinguishing techniques for many materials in the space environment.

PROGRAM STATUS: A similar facility is being planned as an STS Mid-deck experiment. Experiments were previously performed on Skylab.

SYSTEM DESCRIPTION: This chamber will be contained within the SS MPS Research Laboratory. A variety of materials, such as chemicals, oils, premixed gases, plastics, powder particle clouds, etc, would be burned within an enclosed chamber. The chamber will be capable of modifying its atmospheric content, and will allow different extinguishing techniques to be tested.

SYSTEM OPERATION: The SS crewman will be required to exchange experiment samples, initiate chamber operations, and monitor experiment progress. Experiments may typically last one hour.

SYSTEM INTEGRATION: Furnace dimensions will be about 1.0 x 0.5 x 0.5 meters, and it will weigh 60 kilograms. Toxic vapors may be produced during processing requiring external vent capability.

SUBSYSTEM SUPPORT:

POWER: 200 watts

DATA MANAGEMENT & COMMUNICATION: Low rate status data

THERMAL SYSTEM: N/A

POINTING STABILITY: N/A

BENEFITS:

SPACE STATION UTILIZATION: There is no particular advantage to a SS concept, compared to the STS mid-deck experiment other than it complements the Research Laboratory.

MAN'S ROLE: The SS crew is essential for sample resupply, experiment initiation, and experiment monitoring.

SYNERGISTIC ADVANTAGES: N/A

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DIRECT BENEFITS: Research value applicable to fire safety on manned spacecraft.

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APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Materials Processing in Space

TITLE: Electrophoresis Operations in Space (EOS)

PRINCIPAL CONTACT: D. Richman

ORGANIZATION: McDonnell Douglas Corporation

MMC CONTACT: D. Wenger

PROGRAM OBJECTIVE: Economic production of pharmaceuticals utilizing an electrophoresis separation facility in the near zero-gravity environment of low earth orbit.

PROGRAM STATUS: Experimentation is on-going with the STS flight program. Clinical tests of the products are scheduled to begin in 1985, and the first full-scale production facility is planned for launch in 1988.

SYSTEM DESCRIPTION: Each production unit consists of a Factory Module and a Resupply Module. The units will initially be launched as Free-Flyers. The MMC SS will provide capabilities for up to four units, while as many as six additional units could be located on an EOS Platform.

Among the pharmaceuticals being considered for production are Beta cells, Interferon, Antitryspin products, Epidermal growth factor products, Growth hormone products, and Antihemophilic products.

SYSTEM OPERATION: The Factory Modules will remain in their orbital position for five years, while the Resupply Modules containing the raw materials and later the separated pharmaceuticals will be exchanged at six month intervals. All servicing could be accomplished with a SS-based TMS as Resupply Modules are transferred through the space station.

SYSTEM INTEGRATION: The SS-mounted EOS units are presumed to be identical to the Free-Flyers, requiring only power and resupply operations. Each unit will weigh 4550 kilograms, and be 4.3 meters in diameter by 2.5 meters long. The Factory and Resupply modules will each represent about half of the total length.

SUBSYSTEM SUPPORT:

POWER: 3,500 watts

DATA MANAGEMENT & COMMUNICATION: Low rate status data.

THERMAL SYSTEM: N/A

POINTING STABILITY: N/A

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

BENEFITS:

SPACE STATION UTILIZATION: The SS represents a less expensive production unit mounting configuration than individual free-flyers, since power and attitude control capabilities are provided.

MAN'S ROLE: The SS crew is necessary for TMS control throughout resupply operations.

SYNERGISTIC ADVANTAGES: N/A

DIRECT BENEFITS: Separation of pharmaceuticals in space without the effects of gravity-induced convection provides a more purified solution with shorter production times.

SPACE STATION USERS CONCEPT

DISCIPLINE: Materials Processing in Space

TITLE: Monodisperse Latex Reactor

PRINCIPAL CONTACT: Dr. J. Vanderhoff

ORGANIZATION: Lehigh University

MMC CONTACT: D. Wenger

PROGRAM OBJECTIVE: Produce consistently sized latex spheres between 0.2 and 12 microns in diameter. The spheres are used to calibrate electron microscopes and the dimensions of cellular pores.

PROGRAM STATUS: The process has been successfully demonstrated on STS flights. Funding, or a commercial investor is now required to develop large scale production hardware.

SYSTEM DESCRIPTION: A mixture of a styrene monomeric emulsion and water is heated to 70°C and allowed to polymerize and form latex spheres.

SYSTEM OPERATION: The SS hardware will consist of a small electronic control package and six 20 liter cells containing the styrene solution and the manufactured spheres. Each cell will produce one size of spheres. The cells will be resupplied at five day intervals by the SS crew.

SYSTEM INTEGRATION: The Reactor can be accommodated within the SS Research Laboratory. Its weight will be approximately 200 kilograms contained within dimensions of 3.0 x 1.5 x 1.0 meters.

SUBSYSTEM SUPPORT:

POWER: 300 watts for 50 days per year.

DATA MANAGEMENT & COMMUNICATION: Low rate status data

THERMAL SYSTEM: Dissipation of 70°C

POINTING STABILITY: N/A

BENEFITS:

SPACE STATION UTILIZATION: SS provides the most simple and least expensive implementation approach for this process. Such implementation may be necessary for economically feasible production.

MAN'S ROLE: The SS crew is required to resupply the sphere production cells and maintain the hardware.

SYNERGISTIC ADVANTAGES: N/A

SPACE STATION USERS CONCEPT

DIRECT BENEFITS: Earth-based facilities can only produce spheres up to 3 microns in diameter. It is hoped that larger microspheres, up to 12 microns, will have medical applications in combatting cancer and glaucoma tumors.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Materials Processing in Space

TITLE: MPS Commercial Development Units

PRINCIPAL CONTACT:

ORGANIZATION:

MMC CONTACT: D. Wenger

PROGRAM OBJECTIVE: Test Engineering Development Hardware for manufacturing commercial MPS products.

PROGRAM STATUS: Projections for MPS Development processes.

SYSTEM DESCRIPTION: It is anticipated that special development hardware will require flight experience as an intermediate step in the transformation of a successful MPS experiment into full scale production hardware. Commercial Development Units will be produced by private industry and transported to the SS Research Laboratory, along with sample materials, by the STS.

SYSTEM OPERATION: SS crew members or an industry representative will monitor Development Unit production runs and adjust/modify the hardware prior to a subsequent test run. Some analysis of the products may be required with the Laboratory equipment. Successful testing will provide the design parameters necessary for large-scale Production Hardware.

SYSTEM INTEGRATION: It is anticipated that each unit of Commercial Development Hardware will require about 60 days of SS Research Laboratory operational time.

SUBSYSTEM SUPPORT:

POWER: Up to 5,000 watts

DATA MANAGEMENT & COMMUNICATION: Low rate status data

THERMAL SYSTEM: Dissipation of 5,000 watts

POINTING STABILITY: N/A

BENEFITS:

SPACE STATION UTILIZATION: Development Hardware design can be simplified by incorporating a manned interface. Adjustments and modifications can be accommodated in one SS flight, as opposed to multiple STS-based launches.

MAN'S ROLE: The SS crew, or an industry representative, is essential for implementing hardware production modifications.

SYNERGISTIC ADVANTAGES: N/A

SPACE STATION USERS CONCEPT

DIRECT BENEFITS: This SS concept simplifies the hardware, reduces the development time, and thereby reduces the investment required for commercialization of a successfully demonstrated MPS process.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Materials Processing in Space

TITLE: MPS Commercial Production Units

PRINCIPAL CONTACT:

ORGANIZATION:

MMC CONTACT: D. Wenger

PROGRAM OBJECTIVE: Space production of commercially viable materials.

PROGRAM STATUS: Projections for successful MPS production processes.

SYSTEM DESCRIPTION: It is anticipated that additional commercial MPS products will develop from successful STS and SS Research Laboratory experimentation. This concept is intended to generically identify the SS requirements for manufacture of these newly developed products.

SYSTEM OPERATION: The SS will provide capabilities to accommodate the Production Units in either of two configurations. Small volume and low power users may be accommodated within the Research Laboratory. Large volume or high power units, or processes not able to withstand the 10^{-3}G level of crew motion accelerations, will require accommodation on an MPS platform. These platforms will be serviced by a SS-based TMS.

SYSTEM INTEGRATION: Our SS Mission Model assumes five types of MPS production facilities with four units of each. The anticipated servicing rate is every 30 days.

SUBSYSTEM SUPPORT:

POWER: Up to 30,000 watts (platform only)

DATA MANAGEMENT & COMMUNICATION: Low rate status data for any onboard SS.

THERMAL SYSTEM: Less than 500 watts dissipation for SS.

POINTING STABILITY: N/A

BENEFITS:

SPACE STATION UTILIZATION: Production Units could be mounted within the Research Laboratory if utility requirements are not excessive. However, primary SS utilization will be TMS resupply and repair capabilities for platform-mounted units.

MAN'S ROLE: The SS crew is required for TMS control and hardware repair functions.

SYNERGISTIC ADVANTAGES: N/A

SPACE STATION USERS CONCEPT

DIRECT BENEFITS: SS resupply, repair, and utility provision capabilities reduce production costs compared to other concepts of manufacturing in space. Reduced production costs should equate to reduced consumer costs for MPS products. Reduced production costs also encourage additional MPS ventures.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Communications

TITLE: Experimental Geostationary Platform (XGP)

PRINCIPAL CONTACT: W. T. Carey, Jr.

ORGANIZATION: NASA/MSFC

MMC CONTACT: D. Wenger

PROGRAM OBJECTIVE: Develop and demonstrate a common bus for assembling large antennae platforms at geosynchronous orbit. The XGP will also demonstrate GEO servicing capability.

PROGRAM STATUS: MSFC is discussing a joint program with Lewis RC. Lewis would provide the communications payload. The Phase A RFP is scheduled for release in the summer of 1983; and they anticipate Phase B funding in FY1985. A private investment firm has initiated contact with NASA.

SYSTEM DESCRIPTION: The XGP Bus will contain the power, attitude control, and housekeeping data/control subsystems, as well as provide the servicing/ resupply interface for an antenna platform. Various communication antennas and hardware, in addition to science instruments will be attached to the Bus.

SYSTEM OPERATION: The XGP mission will probably precede SS implementation of Reuable OTV capability and will, therefore, be delivered to the SS with its GEO boost stage already mated. The XGP will be docked to the SS while its booms and antennas are deployed and aligned by the SS crew. Further payload checkout at this point would be a program option. The transfer stage would then be launched to carry the XGP to geostationary orbit. The XGP will carry a standardized refueling/servicing interface and will provide the first demonstration of these capabilities at geostationary orbit.

SYSTEM INTEGRATION: The XGP will weigh 5450 kilograms, not including its transfer stage. Its stowed configuration diameter will be 4.5 meters, with a length of 9 meters, again not including its transfer stage. Its deployed configuration includes an envelope 35 meters in diameter and 30 meters long.

SUBSYSTEM SUPPORT:

POWER: 200 watts for alignment tools and P/L Test Equipment

DATA MANAGEMENT & COMMUNICATION: N/A

THERMAL SYSTEM: N/A

POINTING STABILITY: N/A

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

BENEFITS:

SPACE STATION UTILIZATION: SS provides an operational base for antenna deployement and alignment, and provides launch support for the transfer stage. SS also becomes the operational base for the XGP refuel/resupply demonstration.

MAN'S ROLE: The SS crew is required for alignment of the XGP antennas prior to orbit transfer. Further crew involvement is optional.

SYNERGISTIC ADVANTAGES: The XGP program represents the first demonstration of the antenna alignment and GEO reservicing capabilities for SS, which will subsequently be utilized by many other programs.

DIRECT BENEFITS: As it becomes increasingly difficult to further improve the efficiency of individual communication satellites, the next option will be to combine the functions of many satellites onto one platform. The XGP represents the first step in developing those platform technologies that will ultimately be required as the geostationary arc reaches its saturation point. Implementation of the antenna platform concept will open previously allocated orbital arc slots for the communications needs of emerging nations.

REFERENCES:

1) Report No. GDC-GPP-79-015 (1), 'Experimental Geostationary Platform Systems Concepts Definition Study', June 1982.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Communications

TITLE: Search and Rescue Satellite-Aided Tracking (SARSAT)

PRINCIPAL CONTACT: T. McGunigal

ORGANIZATION: NASA Headquarters

MMC CONTACT: D. Wenger

PROGRAM OBJECTIVE: Location of downed aircraft and maritime vessels in distress by the identification of Emergency Locator Transmitter signals.

PROGRAM STATUS: The first U.S./French/Canadian payload is scheduled for launch on the NOAA 8 weather satellite on March 28, 1983. The Russians have had a similar payload operating on Cosmos 1383 since September, 1982. It is anticipated that the programs will continue on a cooperative basis.

SYSTEM DESCRIPTION: The payload receives and retransmits the distress signals of ship and aircraft Emergency Locator Transmitters (ELT). Each payload provides about 25 minutes of data per pass and repeats each pass 5 times per day. It is desirable to have 4 or 5 payloads operational in order to reduce rescue times.

SYSTEM OPERATION: The ground station is able to determine the ELT location to within 20 kilometers by knowing the satellite position at the time of signal transmission and by interpreting the Doppler shift of the recorded signal. Ground crews are then able to narrow their search pattern to locate the downed aircraft or ship in distress.

SYSTEM INTEGRATION: The payload consists of a small electronics package, less than a 0.5 meter cube, and a small antenna. Any low earth orbit altitude is adequate, however higher inclination angles, above 57 , are desirable.

SUBSYSTEM SUPPORT:

POWER: Less than 100 watts.

DATA MANAGEMENT & COMMUNICATION: Independent of SS data systems.

THERMAL SYSTEM: N/A

POINTING STABILITY: N/A

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

BENEFITS:

SPACE STATION UTILIZATION: SS will provide another payload carrier. The payload could be mounted on either the SS, of limited application at 28.5 inclination, or aboard the polar orbiting Earth Observations Platform. The weather satellites typically operate for only 2-4 years. Either SS concept would provide a much longer operating life.

MAN'S ROLE: The SS crew would be useful for payload repair or replacement.

SYNERGISTIC ADVANTAGES: Data from a SS payload can be used in conjunction with other SARSAT payload data to define the ELT position with greater accuracy.

DIRECT BENEFITS: The Cosmos 1383 payload has been credited with saving the lives of 15 people in the six month period of September 1982 through February 1983. There are also the political benefits of a program sharing data with Russia, Canada, and France.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Communications

TITLE: Orbiting Deep Space Relay Station (ODSRS)

PRINCIPAL CONTACT: H. Fosque

ORGANIZATION: NASA Headquarters

MMC CONTACT: D. Wenger

PROGRAM OBJECTIVE: Replace three existing deep space network ground stations with one space relay station.

PROGRAM STATUS: The program is not considered to be affordable, nor technically advantageous presently. It is, therefore, on indefinite hold.

SYSTEM DESCRIPTION: The present concept for ODSRS is a 28 meter diameter cryogenically cooled antenna located at geosynchronous orbit to receive data from deep space probes and retransmit that data to a ground station. OSDRS would similarly be utilized to relay ground commands to the spacecraft.

SYSTEM OPERATION: ODSRS would require two or three orbiter launches to deliver its hardware to SS. It would be assembled, aligned, and tested at the Space Station, then mated to an OTV for transfer to geosynchronous orbit. Resupply missions for propellant and cryogens would be required every five years.

SYSTEM INTEGRATION: SS support requirements include the capabilities to assemble, align, test, and boost a structure of this magnitude and complexity. The ODSRS will weight 8,500 kilograms.

SUBSYSTEM SUPPORT:

Power: Adequate for assembly, alignment, and test operations.

Data Management & Communication: Test data system would be ODSRS provided.

Thermal System: N/A

Pointing Stability: N/A

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

BENEFITS:

Space Station Utilization: ODSRS can not realistically be assembled and tested without a Space Station. SS also becomes the operational base for the GEO transfer and resupply missions.

Man's Role: The SS crew is essential for ODSRS assembly, alignment, test, and OTV mating operations.

Synergistc Advantages: N/A

DIRECT BENEFITS: Proposed ODSRS advantages are to be reduced operational/maintenance costs, and/or improved system performance compared to the existing ground stations. Neither of the benefits is attainable at this time.

REFERENCES:

JPL Publication 79-30, 'Orbiting Deep Space Relay Station', April 1, 1979

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Communications

TITLE: Commercial Communications Satellites

PRINCIPAL CONTACT:

ORGANIZATION:

MMC CONTACT: D. Wenger

PROGRAM OBJECTIVE: Provide cost effective point-to-point and direct broadcast communications relay capabilities to the world population.

PROGRAM STATUS: Communication satellites of the SS era are anticipated to be follow-ons to present generation programs. Antenna platforms may become a reality after the year 2000.

SYSTEM DESCRIPTION: This mission represents a 10 year traffic model projection for the 1990 decade. The SS becomes applicable to this model with the implementation of the Reusable OTV. There is no SS role for Commercial Communication Satellite launch or operations without the Reusable OTV. A 1992 Reusable OTV capability would accommodate 130 of the satellites.

These would be a new generation of satellites designed to be compatible with STS and OTV launch capabilities, in general, larger and heavier than present satellites. GEO refueling and servicing could be implemented by 1996.

SYSTEM OPERATION: The Communication satellites will be launched to SS with the STS. At SS they are mated to the Reusable OTV, probably in multiples to maximize the OTV efficiency for geosynchronous delivery.

Geo refueling and servicing operations will be based at the SS.

SYSTEM INTEGRATION: SS support requirements include the satellite/OTV mating and checkout capabilities, and the operational base for GEO servicing. The satellites will weigh between 900 and 5450 kilograms.

SUBSYSTEM SUPPORT:

Power: N/A

Data Management & Communication: N/A

Thermal System: N/A

Pointing Stability: N/A

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

BENEFITS:

Space Station Utilization: Operations for delivery and servicing of GEO communication satellites represent about 55% of the total reusable OTV utilization in our SS Traffic Model.

Man's Role: The SS crew is necessary for the OTV operations in support of communication satellites.

Synergistic Advantages: N/A

DIRECT BENEFITS: SS and Reusable OTV implementation will allow communication satellites to continue to grow in size and increase the utilization efficiency of the geostationery arc.

REFERENCES: The following SS Communications Traffic Model represents a market projection for OTV compatible communications satellites in the 1990's:

	Program	1'st Launch Date	Quantity of Satellites	Satellite Weight	Refueling Capability
C2A	INTELSAT VII	1993	13	2725-4550 KG	Yes
C2B	TELESAT -K, -N	1990	2	1350 KG	No
C2C	TELESAT F/O	1996	2	2725-4550 KG	Yes
C2D	SBS F/O	1994	4	2725-4550 KG	Yes
C2E	SATCOM F/O	1990	5	2275 KG	No
C2F	TELSTAR-3 F/O	1993	3	2725-4550 KG	Yes
C2G	WESTAR F/O	1993	4	1350 KG	No
C2H	ADVANCED WESTAR-2	1994	4	2725-4550 KG	Yes
C2I	TDAS	1993	4	2725-4550 KG	Yes
C2J	GALAXY F/O	1992	5	1350 KG	No
C3K	SYNCOM F/O	1994	4	2725 KG	No
C2L	G-STAR F/O	1994	4	2725-4550 KG	Yes
C2M	SPC F/O	1991	6	1350 KG	No
C2N	M-SAT	1993	2	900 KG	No
C20	SBTS F/O	1992	4	1350 KG	No
C2P	MEXSAT F/O	1992	2	1350 KG	No
C2Q	SATCOL F/O	1991	4	1350 KG	No
C2R	AUSSAT F/O	1993	4	1350 KG	Yes
C2S	ITALSAT F/O	1992	2	1350 KG	No
C2T	NORDSAT F/O	1995	3	1350 KG	Yes
C2U	ARABSAT F/O	1992	2	2275 KG	No
C2V	PALAPA F/O	1991	2	1350 KG	No
C2W	CHICOMSAT F/O	1991	8	1350 KG	No
C2X	Regional COMM SATS	1991	7	1350 KG	No
C2Y	Data Trans F/O SATS	1993	4	2275 KG	Yes

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

	Program	1'st Launch Date	Quantity of Satellites	Satellite Weight	Refueling Capability
C2Z	Banking SATS	1990	3	1350 KG	No
C2AA	MAIL F/O	1995	3	1350 KG	Yes
C2AB	STC F/O	1993	6	1350 KG	Yes
C2AC	DBS F/O	1992	15	1350 KG	No
C2AD	CHINA DBTV	1991	8	1350 KG	No
C2AE	CANADA DBTV F/O	1995	4	2725-4550 KG	Yes

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Technology Development/Structures

TITLE: Thermal Driven Shape Control. (MMCX-2001)

PRINCIPAL CONTACT: H. M. Adelman (804) 827-3451

ORGANIZATION: NASA/LRC

MMC CONTACT: W. Nobles (303) 977-0290

PROGRAM OBJECTIVE: Precise shape control of structures by means of controlled thermal gradients.

PROGRAM STATUS: Opportunity. Not funded. No detail development.

SYSTEM DESCRIPTION: A large flexible panel will be attached to the space station. Heaters will be mounted to the panel at a number of locations. Sensors located on the panel will detect deviations from the required shape and trigger the heaters to generate a temperature distribution in the panel which will offset the unwanted distortions. This experiment could be combined into other large structure assembly experiments.

SYSTEM OPERATION: See description above. Thermal input from incident sunlight will need to be considered in operation planning.

SYSTEM INTEGRATION: No constraints on orbit altitude or inclination.

Size and weight are undefined.

SUBSYSTEM SUPPORT: Power for heater is the only significant requirement. Estimated upper limit of 1 kilowatt.

BENEFITS: Possible technology for shape control of large lightweight structure. Crew support required for assembly of test panels.

This experiment could be incorporated with other large structure technology experiments.

DIRECT BENEFITS: N/A

REFERENCES: N/A

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Technology Development/Communications

TITLE: Large Antenna Development (MMCX-2002)

PRINCIPAL CONTACT: W. Grantham (804) 827-3631

ORGANIZATION: NASA/LRC

MMC CONTACT: W. Nobles (303) 977-0290

PROGRAM OBJECTIVE: Prove enabling technologies associated with short and long baseline LSA receiver system designs suitable for radio astronomy and search and rescue use.

PROGRAM STATUS: Opportunity, not funded. For schedule planning purposes assume initial implementation in 1993 with 3 operational periods of 90 days each.

SYSTEM DESCRIPTION: Microwave receivers and antennas would be implemented for orbital operation with antenna baseline lengths up to 500 ft. Known earth and galactic targets would be used to evaluate system design and performance.

Short baseline - Utilize extreme ends of space station as baseline separation of interferometric antennas.

Long Baseline - Utlize space station and Free Flyer.

SYSTEM OPERATION: See description above.

SYSTEM INTEGRATION: No constraints on orbit altitude or inclination.
Size and weight: TBD
Mounting Constraints: The short baseline version of the development will require the antenna elements to be located on opposite extremes of the station. The long baseline version will require one antenna element located on the station and the other on a TMS vehicle flying in a precisely known orientation and distance from the station.

EMI Constraints: TBD
Contamination Constraints: None

SUBSYSTEM SUPPORT: TBD

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

BENEFITS: Improve Radio Astronomy systems and provide baseline evaluation of potential search and rescue techniques.

Mans Role: EVA crew activities will be required to install the antenna elements on both the station and on the TMS.

Operation of the TMS will be under the control of the space station control center.

DIRECT BENEFITS: N/A

REFERENCES: N/A

SPACE STATION USERS CONCEPT

DISCIPLINE: Technology Development/Advanced Energetics

TITLE: Large Solar Concentrator (MMCX 2003)

PRINCIPAL CONTACT: E. J. Conway (804) 827-3781

ORGANIZATION: NASA/LRC

MMC CONTACT: W. Nobles (303) 977-0290

PROGRAM OBJECTIVE: To develop and deploy a large permanent mirror facility to capture and concentrate AM-0 solar radiation. To accurately establish the optical characteristics of this facility through systematic measurements, and to assess the long-term stability of the optical characteristics of the mirror.

PROGRAM STATUS: Opportunity, not funded. For schedule planning assume initial implementation in 1995. This facility is envisioned as operating in support of several advanced energetics experiments. It is assumed a total of 10 operations with varying duration depending on the specific mission.

SYSTEM DESCRIPTION: The mission will develop the facility necessary for other Advanced Energetics missions. It will require development and deployment of a large stable concentrating reflector, and will permit assessment of the stability of reflecting optical coatings, and the mechanisms for producing and holding optical quality reflector shapes in the space environment.

SYSTEM OPERATION: TBD

SYSTEM INTEGRATION: No constraints on orbit altitude or inclination. The concentrator will require sun tracking to a degree of accuracy (TBD). The optical surfaces will be sensitive to contamination build up on the surfaces. The periodic cleaning or refurbishment of these surfaces could well be one of the aspects of technology to be addressed in the effort.

SUBSYSTEM SUPPORT: All TBD

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

BENEFITS: This facility would be required for other experiments and would be a test item itself for optical coatings and shape. Currently, space solar energy is only used as a power source with large flat arrays of photovoltaic cells. Other conversion schemes for solar energy (such as solar-pumped lasers, solar-sustained plasmas and solar thermal engines) have been conceived, but most require solar concentration. This mirror would provide the well-characterized, high-quality concentrator in the AM-0 environment necessary to properly develop and test advanced energy concepts.

Mans Role: EVA operations will be required to install the concentrator and to periodically set up the focal plane instruments and to perform maintenance on the concentrator.

Synergistic Advantages: See above under status.

DIRECT BENEFITS: N/A

REFERENCES: N/A

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Technology Development/Advanced Energetics

TITLE: Solar Pumped Lasers (MMCX-2004)

PRINCIPAL CONTACT: E. J. Conway (804) 827-3781

ORGANIZATION: NASA/LRC

MMC CONTACT: W. Nobles (303) 977-0290

PROGRAM OBJECTIVE: To demonstrate, calibrate, and test the operation of a solar-pumped laser using the AM-0 solar spectrum and to use a large, high-quality optical concentrator deployed and characterized under an earlier mission objective. To provide a realistic comparison of several solar laser types.

PROGRAM STATUS: Opportunity, not funded. For schedule planning use initial implementation of 1996. Assume three operations with 90 day duration each.

SYSTEM DESCRIPTION: The mission will demonstrate for the first time solar pumped lasing using the full solar spectrum (rather than a simulated spectrum). It will provide for the accurate measurement of solar laser efficiency which is spectrum and temperature-dependent and will provide for long-term operation to assess lasant stability and lasant reconstitution efficiency. The laser system will utilize the solar concentrator developed under an earlier technology development mission.

SYSTEM OPERATION: TBD

SYSTEM INTEGRATION: The operation of the solar concentrator will continue as before and will require sun tracking. The operation of the laser is TBD.

SUBSYSTEM SUPPORT: All TBD

BENEFITS: Solar-pumped lasers offer potentially revolutionary advances in space power and propulsion. This will be their first severe space test. Solar-pumped lasers offer low-maintenance, low-cost solar conversion. Long-term tests will assess the claim of low maintenance. Several lasants can be compared.

DIRECT BENEFITS: N/A

REFERENCES: N/A

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Technology Development/Advanced Energetics

TITLE: Laser-to-Electric Energy Conversion (MMCX-2005)

PRINCIPAL CONTACT: E.J. Conway (804) 827-3781

ORGANIZATION: NASA/LRC

MMC CONTACT: W. Nobles (303) 977-0290

PROGRAM OBJECTIVE: To characterize and compare for space operation the performance of laser-to-electric power converters, and to demonstrate short-range laser-power transmission in space.

PROGRAM STATUS: Opportunity, not funded. For schedule planning assume implementation of this phase in 1996. There will be four operations of 90 days each.

SYSTEM DESCRIPTION: Using a solar-pumped laser deployed and characterized under an earlier mission objective, transmission over the longest spacecraft dimension will be performed and the intensity pattern at the convertor site measured. An assessment of convertor performance, efficiency, stability for long-term operation and resistance to environmental interference or degradation will be performed for a set of convertors.

SYSTEM OPERATION: TBD

SYSTEM INTEGRATION: TBD

SUBSYSTEM SUPPORT: TBD

BENEFITS: By flight time, terrestrial R & D will have developed several useful laser-to-electrical power conversion devices. Their efficiency, stability and reliability will require extensive space testing. Their environmental interaction and the maturity of the technologies will be assessed and improved as required.

The high cost and limited quantity of electric power in space has been identified as a limiting factor to expanding space activities. A change of function, from each spacecraft generating its own power to specialized available power stations producing and beaming power, could provide much more available power at reduced costs. R & D to assess these possibilities will require substantial space testing.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Technology Development/Advanced Energetics

TITLE: Laser Propulsion Test (MMCX-2006)

PRINCIPAL CONTACT: E.J. Conway (804) 827-3781

ORGANIZATION: NASA/LRC

MMC CONTACT: W. Nobles (303) 977-0290

PROGRAM OBJECTIVE: To measure the thrust and specific impulse of one or more laser propulsion systems, and to assess the adequacy of ground-based measurements, and to test the life expectancy of a laser engine.

PROGRAM STATUS: Opportunity, not funded. For schedule planning assume initial implementation in 1997. Mission duration is 90 days.

SYSTEM DESCRIPTION: The mission will be the first systems-level test of laser propulsion in space. It will test thrust and specific impulse as well as system characteristics such as steady-state wall temperature, propellant mass flow rate. A high-power laser, either solar-pumped or electrically pumped, will be required for this mission. Life tests will be performed. An adequate laser power source operating at the correct optical frequency will be required. Laser pointing and tracking will not be required since transmission can be over a distance of approximately the longest dimension of the space station. Adjustment, control, alignment, and repair are expected to require manned interaction. Depending upon the magnitude of the laser thrust, an opposed non-laser engine may be required.

SYSTEM OPERATION: TBD

SYSTEM INTEGRATION: TBD

SUBSYSTEM SUPPORT: TBD

BENEFITS: Studies show that the laser propulsion offers large cost savings for OTV's operating in a heavy traffic mode. By the early 1990's, prototype laser propulsion systems will be developed and tested on the ground. Their further development will require verification by a space test of the performance in test chambers. This mission is designed to test propulsion system parameters and establish a reliable estimate of benefit.

Several studies have shown that laser propulsion for OTV applications could be much less expensive than chemical propulsion. Without aggressive research, technology development will not be realized. This mission is designed to demonstrate and advance the state-of-the-art in laser propulsion.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Technology Development/Advanced Energetics

TITLE: Solar Sustained Plasmas (MMCX-2007)

PRINCIPAL CONTACT: E. J. Conway (804) 827-3781

ORGANIZATION: NASA/LRC

MMC CONTACT: W. Nobles (303) 977-0290

PROGRAM OBJECTIVE: To demonstrate, contain, and characterize solar-sustained plasmas and to operate, and refine MHD electric power generation in space and plasma thruster performance.

PROGRAM STATUS: Opportunity, not funded. For schedule planning assume initial implementation in 1998. Mission duration of 90 days.

SYSTEM DESCRIPTION: Concentrated sunlight will excite a plasma. Characteristics of the plasma and its containment system will be assessed in terms of theoretical performance and prior terrestrial tests. After suitable control and understanding have been achieved, the plasma will be used in MHD electrical generating systems to identify their space feasibility and operating constraints. The plasma will also be assessed as the exhaust medium for thermal plasma thrusters and for MPD thrusters.

Operation.and testing of these devices will require a large, high-quality solar concentrator (developed and put into operation during an earlier mission), a high-temperature thermal radiator, and diagnostic equipment both for the plasmas and for device operation. Control by on-board scientist will be required.

SYSTEM OPERATION: TBD

SYSTEM INTEGRATION: TBD

SUBSYSTEM SUPPORT: All TBD

SPACE STATION USERS CONCEPT

BENEFITS: The direct use of solar radiation to produce plasmas will enable smaller, simpler space power and propulsion systems. Plasma devices which operate at high temperature require only small radiators to reject waste heat and thus offer important system and economic advantages for future applications.

Large amounts of free but low density energy exist in space in the form of sunlight. Capture, concentration to useful levels, and control of this energy is presently accomplished with photovoltaic cells and storage batteries. Optical concentration of sunlight and the production of high-temperature and ionized gases could provide an attractive option for the future, especially for near-earth space processing requirements.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Tecnology Development/Servicing

TITLE: OTV Servicing (MMCX-2008)

PRINCIPAL CONTACT: W. Wales (205) 453-2796

ORGANIZATION: NASA/MSFC

MMC CONTACT: W. Nobles (303) 977-0290

PROGRAM OBJECTIVE: To provide the technology required to maintain an Orbital Transfer Vehicle (OTV) on-orbit between flights. Initial experiments in the OTV technology evolution could be performed in ground facilities or from the Orbiter. However, the more complex, longer duration tests/experiments will require the support of the space station.

PROGRAM STATUS: Candidate, not funded. For schedule planning assume initial implementation in 1992 with six subsequent operations of 90 days duration each.

SYSTEM DESCRIPTION: The proposed mission(s) are required to develop the technology needed for servicing the Orbital Transfer Vehicle system and maintaining it from an on-orbit base. Those issues of major concern are: the refueling, gauging and preservation of the OTV propellants; the maintenance, replacement and checkout of avionics components; the servicing and replacement of propulsion system components; installation of any aerodynamic braking or aeromaneuvering system; and the integration and checkout of the OTV with another stage, single or multiple type payloads; and/or a manned crew transfer module.

Due to the magnitude of this mission(s) a large number of experiments will be required and developed over a long period of time utilizing the manned space station.

SYSTEM OPERATION: See description above. Details are TBD.

SYSTEM INTEGRATION: Orbit altitude and inclination must be compatible with the type of planned OTV operation.

No pointing or attitude control constraints other than those inherently provided by the station will be required.

Provision of adequate work space and facilities support to perform the OTV assembly, maintenance, checkout and load attachment operations will be required. Also fuel loading and deployment to a safe separation distance from the space station prior to starting the OTV motor will need to be provided. After completion of the mission the capability of rendezvous with the returned OTV to bring it back to the station for refurbishment will be required.

SPACE STATION USERS CONCEPT

SYSTEM INTEGRATION: (Con't)

Contamination environment constraints will probably be derived from the nature of the planned payload for the OTV rather than the OTV itself.

SUBSYSTEM SUPPORT: All TBD

BENEFITS: The development of this technology will enable the OTV to remain on-orbit for extended periods of time, thus allowing the full shuttle capability to be devoted to other payloads. The technology required to develop the space-based OTV will have significant impacts on other programs utilizing the space station's servicing, maintenance, and operational facilities.

Mans Role: Man will play an essential role in the assembly and maintenance operations for the OTV.

Synergistic Advantages: Experiments relative to the overall management of propellants require long duration tests in a zero-gravity space environment. Storage tests can best be accomplished in a natural space environment. OTV and payload and added stage handling will utilize space station handling equipment. These tests are essential to establish the commonality of equipment on the station to support multiple programs. In addition the TMS located on the station can operate in conjuntion with and in support of the OTV operations.

DIRECT BENEFITS: N/A

REFERENCES: N/A

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Technology Development/Power Systems

TITLE: Low Cost Solar Panel Technology (MMCX-2009)

PRINCIPAL CONTACT: L. Slifer (301) 344-8841

ORGANIZATION: NASA/GSFC

MMC CONTACT: W. Nobles (303) 977-0290

PROGRAM OBJECTIVE: To provide the technology development and demonstration of spacecraft solar panels that embody features that allow them to be low cost, but nearly as long-lasting and efficient as current panels. The solar panels would incorporate modular design features to allow easy replacement of malfunctioning sections.

PROGRAM STATUS: Opportunity. Not funded. No detailed concept development.

SYSTEM DESCRIPTION: This mission would provide testing and demonstration of the technology for design and manufacture of low cost solar panels. Their costs would be greatly reduced by the use of design features suitable for space, but with application of commercial standards used for the production of reliable earth-based solar panels. The Space Station makes possible the continuous, long-term test, in parallel of several candidate solar panel and power system designs, under real conditions. It makes available the space vacuum, the orbital radiation environment, the atomic oxygen flux,and the thermal cycling of continuous, frequent orbital eclipses. The thermal cycling that solar panels must endure is one of the most important and least understood causes of solar panel failure. This mission would allow us to understand the causes of these failures.

SYSTEM OPERATION: Once installed the system will operate in an automated mode similar to the station solar arrays. It will require a solar tracking drive and the power electronics required to integrate the power output into the station power system.

SYSTEM INTEGRATION: Because of the solar tracking requirements the mounting location for the experiment solar array module will need to be carefully integrated into the station architecture to be compatible with the main solar arrays and to avoid shadowing. Also, to avoid blocking fields of view of other payload packages. The power output from the experiment will need to be integrated into the station system for disposition. This will require compatibility with station bus voltage levels and criteria.

SUBSYSTEM SUPPORT: See integration and operation sections above.

SPACE STATION USERS CONCEPT

BENEFITS: Since the cost of solar arrays is a major factor in the overall cost of space systems, the major benefit would come from lowered solar panel costs. Based on the estimates of a solar panel manufacturer, the costs might be reduced by a factor of approximately three. The modular design would allow flexibility of configuration and easy replacement.

While manufacturing to commercial standards implies lower proven life expectation for individual panels, their usability would not be seriously impaired if they are designed in modular sections that are intended to allow individual service and replacement by astronauts. The capability to replace a panel if it fails after several years, instead of having to make certain that it will last ten years or longer, is the major force to reduce the overall cost of solar panel systems. Commercial acceptance standards may imply lower efficiency solar cells, but any reduction of efficiency should be acceptable, even if a somewhat larger area is required, because of the greatly reduced procurement cost. The Space Station system allows continuous observation and test of candidate panels and their immediate, easy replacement by the astronauts if they go bad.

DIRECT BENEFITS: N/A

REFERENCES: N/A

SPACE STATION USERS CONCEPT

DISCIPLINE: Technology Development/Propulsion Systems

TITLE: Fluid Management Technology (MMCX-2010)

PRINCIPAL CONTACT: T. Labus (216) 433-4000 x 233

ORGANIZATION: NASA/LeRC

MMC CONTACT: W. Nobles (303) 977-0290

PROGRAM OBJECTIVE: To provide a technology base for systems requiring storage, acquisition and transfer of earth storable and cryogen fluids under controlled reduced gravitational conditions.

PROGRAM STATUS: Opportunity, not funded, no detailed concept development. Based on evolution from STS/Spacelab experiments and development activities. Technology is essential to space station design. Technology development required for subsystem design evolution.

SYSTEM DESCRIPTION: The missions proposed will provide the technology for the long term storage, acquisition and transfer of both single and two-phase fluids. Key issues regarding fluid mechanics, heat transfer and thermodynamics of these complex physical systems need to be addressed. Specific experiments must be conducted on surface tension screen acquisition devices, pool boiling, two-phased flow boiling, fluid reorientation and transfer utilizing noncryogenic fluids.

Because of the unlimited number of experiments which could potentially be conducted in this category, this mission could substantially benefit from a manned technology development laboratory. It is envisioned that this laboratory could be connected to the space station through some isolation structure or be flown in a manned free flyer to minimize extraneous disturbances.

SYSTEM OPERATION: TBD

SYSTEM INTEGRATION: No orbit constraints on altitude or inclination. No constraints on pointing or attitude control over those provided by the space station. No contamination constraints.

SUBSYSTEM SUPPORT: All TBD

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

BENEFITS: Life Support Systems, environmental control, and propellant transfer and management systems are a requisite to a successful space station. The increased efficiency of conducting these operations will benefit from a test bed developmental laboratory designed for this type of operation.

DIRECT BENEFITS: N/A

REFERENCES: N/A

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Technology Development/Propulsion Systems

TITLE: Low Thrust Propulsion (MMCX-2011)

PRINCIPAL CONTACT: D. Byers (216) 433-4000 x 6792

ORGANIZATION: NASA/LeRC

MMC CONTACT: W. Nobles (303) 977-0290

PROGRAM OBJECTIVE: The objective is to develop propulsion thrusters with thrust levels that are commensurate with the drag forces and disturbance torques anticipated on the space station. The capability to provide continuous nulling of these forces is desirable to minimize acceleration levels on the station, to maintain constant orbit parameters, and to achieve a stable platform for instruments requiring precise pointing. The areas of concern are the fuel and/or power consumption of these thrusters and the potential contamination and plume effects.

PROGRAM STATUS: Opportunity, not funded. For schedule planning purposes assume implementation of first flight in 1994. Assume 3 operational periods of 90 days each.

SYSTEM DESCRIPTION: The development thruster will be installed such that the thrust vector will be directed through (or near) the center of mass of the station. It will be oriented in a direction such that the thrust is counter to the drag forces.

SYSTEM OPERATION: This experiment will probably operate in conjunction with those missions whose objective are to determine to effects of such thrusters on solar arrays. This will require the thrusters to be installed at various locations with respect to the solar array locations. Once the thruster units and associated monitoring instruments have been installed (Crew EVA installation) they will be operated under automated control from the station data management system with periodic reprogramming by the crew as required.

In general the thruster will point in a aft direction such that the thrust generated can contribute to the general drag make up requirement.

Evolutionary Approach: The initial performance verification of alternative thruster types would require a test bed installation on the station in a location which could be easily accessed by the crew. This performance testing would be at a component or single thruster level rather than as an integrated station system level. The location of this test bed should be such that the thrust is directed through the near vicinity of the station center of mass and counter to the drag force vector. After adequate performance data has been obtained a complete system design for the station could be accomplished and integrated. In addition, the utilization of such a drag make-up system for platforms designed to station keep with the space station would be beneficial.

SPACE STATION USERS CONCEPT

SYSTEM OPERATION: (Con't)

Mission Concepts: It is anticipated that a variety of thruster concepts would need to be evaluated over extended periods of time. It will be necessary to monitor thrust levels, throttling, fuel consumption, power requirements and life/reliability characteristics. In addition, the effects of the thruster plume on the space station environment will need to be determined. These effects are difficult to determine quantitatively. Environmental monitoring instruments of various kinds will be required to determine thruster effects and these measurements used in a predictive analytical model to evaluate the performance results of the candidate thrusters.

Because of the requirement for extended performance testing of any candidate thruster, the test set up should be easily accessible to the crew on EVA for installation and adjustment. The instrumentation should be automated for continuous monitoring and control.

SYSTEM INTEGRATION: No constraints on orbit altitude or inclination. Mass and volume are TBD, however the dry weight of the system is estimated as less than 25 kg. The anticipated propellant mass in less than 20 kg. Volume of a truster module is less than 0.1 m^3.

Thruster modules will in general be mounted on the aft portion of the station and directed aft so as to counter the station drag forces.

Contamination is not a constraint other than that the contamination environment during operational periods of the thruster should be known to ascertain if it interacts with the thruster plume in any way. In particular with respect to any effects on the solar arrays.

SUBSYSTEM SUPPORT:

Power: Up to 1.5 KW.

Thermal Control: TBD. There may be a need for propellant thermal control maintenance but this will probably be internal to the experiment hardware.

Pointing Stability: None other than the attitude control inherently provided by the station. Pointing relationships with respect to solar arrays and any other sensitive areas will be considered in the design of the operational locations for the thrusters.

Data Management: Control of the experiment is automated under the control of the data management system except for periodic parameter changes initiated by the crew. There are no real time data requirements except as needed for crew or equipment safety alerting.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

BENEFITS: Sustained controlled acceleration environments for space systems are enabled by low thrust, precisely controlled, propulsion systems.

Mans Role: Man's role is primarily the installation and reconfiguration of the hardware modules, and to monitor the results in a reactive mode.

Synergistic Advantages: The combination of this development activity with investigations of solar array technology to investigate voltage level optimization and plasma effects will be advantageous.

DIRECT BENEFITS: N/A

REFERENCES: N/A

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Technology Development/Power Systems

TITLE: Large Space Power System Technology (MMCX-2012)

PRINCIPAL CONTACT: M. Valgora (216) 433-8287

ORGANIZATION: NASA/LeRC

MMC CONTACT: W. Nobles (303) 977-0290

PROGRAM OBJECTIVE: Demonstrate viability of multi-voltage systems for large, high power solar array systems for space platforms.

PROGRAM STATUS: Opportunity. Not funded. No detailed concept development.

SYSTEM DESCRIPTION: A large solar array segment (sized up to 20 KW) will be assembled in modular form capable of generating power at various voltages from 200 to 1000 volts. This power will be brought into a collection system where it will be converted to AC (high frequency) for transmission to a power distribution system at least 50 m away. Transmission will be over several lines. With the distributor, the power will be conditioned for users (possibly 120v, 60 cycle).

SYSTEM OPERATION: Since the primary power for the station is solar and the integration of the station arrays is a major consideration, then the integration of such a test array will require the adaptation of a module of the basic power system. Separate routings for the power output from the test array segment will be required to meet the experiment objectives. The array will be pointed and sun tracking accomplished by the station solar array drives. Power conditioning, control, distribution and utilization will need to be integrated into the station operation planning.

SYSTEM INTEGRATION: No constraints on orbit altitude and inclination. See operation section for integration aspects with station solar array system and power system. Size and weight will be constrained to match a solar array module.

SUBSYSTEM SUPPORT: See description and integration above. System will supply power to station.

BENEFITS: Provides a test bed for optimizing and verifying operating voltage levels for solar array operation.

Mans Role: Primarily to install the test module.

DIRECT BENEFITS: N/A

REFERENCES: N/A

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Technology Development/Power Systems

TITLE: Solar Array Plasma Effects (MMCX-2013)

PRINCIPAL CONTACT: (1) John Stevens, (2) C. Purvis (216) 433-5224

ORGANIZATION: NASA/LeRC

MMC CONTACT: W. Nobles (303) 977-0290

PROGRAM OBJECTIVE: To obtain essential knowledge on power systems operating in an ion thruster generated plasma plume. This understanding is needed for design and development of advanced photovoltaic space power systems with high power and high voltage.

The effects of both natural plasma environment and ion engine generated plasma environment must be determined. Power losses, array degradation and electromagnetic interference are of major concern and must be carefully controlled. Data must be obtained for a variety of thruster propellants and useful for array type, size and voltage scaling design consideration.

Prototypes of advanced photovoltaic space power systems must be operated in the vicinity of an ion thruster in order to gain essential experimental data. This data will be analyzed to yield basic knowledge about the physical processes and ultimately verification of analytical models and practical power system designs.

PROGRAM STATUS: Opportunity. Not funded. No detailed concept definition. For operational schedule planning, assume initial implementation in 1993.

SYSTEM DESCRIPTION: Both plasma and concentrator solar arrays must be analyzed and tested including the effect of modifications incorporating mitigation techniques such as insulating and biasing. Operating constraints such as configuration and spacing from thrusters must be determined.

The effects to be studies are:

- Pinhole effects at positive potentials, secondary emission
- Sheath processes, non-linear expansion with potentials
- Magnetic field constraints on particle trajectories
- High electric field emission of electrons
- Ultraviolet radiation effects - photoemission
- Ram and wake effects due to spacecraft velocity
- Arc and corona breakdown (avalanche) effects

Array areas of 150 square meters will be required for each of the test configurations to be evaluated. The duration of the test operation will be 6 months for each configuration. These test arrays will need to have a solar tracking provision and should be incorporated with the station solar arrays if possible.

SPACE STATION USERS CONCEPT

SYSTEM DESCRIPTION: (Con't)

The ion thruster will be located on the station to simulate its use as a drag make-up thruster.

SYSTEM OPERATION: The solar array part of the experiment will require automated tracking drives just as the station solar arrays, and the angular momentum of the driven array will need to be controlled and accommodated by the station attitude control system.

When interaction of the ion thruster operation with the solar array is to be studied it will be conducted by a crew member in charge of the investigation such that any deleterious or hazardous conditions which develop can be controlled expeditiously. Various sensors and monitors will be incorporated into the array panel to make the necessary observations. These sensors will be connected to onboard monitors available to the crewman in charge. The effects on the array will be monitored by the responsible crewman until confidence has been established that no hazardous conditions will develop.

Interaction effects will be studied as a function of various angles between the thruster and the array as the array goes through its solar tracking maneuvers, as a function of daylight and dark conditions, latitude effects, and controlled voltage parameters on the array.

SYSTEM INTEGRATION: Due to the complexity of the overall station integration considerations, it will be necessary to integrate the solar test array into the station solar array assembly as a module. This will provide the same solar viewing as the station solar arrays with a minimum amount of shadowing from the station. Also the array will be operated in the undisturbed flow of the natural plasma and not in the station-wake. It is desirable to operate during the solar maximum phase of the solar cycle.

The ion thruster can be configured to operate at various locations on the station to provide a variety of positional relationships between the thruster and the test array.

The desired area of the array is 150 square meters. Weight has not been estimated.

The array under test will be subjected to the normal operating environment of the station solar arrays. This includes orbiter docking, operations. contamination environment, etc.

There are no specific requirements for altitude or orbit inclination.

Sensor output from the test array and from the ion thruster will be conditioned to be compatible with the station command and data management system.

Operator control and display capability will be required.

SPACE STATION USERS CONCEPT

SUBSYSTEM SUPPORT:

Power: the array will provide a substantial increment the station power system.

Data Management and Communication: See under integration.

Thermal Control: Other than disposition of power output from the array, the system will be designed for passive thermal control of the array. The thermal control of the ion thruster is TBD.

Pointing and Stability: See under operation above.

BENEFITS: The Space Station facility is required for this mission because of: the large separation distances required between the ion source and the power system, the operation of large scale, high voltage, prototype solar arrays and the operational space environment.

Man Role: Will be to install the test equipment and to control and monitor the operation during its early stages to prevent hazardous situations from developing.

This experiment can be advantageously combined with other solar array experiments such as the "Large Space Power Technology Demonstration" and the "Low Cost Solar Panel Technology".

DIRECT BENEFITS: N/A

REFERENCES: N/A

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Technology Development/Thermal

TITLE: Advanced Radiator Technology (MMCX-2014)

PRINCIPAL CONTACT: T. Mroz (216) 433-7275

ORGANIZATION: NASA/LeRC

MMC CONTACT: W. Nobles (303) 977-0290

PROGRAM OBJECTIVE: Demonstration and technical verification of advanced space radiator concepts under actual operational space station conditions (zero-gravity, space vacuum, space plasma, attitude control maneuvering perturbation, etc. Determine operational characteristics, constraints and effects of space station/radiator interface. The initial selection is for demonstration and technical verification of an advanced liquid droplet space radiator concept.

PROGRAM STATUS: Opportunity, not funded, no detailed concept definition available.

SYSTEM DESCRIPTION: The candidate liquid droplet radiator system could be intergrated/connected to the space station thermal management system at the heat rejection interface point. The system assembly would be installed as an auxilliary experimental heat rejection system. Waste heat load would be supplied by the space station (as an option a separate heat source could be used) commensurate to the size of the liquid droplet radiator system. It will operate at actual space station radiator conditions of inlet and outlet temperature, zero gravity, vacuum, solar radiation, attitude correction and maneuvering perturbations and with the interface of space plasma. Performance will be evaluated for efficiency of waste heat rejection, response, temperature distribution, controllability, flow rate, potential of loss of working fluid and space station contamination due to vaporization and maneuvering and effect of space plasma interface on liquid droplet streams trajectory. Zero-gravity effects on droplet generation, trajectory and collection and performance will be determined. Performance, failure modes, and lifetime potential will be evaluated using operational data to correlate space and ground test data. Mission will require evaluation under startup, shutdown, full and part load operation.

SYSTEM OPERATION: See above under system description.

SYSTEM INTEGRATION:

Orbit Parameters: No constraints.

Mass Volume: TBD

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

SUBSYSTEM SUPPORT:

Power: Pump power will be required, amount TBD.

Thermal Control: The heat load to the radiator will need to be supplied by the station. No other requirements.

Altitude Stabilization: Nothing above Space Station control required.

BENEFITS: Technology verification/demonstration of advanced radiator system less that 1/4 of the weight of flat plate, tube-fin and heat-pipe radiator designs. Radiator concept does not require surface coatings or armor-plate protection. Radiating area is impervious to micro meteriod damage. Liquid droplet radiator is suitable for low temperature (300K) and high temperature (1000K) NASA and DOD applications in kW and MW range. System is deployable, offers compact stowed configuration and can be designed to survive launch environment.

DIRECT BENEFITS: N/A

REFERENCES: N/A

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Technology Development/Attitude Control

TITLE: Attitude Control System Development (MMCX-2015)

PRINCIPAL CONTACT: James Randolph (213) 354-2732

ORGANIZATION: NASA/JPL

MMC CONTACT: W. Nobles (303) 977-0290

PROGRAM OBJECTIVE: To provide a test bed for the development of adaptive attitude control capabilities appropriate for large coupled body structures in space. this will include the validation of performance and stability improvement sensing strategies and mechanization, control gain update subroutines and reconfiguration schemes, and adaptive control algorithms, the development of hardware, algorithms and systems for active vibration damping, cooperative payload pointing, modular control, control during deployment, and precision pointing/stabilization, and the validation of sensing strategy/mechanization, identification algorithms and integrated flight control dynamics reconstruction subsystem; establishing off-line and real-time knowledge of flexible Space Station and payload dynamics.

PROGRAM STATUS: Opportunity. Not funded. No detailed concepts have been developed. The scheduled implementation date is 1992 in concert with the date for large structures technology implementation.

SYSTEM DESCRIPTION: The system will consist of a group of sensors, (alignment, relative motion, etc) actuators, dampers, and software programs integrated into a large space structures test assembly. Once the assembly has been completed to meet the objectives of the assembly technology development mission, then it can be used to meet the objective of this mission. It can operate in two modes: first, while still attached to the station and second, in a detached mode deployed by a Teleoperator Maneuvering System with telemetry of the command and sensor data.

SYSTEM OPERATION: A variety of investigations are envisioned. Stimulation of natural vibration modes of the structure, as well as control and damping functions will be performed. These operations will be carried out while the structure is still attached to the station as well as after it has been deployed.

The deployed operation will probably be at a significantly higher altitude to permit atmospheric drag forces on the structure to be reduced to a minimum during the separated operation phase. Also during this phase the operation of the experiment will probably be done under ground control because of data communication link considerations.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

SYSTEM INTEGRATION: There are no particular requirements for orbit inclination. The highest practical altitude is preferable to minimize atmospheric drag effects, however, any space station altitude is acceptable. The test structure can be boosted to an acceptable altitude for testing after assembly and initial operation on the station.

There are no pointing requirements. Vibrational and attitude perturbations from the station will be of concern and should be minimized as much as possible. It they are not acceptable for the purpose of this experiment the operations prior to separation of the test structure from the station will be minimized. Contamination is not a concern.

SUBSYSTEM SUPPORT:

Power: Approximately one kilowatt will be required for the sensors, actuators and data acquisition system

Data Management and Communication: Data reduction processing, control algorithms and actuator control functions will be required. During the deployed phase of the investigation communication links between the test bed structure vehicle and the space station (and to ground control) will be required.

Thermal Control: No requirements on the space station.

Pointing and Stability: See above under integration.

BENEFITS: These experiments will establish in-flight control performance of large flexible structures. In addition, they will determine vehicle inertia/CG and mode shapes and frequencies which will assist future design concepts. It is expected that new concepts in attitude control of large space structures will require the development of new algorithms as well as new measures of performance evaluation which will be developed during these experiments. Control of large space structures requires the understanding of new control algorithms, in parallel, with the development of various structural configurations. The Space Station provides a unique facility to develop these control schemes in an unlimited dimensional environment with zero gravity. This experiment will be the final proof test of control techniques for various configurations of large space structures, taking advantage of the control algorithms and concepts developed.

Mans Role: The primary role for man in these experiments is in the assembly of the required large structures and the installation of the required sensors and actuators. The actual performance of the investigations will be by computer driven excitations and control functions.

Synergistic Advantages: This group of investigations can be advantageously combined with the large structures technology development mission.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DIRECT BENEFITS: N/A

REFERENCE: N/A

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Technology Development/Communications

TITLE: Antenna Range Facility (MMCX-2016)

PRINCIPAL CONTACT: J. Randolph (213) 354-2732

ORGANIZATION: NASA/JPL

MMC CONTACT: W. Nobles (303) 977-0290

PROGRAM OBJECTIVE: To expedite the development of large diameter antennas for communication satellites, OVLBI, ODSRS, etc., providing a realistic environment for development and prototype qualification testing of subsystems and equipment for control of surface distortions and feed structure deflections.

PROGRAM STATUS: Opportunity, not funded. For schedule planning purposes assume initial implementation in 1994 with a total of 3 operational periods of 90 days each.

SYSTEM DESCRIPTION: A facility would be developed to provide in-situ pattern measurements of antenna beam quality and multiple simultaneous beam isolation. A Space Station based TMS would be used to measure RF pattern illumination.

SYSTEM OPERATION: See description above.

SYSTEM INTEGRATION: The test antenna platform would require mounting at some appropriate location on the station. The receiver gear would be deployed on the TMS and maneuvered to provide the antenna pattern characterization measurements.

There are no constraints on orbit altitude or inclination. There are no pointing constraints over the inherent space station attitude control capability.

Size, weight (TBD).
No contamination constraints,
Minimum RFI from Station operations.

SUBSYSTEM SUPPORT:

Power: TBD

Data Management: TBD

Thermal: TBD

Pointing Stability: No requirement.

SPACE STATION USERS CONCEPT

BENEFITS: The precision testing of multibeam communications antennas, and large aperture phased array antennas is extremely difficult if not impossible in earth based ranges. The presence of such a facility would greatly enhance the development of these precision pointing antenna technologies.

Role of Man: EVA activities would be required to install and reconfigure the antennas as a function of the development testing. Installation of the receiver monitors onto the TMS would also be required. Subsequent deployment of the TMS to perform the range measurements would require control by the Space Station control center.

DIRECT BENEFITS: N/A

REFERENCES: N/A

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Technology Development/Communications

TITLE: Laser Communications and Tracking (MMCX-2017)

PRINCIPAL CONTACT: J. Randolph (213) 354-2732

ORGANIZATION: NASA/JPL

MMC CONTACT: W. Nobles (303) 977-0290

PROGRAM OBJECTIVE: To provide the technology base for the development of Medium-Range (10 km), Low Power (100 W) solid state laser communication links using laser optical technology. In addition, the experiment would enable the development and testing of a VLSI superwafer laser array.

PROGRAM STATUS: Opportunity, not funded. For schedule planning purposes assume an implementation flight in 1994 with 2 follow-on flights. Each to represent a 90 day operational test program.

SYSTEM DESCRIPTION: The experiment would utilize "node" assemblies containing laser superwafers. "Nodes" would be placed on the space station appendages and on a teleoperator maneuvering system (TMS). Tests of the communication link between the Space Station and a TMS for various attitudes and ranges would include acquisition and tracking tests along with measurements of bit error performance. The experiments would verify that spherical communication coverage is possible around the space Station. The experiments would require adaptive experimental node placement for the nodes located on the Space Station.

SYSTEM OPERATION: The TMS mounted nodes could be installed onto the TMS vehicle and monitored during its normal operational missions with perhaps some specific added maneuvers and stay time to optimize the checkout of the developmental communications link. The TMS would be under the normal control authority of the space station operator. The operation of the test equipment would be the responsibility of a test director crewman who would coordinate with the control for the TMS.

SYSTEM INTEGRATION: No constraints on orbit altitude or inclination. The station mounted nodes would need to be installed at outboard locations to provide minimum fields of view blockage by the station modules. This could however, be in the most mature version of the developmental testing. The initial feasibility demonstrations could operate satisfactorily with more constrained fields-of-view. The installation of these laser superwafer nodes will require crew EVA operations and they will require power and data bus lines to the installed locations.

SPACE STATION USERS CONCEPT

SUBSYSTEM SUPPORT:

Power: Less than 1 KW.

Data Management and Communications: Interconnects of the nodes with the communication system as a source of test messages will be required.

Thermal Systems: The laser wafers will require low operating temperatures to be maintained (TBD).

Pointing and Stability: No constraints in excess of normal space station attributes.

BENEFITS: This communications system will provide redundant spherical communications coverage around the Space Station; will allow simultaneous communications, ranging, and pointing angle data; can be used for data relay and structure position determination; will provide proximity position and orientation data for docking approach; and will support other capabilities including wide bandwidth channels such as digital stereo imaging from a TMU, STS orbiter, or from EVA experiments.

Mans Role: The primary role for man is the EVA operations required to install the "nodes" on the station and on the test vehicle TMS.

Synergistic Advantages: The requisite presence of the TMS will greatly reduce the cost of conducting the development activity on this device.

DIRECT BENEFITS: N/A

REFERENCES: N/A

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Technology Development/Structures

TITLE: Structural Strain Monitoring (MMCX-2018)

PRINCIPAL CONTACT: Joseph Heyman (804) 827-3418)

ORGANIZATION: NASA/LRC

MMC CONTACT: W. Nobles (303) 977-0290

PROGRAM OBJECTIVE: Develop technology necessary to examine spacecraft structures and provide long-term structural verification through advanced Nondestructive Evaluation (NDE). Test such systems on early spacecraft missions and improve to meet monitoring needs.

PROGRAM STATUS: Opportunity, not funded. No detailed planning.

SYSTEM DESCRIPTION: Advanced acoustic emission sensors designed and built into the spacecraft structure will be monitored during the mission by a preprogrammed computer. The sensors will be developed and tested on the ground and will take advantage of current R&D program output to provide state-of-the-art sensors. Additional sensors designed to monitor strain with acoustics and fiber-optic interferometric sensors which have been developed at LeRC will be structurally integrated as well.

These sensors could also be incorporated into other technology demonstration missions for large structure technology.

SYSTEM OPERATION: Ground installation of sensors into structure elements would be performed prior to launch. Assembly crews would make instrumentation hookup to onboard data bus for computer monitoring by the station data management system.

SYSTEM INTEGRATION: See operation section above

SUBSYSTEM SUPPORT: Support requirements are negligible.

BENEFITS: Utilizes long duration aspect of large space structures to develop useful performance monitoring technology.

DIRECT BENEFITS: N/A

REFERENCES: N/A

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Technology Development/Safety

TITLE: Fire Safety

PRINCIPAL CONTACT: T. Labus (216) 433-4000 x 233

ORGANIZATION: NASA/LeRC

MMC CONTACT: W. Nobles (303) 977-0290

PROGRAM OBJECTIVE: *To provide the tecnology base for the extinquishment of* fires and for the control of combustion processes under low gravity.

PROGRAM STATUS: Opportunity, not funded. For schedule planning purposes assume initial implementation flight in 1990 with a total of 3 operational periods of 90 days each.

SYSTEM DESCRIPTION: This mission will provide the base technology required for the extinguishment of fires and for the control of combustion processes in confined environments. Combustion technology experiments in space involve the interaction between a number of complex physical disciplines such as heat transfer, fluid mechanics, mass transfer and chemical kinetics. Specific technology experiments to determine the effects of low-gravity should be conducted to determine the combustion mechanisms of solid, liquid and gaseous systems.

The system is envisioned to require dedicated laboratory space roughly equivalent to four times the volume of the STS space lab.

SYSTEM OPERATION: TBD

SYSTEM INTEGRATION: No constraints on orbit altitude or inclination. No attitude control or stability requirements other than the inherent characteristics of the station. As stated under the description, a dedicated laboratory space will be required that can be isolated from the remainder of the station.

Size and weight are TBD.
Contamination is not a concern to this experiment, however the venting of the combustion products may well cause serious contamination concerns for other elements of the station.

SUBSYSTEM SUPPORT: All TBD

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

BENEFITS: Technology experiments on fire safety will provide information to designers of Space Station extinguishment systems. In addition, this knowledge can be made available to materials scientists involved in controlled combustion processes related to in-space materials processing. Fundamental data on classical combustion processes could be used to validate existing zero gravity theories on such physical phenomena as droplet combustion, flammability limits, smoldering, etc. This data would find direct applications in numerous terrestrial situations.

NASA studies, as well as work by recognized experts in the academic and industrial community, have provided strong advocacy and justification for combustion research in space. The long-duration, low gravity levels obtainable on Space Station will allow successful conduct of numerous combustion technology experiments.

Mans Role: Man will be required to participate in the combustion experiments to set up, to conduct and observe.

Synergistic Advantages: Many potential Space Station experiments can be conducted in the area of Fire Safety Technology. These missions could substantially benefit from a manned technology development laboratory for their successful conduct.

DIRECT BENEFITS: N/A

REFERENCES: N/A

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Technology Development/Materials

TITLE: Spacecraft Materials Technology (MMCX-2020)

PRINCIPAL CONTACT: D. R. Tenney (804) 827-3110

ORGANIZATION: NASA/LRC

MMC CONTACT: W. Nobles (303) 977-0290

PROGRAM OBJECTIVE: To provide a technology data base for long term use of advanced materials in space.

PROGRAM STATUS: Opportunity, not funded. For schedule planning, assume initial implementation in 1992 with a continuous exposure of test materials for an indefinite term.

SYSTEM DESCRIPTION: The proposed mission would provide a unique opportunity to develop a long term space environmental durability data base on advanced thermal control coatings, adhesives, composites, and polymer films. Specific experiments would be developed to evaluate the effects of each exposure parameter, both singly and combined, on the properties of these materials. Insitu evaluation of properties could be performed.

SYSTEM OPERATION: Once test exposure locations have been selected and installed, periodic EVA visits would be scheduled to install, observe and retrieve samples.

SYSTEM INTEGRATION: No constraints on orbit altitude or inclination. Attitude of the test locations with respect to the velocity vector ram effects would be selected during the experiment design. No constraints on attitude stability over that inherent in the space station.

Size and Weight: TBD
Exposure to the Contamination Environment would be one of the areas of interest.

SUBSYSTEM SUPPORT:

Power: TBD

Data Management: TBD

Thermal Control: TBD

Pointing Stability: None required.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

BENEFITS: Long term exposure data is not available, therefore, a data base would be generated that would provide a basis for more efficient space structure design. The generated data would provide verification for ongoing materials exposure programs in ground-based facilities.

Mans Role: Install test platforms, install, monitor and retrieve test specimens. All on EVA.

DIRECT BENEFITS: N/A

REFERENCES: N/A

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Technology Development/Servicing

TITLE: Satellite Servicing (MMCX-2021)

PRINCIPAL CONTACT: W. Wales (205) 453-2796

ORGANIZATION: NASA/MSFC

MMC CONTACT: W. Nobles (303) 977-0290

PROGRAM OBJECTIVE: To provide the technology required to serve free-flying spacecraft/satellite at an orbital support facility. The servicing of satellites includes not only periodic support but repair and checkout of defective satellite systems. The retrieval and redeployment may be a function of the space station; however, it is not a part of this technology development mission.

PROGRAM STATUS: Planned, not funded. For schedule planning assume initial implementation in 1992 with 6 subsequent operational periods of 90 days each.

SYSTEM DESCRIPTION: The proposed mission(s) are required to develop that technology needed for servicing satellites in space at a manned facility and/or remotely from the manned facility. The issues of major concern are: subsystems module replacement and checkout, grapple/attachment tecniques, fluid transfer, remote servicing/checkout, and orbital assembly of satellites (limited). The technology development mission(s) selected will represent a cross section of those satellite functions and services required from the support facility.

Due to the magnitude of this mission(s) and possibly the varied services required, a large number of experiments may be required and developed over a long period of time utilizing the space station.

SYSTEM OPERATION: Servicing facilities for satellites both at the manned space station and as a remote capability will both be required. This technology will encompass the generations of spacecraft with no provision for servicing, those with limited anticipatory design such at the Multi Mission Spacecraft (MMS) and finally those designed with automated servicing anticipated from the inception.

Station activities will include the preparation of the servicer vehicle for each specific mission, the provisioning and logistics required to support such missions, and the operational control of the servicers during the rendevous, hard dock, servicing, undock and return of the servicer. Alternatively, for those satellites returned to the station for servicing, it will include the actual hands on maintenance or repair operations required by the satellite prior to return to its operational station.

SPACE STATION USERS CONCEPT

SYSTEM INTEGRATION: See operations description above. No constraints on orbit altitude or inclination. No specific constraints on pointing or stability other than those inherent in the station capabilities. Location of the maintaintance facility will be a consideration of station architecture design to optimize the rendevous and docking with the satellite/servicer stacks coming into the station for maintenance operations. Contamination constraints will need to be considered primarily for the specific satellite being returned for service.

SUBSYSTEM SUPPORT: All TBD

BENEFITS: The development of this technology will enable satellites to remain operational for much longer periods of time. Satellites would not be required to be designed for very long lifetime since the service capability is available. Systems redundancy and mass could be reduced. In essence, the satellite could be built cheaper and have a longer life through the on-orbit servicing capability.

Experiments relative to the attaching and servicing of satellites require these activities be performed in the operational environment. Handling equipment and remote servicing systems and fluid handling systems can be developed more effectively in the zero-gravity environment of space.

Mans Role: The outfitting and preparation of the servicer vehicle will require EVA or IVA activities to prepare it for the particular mission. For those maintenance operations or repairs which cannot be automated, the satellite will be returned to the space station where the crew will perform the needed repair and maintenance operations.

Synergistic Benefits: The servicers for the satellites can be transported on the TMS resident at the space station rather than having to duplicate these capabilities in the servicer vehicle.

DIRECT BENEFITS: N/A

REFERENCES: N/A

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Technology Development/Structures

TITLE: Large Structures Technology (MMCX2022)

PRINCIPAL CONTACT: (1) J. Randolph (2) B.R. Hanks (3) W. Wales

ORGANIZATION: (1) NASA/JPL (2) NASA/LRC (3) MSFC

MMC CONTACT: W. Nobles (303) 977-0290

PROGRAM OBJECTIVE: To provide a technology base for the design and analysis of very large and light weight space structures having dimensions larger than are compatible with Space Shuttle experiments. Assembly and testing of very large space structures will require utilization of the Space Station as a base for these activities. Maintaining a long lifetime stable platform for assembly and inertial structual characterization testing is important for the evolution of large structures technology.

PROGRAM STATUS: The status is as an identified opportunity. The concept has not been developed in any detail and has not been funded. For schedule planning purposes the implementation period for this activity on-board the station is 1992.

SYSTEM DESCRIPTION: A large exterior mounting and work station facility that can be used for assembly and environmental testing will be required on the Space Station. This facility will include data acquisition and analysis capabilities, mechanical operations support and maintenance capabilities, and a supply of goods and tools to allow modifications to large structure designs while on-orbit. Complete dynamic testing capabilities will be required to determine mode shapes, inertial properties, damping/influence coefficients, and other design parameters necessary to characterize the stability and dynamics of very large space structures. Storage facilities for the components prior to assembly will be required. Characterization of these facilities and equipments cannot be done until the assembly mission has been selected and definitized.

SYSTEM OPERATION: The functional requirements analysis of the mission will identify the nature of the assembly work platform, component storage provisions, assembly tools, thermal considerations for component handling during assembly operations, operational and structural integration with the space station, diagnostic instrumentation for performance characterization, data processing requirements, assembled structure utilization planning or disassembly/disposition planning.

The assembly operations will likely involve manned participation with EVA activities. The Manned Maneuvering Unit (MMU) will be a useful tool to perform joining of outboard joints of large light weight structures during development and verification phases. Investment in automation of assembly processes would seem to be premature until the technology has been proven and matured.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

SYSTEM OPERATION: (Con't)

Once the assembly of the structure has been completed, the initial phase of performance verification could be performed while still attached to the station. Subsequent phases with the structure detached from the station could be performed with deployment and control by means of a Teleoperator Maneuvering System (TMS). Operation in this mode would require development of diagnostic instrumentation capable of operating detached from the station and with data telemetry links to the station.

It should be anticipated that several concepts and applications for such large lightweight structures will need to be explored. For estimating purposes assume 4 typical operations will be required with a potential duration for each operation over a period of 90 days. This period would encompass launch, hardware transfer to stowage, assembly construction, model testing over a range of operating conditions (day night cycles, beta angles), space exposure effects, disassembly/disposition operations, restow and re-install into orbiter for return.

SYSTEM INTEGRATION: The are no particular requirements on orbit altitude or inclination. Weight estimate are gross ranging up to a dedicated STS payload of 60,000 pounds. This would seem to be an extreme upper limit. Light weight, beam type elements would probably not be dense enough to add up to such a weight for a dedicated orbiter payload. The assembled dimension of a test structure is estimated as 300 meters. Contamination and acceleration levels are not of concern. Drag effects from the structure would need to be considered in station operations planning, as would compatibility of the structure with the solar array operation.

SUBSYSTEM SUPPORT:

Power: TBD
Thermal: Passive design-no thermal loads on station.
Pointing: No requirement.
Data Management: TBD

BENEFITS: Large and light weight structures can be fabricated and assembled in the space environment where they are to operate. Unique features can be incorporated into such constructions that are not possible to achieve with 1 G structures that must be launched into orbit.

Space Station can provide the staging, crew capability and assembly platform required to implement such development.

EVA crew activities will enhance and keep the costs of such exploratory development down. Automation of such assembly operations should only be undertaken after the concepts have been proven and developed.

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

BENEFITS: (Con't)

The large structures technology can be combined with other investigation interests such that the structures can be applied to some specific purpose once they have been assembled. These applications include antennas, optical elements and others.

DIRECT BENEFITS: N/A

REFERENCES: N/A

APPENDIX C MISSION CONCEPT REFERENCE DATA

SPACE STATION USERS CONCEPT

DISCIPLINE: Technology Development/Attitude Control

TITLE: Tether Dynamics Technology MMCX-2023)

PRINCIPAL CONTACT: A. Potter (713) 483-2576

ORGANIZATION: NASA/JSC

MMC CONTACT: W. Nobles (303) 977-0290

PROGRAM OBJECTIVE: To provide a technology base for the utilization of long tethers operated from the space station or other orbiting vehicles. This will include scientific investigation of interations of the tether with the electro dynamic space environment, as well as the use of a tether to deploy and retrieve various instrument platforms.

PROGRAM STATUS: Initial tethered satellite investigations are planned to be conducted from the STS orbiter. It is anticipated that the application of this embryonic technology will need to be further developed for space station applications. For schedule planning assume an implementation date for the station operations in 1995.

SYSTEM DESCRIPTION: The tether deployment reel and deployed vehicle will be installed on an experiment payload structure attached to one of the payload docking ports. Depending on whether the planned investigation is deployment downward on upward will determine the location on the station.

SYSTEM OPERATION: The tethered vehicle will be deployed, operated for the requisite period of time to obtain the required data and then retrieved.

SYSTEM INTEGRATION: See description above. Any orbit altitude and inclination is acceptable. The only pointing and attitude control required is that necessary to deploy and retrieve the vehicle on the tether.

There are no contamination or vibration constraints. Volume and mass of the stowed equipment are initially estimated at 250kg and 100 cu ft.

SUBSYSTEM SUPPORT:

Power: Estimated at 1 kW.

Data Management and Communications: TBD

Thermal System: Deployed vehicle will have passive thermal control.

Deployment System: TBD

Pointing Stability: None required

SPACE STATION USERS CONCEPT

BENEFITS: The ability to deploy, control, and retrieve long tethers from an orbiting spacecraft in a safe and successful manner would permit several useful applications. Long tether systems have been proposed for research on the atmosphere and ionosphere, VLF antennas, and electrodynamic thrust and drag control. Basic engineering research on the control and stability of long tethers in orbit is needed before these applications can be realized.

DIRECT BENEFITS: N/A

REFERENCES: N/A