NASA Conference Publication 2411

Solar Terrestrial Observatory Space Station Workshop Report

Proceedings of a mini-workshop held at the
NASA George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama
June 6, 1985

NASA

NASA Conference Publication 2411

Solar Terrestrial Observatory Space Station Workshop Report

W. T. Roberts, *Editor*
George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama

Proceedings of a mini-workshop held at the
NASA George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama
June 6, 1985

NASA
National Aeronautics
and Space Administration

Scientific and Technical
Information Branch

1986

TABLE OF CONTENTS

CONFERENCE PUBLICATION

SOLAR TERRESTRIAL OBSERVATORY

SPACE STATION

WORKSHOP REPORT

INTRODUCTION

On June 6, 1985, a Solar Terrestrial Observatory (STO) "Mini-Workshop" was held at the Marshall Space Flight Center. The purposes of this one-day workshop included:

1) Review of the instruments to be placed on the initial STO at Space Station IOC and to develop brief descriptive writeups on each instrument.

2) Review of the placement of these instruments (i.e., on the manned Space Station, on the polar platform, and on the co-orbiting platform).

3) Development of operational scenarios for the STO with emphasis on the "campaign mode" definition.

The participants at this workshop were:

Dr. J. L. Burch, Southwest Research Institute

Dr. C. R. Chappell, Marshall Space Flight Center

Dr. R. L. Moore, Marshall Space Flight Center

Mr. W. T. Roberts, Marshall Space Flight Center

Dr. S. D. Shawham, NASA Headquarters

Dr. W. W. L. Taylor, TRW

Dr. S. T. Wu, University of Alabama in Huntsville

This report will not address the science goals and objectives since that subject has been adequately covered by the Solar Terrestrial Observatory Science Study Group Report [1] dated October 1981 and in preceding workshops [2,3]. Also a conceptual design and analysis study has been performed [4] for a space platform version of the STO.

INITIAL STO INSTRUMENTS

The initial STO on the IOC Space Station will consist primarily of instruments which have been developed and flown on previous STS missions. The instruments will have undergone those modifications required to transition them from missions on the STS which normally last from 7 to 14 days to the STO mission on Space Station with durations of years. The Space Station should be capable of supporting these instruments since the present instrument interfaces are the accommodation requirements which STO will provide as payload design requirements. Thus the thermal, power, command, and data interfaces would be functionally identical to those interfaces with the Shuttle/Spacelab.

The STO instruments, which are expected to be developed and available by the 1992 time period, include atmospheric instruments (interferometers and spectrometers), an airglow and auroral emissions instrument (low light level television), two accelerator systems and an associated beam diagnostic package, a wave injector, a free-flying subsatellite, an ejectable probe package (which can include diagnostic probes or chemical release cannisters), a tethered subsatellite system, and solar instruments (radiometers, coronagraphs, and telescopes).

The only instrument about which there is some uncertainty is the ejectable probe and its ability to support the chemical release cannisters. Further definition of this capability should be acquired over the next year.

Further, a study has been initiated to create a data base on the STO. This data base will include not only the Space Station accommodation requirements, but also the specific instrument modifications which will be required to transition the instruments to the Space Station. The study will also provide data on STO support systems (either Space station provided or STO Project provided) and a detailed implementation plan.

Brief writeups on each of the STO instruments are given in the following pages.

Title: SOFT X-RAY TELESCOPE (SXRT)

Prepared by: Ron Moore, MSFC

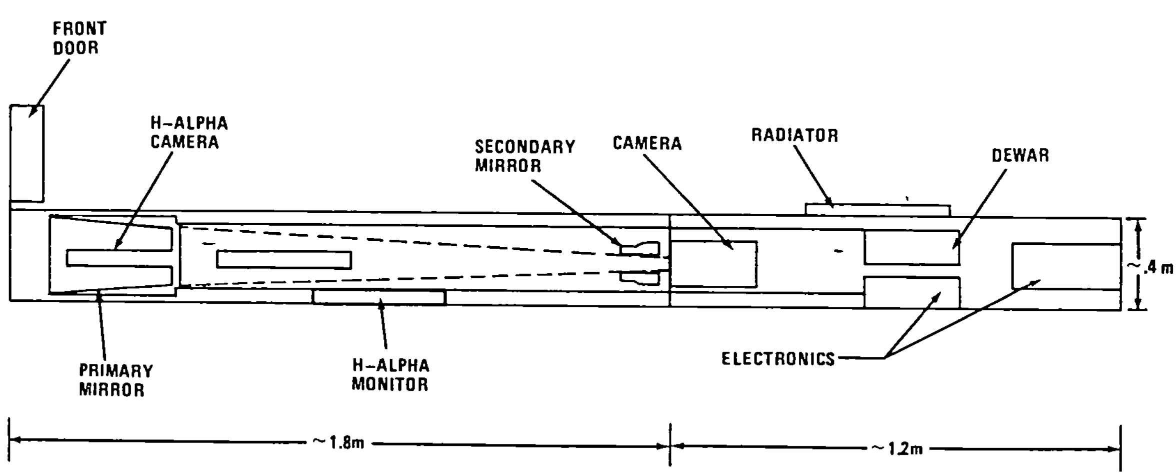
Short Description: The soft X-ray telescope will provide direct images of the solar corona with spatial resolution of about 1 arcsecond. These images will show the global structure of the corona, the location and area of coronal holes, and the presence of even the smallest active regions and flares. The good spatial resolution will show the fine-scale magnetic structure and changes in these phenomena. These observations are essential for monitoring, predicting, and understanding the solar magnetic cycle, coronal heating, solar flares, coronal mass ejections, and the solar wind. These observations complement those of the White Light Coronagraph and Ultra-Violet Coronal Spectrometer; the SXRT will detect active regions and coronal holes near the east limb, thereby giving a week or more of advanced warning for disturbed geomagnetic conditions at Earth. The instrument consists of a grazing incidence collecting mirror with a full-disk film camera at the primary focus, and a secondary relay optic that feeds a CCD camera with a field of view about the size of an average active region.

Instrument Characteristics:

Mass:	170 kg
Volume:	1 cubic meter
Power:	4 amps at 28 Vdc (112 watts)
Data Rate:	Digital: 100 kbps; Film: 1000 frames; H-alpha TV: 4.2 MHz
Pointing:	Direction: Sun-centered; Accuracy: 60 arcsec; Drift: 0.1 deg/hr; Jitter: 5 arcsec peak to peak at 0.02 to 0.5 Hz

General Comments: Early versions of this instrument have flown successfully on rockets. Improved versions are planned to fly on rockets and on SPARTAN. On STO, images from the H-alpha camera should be monitored by the crew and by scientists on the ground.

For more information contact: Dr. John Davis, American Science & Engineering



Title: SOLAR ULTRAVIOLET SPECTRAL IRRADIANCE MONITOR (SUSIM)

Prepared by: Ron Moore, MSFC

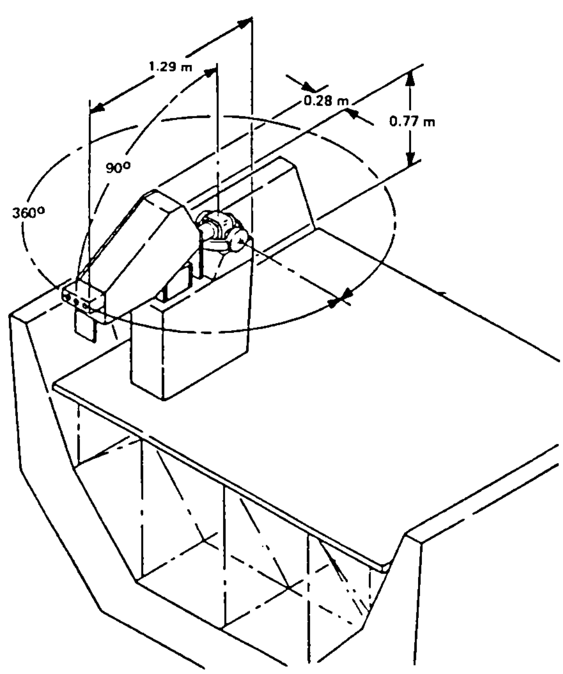
Short Description: SUSIM measures the ultraviolet flux from the entire Sun with high absolute accuracy over the wavelength range 120 to 400 nm with a resolution of 0.1 nm. SUSIM consists of two identical double-dispersion scanning spectrometers with 5 photodiodes, 2 photon counters, and a deuterium lamp calibration source, all sealed in a canister pressurized to 1.1 atmosphere of argon. One spectrometer is used almost continuously during sunlight; the other is used once per day as a calibration check. The observations will yield improved absolute measurements of the ultraviolet solar flxues, provide an accurate reference for studies of variability of the solar fluxes on the time scales of the solar cycle and longer, and measure shorter term changes as well. These measurements complement the ACR measurements of the total solar irradiance. The data will be used to study the physical behavior of the Sun and the Earth's atmosphere, weather, and climate.

Instrument Characteristics:

Mass:	135 kg
Volume:	0.5 cubic meters
Power:	700 watts
Data Rate:	0.5 kbps
Pointing:	Direction: Sun; Accuracy: 5 arc min; Scanning range: 0.5 deg

General Comments: SUSIM will fly on Spacelab 2 and on Sunlab.

For more information, contact: Dr. Guenter Brueckner, Naval Research Laboratory



Title: WHITE LIGHT CORONAGRAPH (WLC) AND ULTRA-VIOLET CORONAL SPECTROMETER (UVCS)

Prepared by: Ron Moore, MSFC

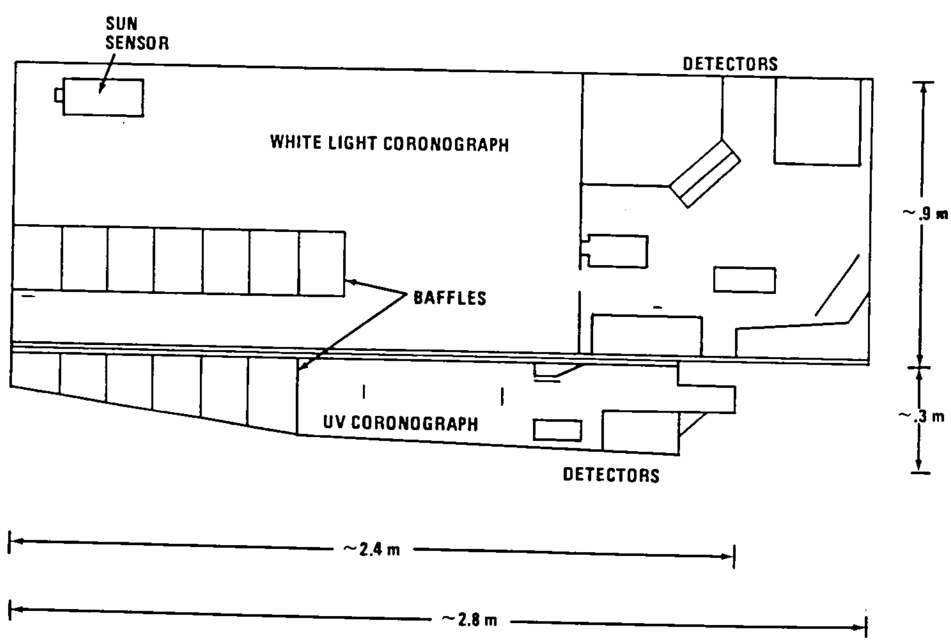
Short Description: The WLC and UVCS together reveal the corona and the roots of the solar wind from 1.5 to 6 solar radii from sun center. The WLC measures the plasma density and spatial structure of the corona and coronal mass ejections at a resolution of about 20 arcsec. The UVCS in combination with the WLC measures the temperature and radial outflow speed of the coronal plasma. These instruments will detect mass ejections from active regions and high speed solar wind streams from coronal holes a few days before the source regions rotate onto the face of the Sun, thus giving a week or more of advanced warning for disturbed geomagnetic conditions at Earth.

Instrument Characteristics:

Mass:	250 kg
Volume:	3 cubic meters
Power:	100 watts
Data Rate:	100 kbps
Pointing:	Direction: Sun center; Accuracy: better than 10 arcsec

General Comments: Early versions of this instrument have flown successfully on rockets. Improved versions are planned to fly on SPARTAN and on SOHO. On STO, images from the WLC should be monitored by the crew and by scientists on the ground.

For more information contact: Dr. John Kohl, Smithsonian Astrophysical Observatory
Dr. Richard Munro, High Altitude Observatory



Title: HIGH RESOLUTION TELESCOPE AND SPECTROGRAPH (HRTS)

Prepared by: Ron Moore, MSFC

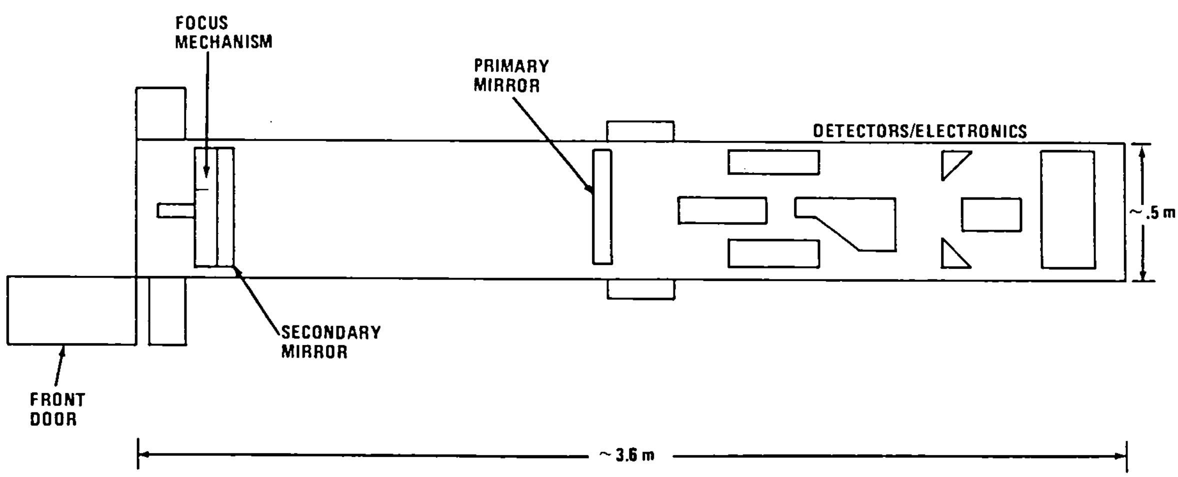
Short Description: The major objectives of HRTS are (1) the investigation of the energy balance and mass balance of the temperature minimum, chromosphere, transition zone, and corona in quiet regions on the Sun as well as in plages, flares, and sun-spots; (2) the investigation of the velocity field of the lower corona to study the origin of the solar wind; (3) the investigation of preflare and flare phenomena. The HRTS instrument consists of a telescope, an ultraviolet spectrograph, and ultraviolet spectroheliograph, and an H-alpha slit display system, all housed in a thermal control canister mounted on an instrument pointing system.

Instrument Characteristics:

Mass:	330 kg
Volume:	2.5 cubic meters
Power:	240 watts at 28 Vdc
Data Rate:	Digital: 3.2 kbps; Film: 1000 frames; H-alpha TV: 4.2 MHz
Pointing:	Direction: Sun; Accuracy: 60 arcsec; Stability: 1 arcsec

General Comments: Early versions of this instrument have flown successfully on rockets. Improved versions are planned to fly on Spacelab 2 and Sunlab. On STO, images from the H-alpha camera should be monitored by the crew and by scientists on the ground.

For more information contact: Dr. Guenter Brueckner, Naval Research Laboratory



Title: ACTIVE CAVITY RADIOMETER (ACR)

Prepared by: Ron Moore, MSFC

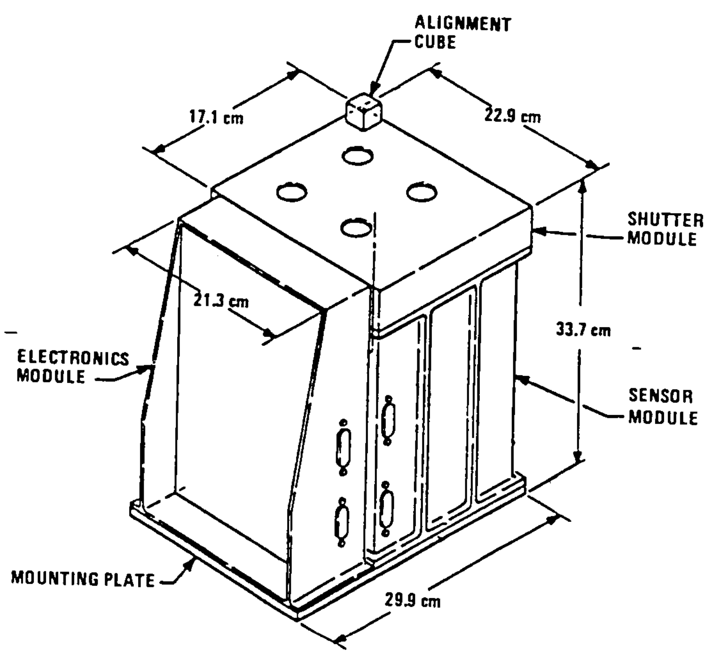
Short Description: The ACR measures the total solar irradiance to determine the magnitude and direction of variations in the total solar radiative output. The ACR is an electrically self-calibrating cavity pyroheliometer capable of measuring the total solar irradiance with an absolute accuracy better than 0.2 percent and capable of detecting changes in the total irradiance smaller than 0.001 percent. The data will be used to study the physical behavior of the Sun and the Earth's climate.

Instrument Characteristics:

Mass:	20 kg
Volume:	0.3 cubic meters
Power:	15 watts
Data Rate:	0.2 kbps
Pointing:	Direction: Sun center; Accuracy: better than 2 deg

General Comments: The ACR has flown successfully on the Solar Maximum Mission and on STS Missions.

For more information, contact: Dr. Richard Willson, Jet Propulsion Laboratory



Title: WAVES IN SPACE PLASMAS (WISP)

Prepared by: William W. L. Taylor, TRW

Short Description: WISP utilizes powerful radio transmitters and sensitive receivers to probe the secrets of the magnetosphere, ionosphere and atmosphere. The scientific objective is to achieve a better understanding of the physical processes occurring in these regions. For example, audio frequency radio waves will be radiated from the long WISP antenna, will travel to the outer reaches of the magnetosphere, and will interact with Van Allen belt particles, releasing some of their energy which amplifies the waves. Study of this interaction will give us a better understanding of a major magnetospheric process, wave-particle interactions. Radio waves from WISP at higher frequencies (AM radio and beyond) will be reflected by the ionosphere and will, for example, advance our understanding of bubbles in the equatorial ionosphere which affect satellite communications.

Instrument Characteristics:

Mass:	1200 kg
Volume:	6 cubic meters
Power:	6 kW initially (evolving to 50+ kW)
Data Rate:	10 Mbs

General Comments:

Heritage is from Spacelab instrument to fly in 1990 and 1992 on SPL 1 and 2.

No scanning is required.

The antenna will be extendable and retractable, but once extended, does not have to be retracted until the end of the WISP mission.

It is expected that a fixed location for the antenna will be adequate for the science on STO.

Antenna mounting must be such that its axis is in the velocity vector or the zenith/nadir vector.

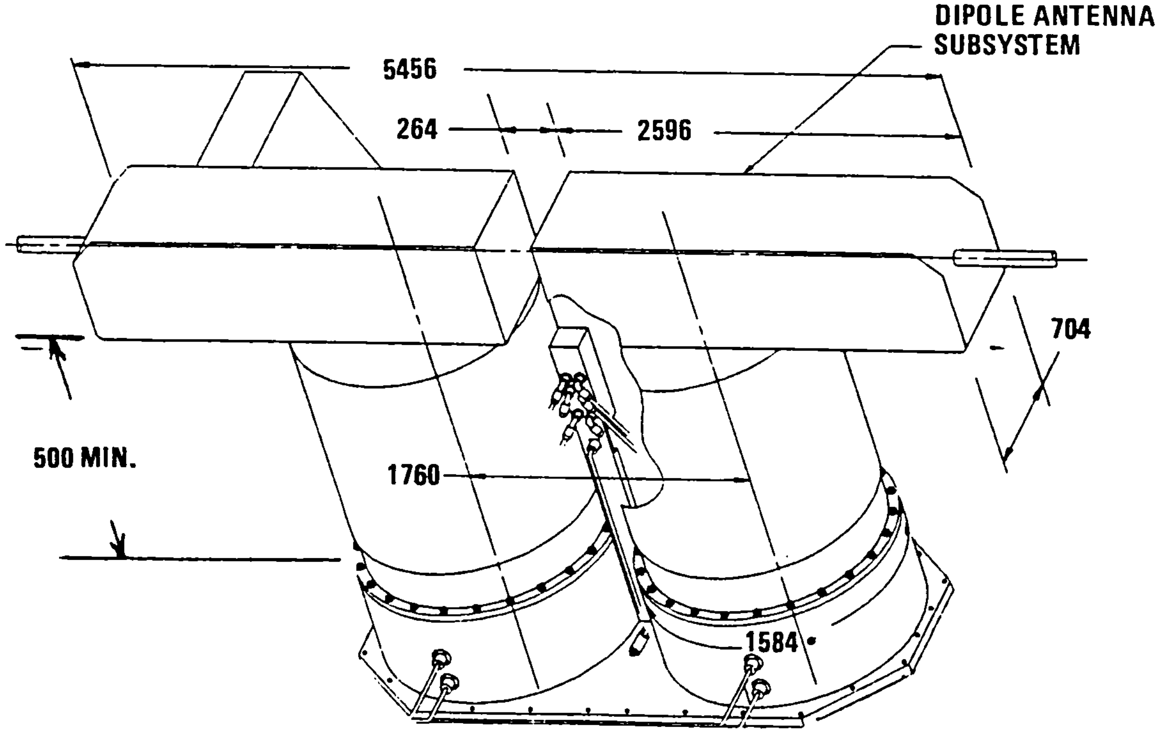
Antenna length may be up to 1000 meters (desired) tip-to-tip (300 meters tip-to-tip initially).

WISP must also be able to connect to the conducting tether wire for an antenna.

Source of Information: WISP development for SPL.

For more information, contact: Robert W. Fredricks or William W. L. Taylor
TRW, R1/1170
One Space Park
Redondo Beach, CA 90278
213-536-2017

WAVES IN SPACE PLASMA INSTRUMENTS INCLUDE 13 BOXES THAT ARE COLD PLATE SIZE PLUS



NOTE: DIMENSIONS IN mm

Title: SPACE EXPERIMENTS WITH PARTICLE ACCELERATORS: SEPAC

Prepared by: Bill Robert, NASA/MSFC

Short Description: The SEPAC instruments consist of an electron accelerator, a plasma accelerator, a neutral gas (N_2) release device, particle and field diagnostic instruments, and a low light level television system. These instruments are used to accomplish multiple experiments: to study beam-particle interactions and other plasma processes; as probes to investigate magnetospheric processes; and as perturbation devices to study energy coupling mechanisms in the magnetosphere, ionosphere, and upper atmosphere.

Instrument Characteristics:

Mass:	600 kg
Volume:	3 cubic meters
Power:	1.5 kW
Data Rate:	512 kbs plus 1 analog and 1 video

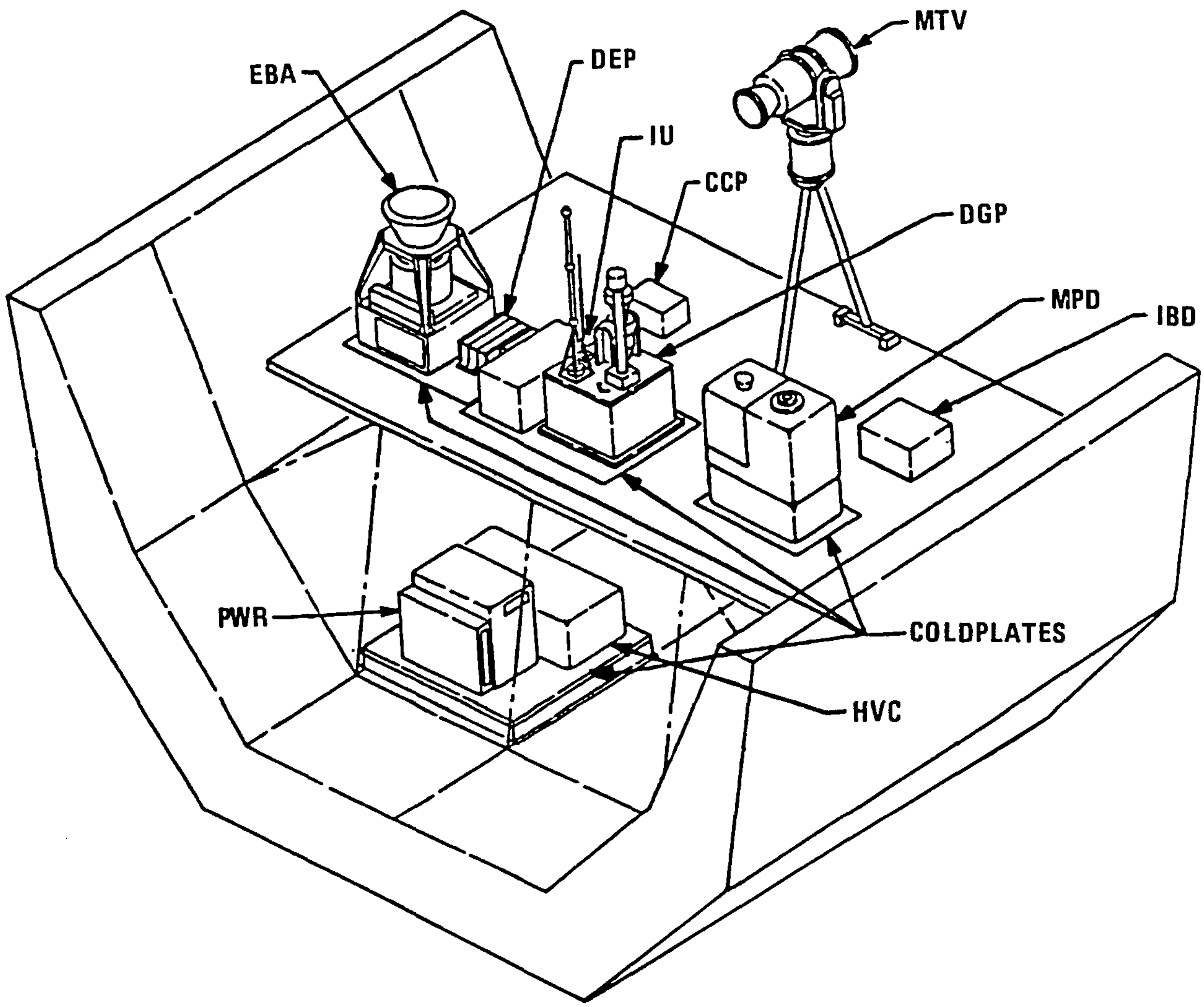
General Comments:

Heritage is from Spacelab instrument flown in 1983 on Spacelab I, and scheduled for reflight on the Earth Observation Mission (1986) and Space Plasma Lab (1990, 1992).

No scanning is required. SEPAC television provides its own pointing system. SEPAC electron accelerator provides deflection coils for beam pointing.

For more information contact: Bill Roberts, PS02
NASA/MSFC
Huntsville, AL 35812
(205) 453-3430

SEPAC PALLET–MOUNTED HARDWARE



Title: THEORETICAL AND EXPERIMENTAL BEAM PLASMA PHYSICS (TEBPP)

Prepared by: Bill Roberts, NASA/MSFC

Short Description: The TEBPP consists of a package of five instruments to measure electric and magnetic fields, plasma density and temperature, neutral density, photometric emissions, and energetic particle spectra during firings of the particle injector (SEPAC) electron beam. The package is deployed on a maneuverable boom (or RMS) and is used to measure beam characteristics and induced perturbations in the near field (<10 m) and mid field (<10 m to 100 m) along the electron beam. The TEBPP package will be designed to investigate induced oscillations and induced electromagnetic mode waves, neutral and ion density and temperature effects, and beam characteristics as a function of axial distance.

Instrument Characteristics:

Mass:	36 kgm
Volume:	0.1 cubic meters
Power:	0.07 kW
Data Rate:	4 Mbs

General Comments:

Heritage is from instrument package being designed for flight on Space Plasma Lab (1992).

TEBPP package will be designed to be deployed and maneuvered at the end of an RMS.

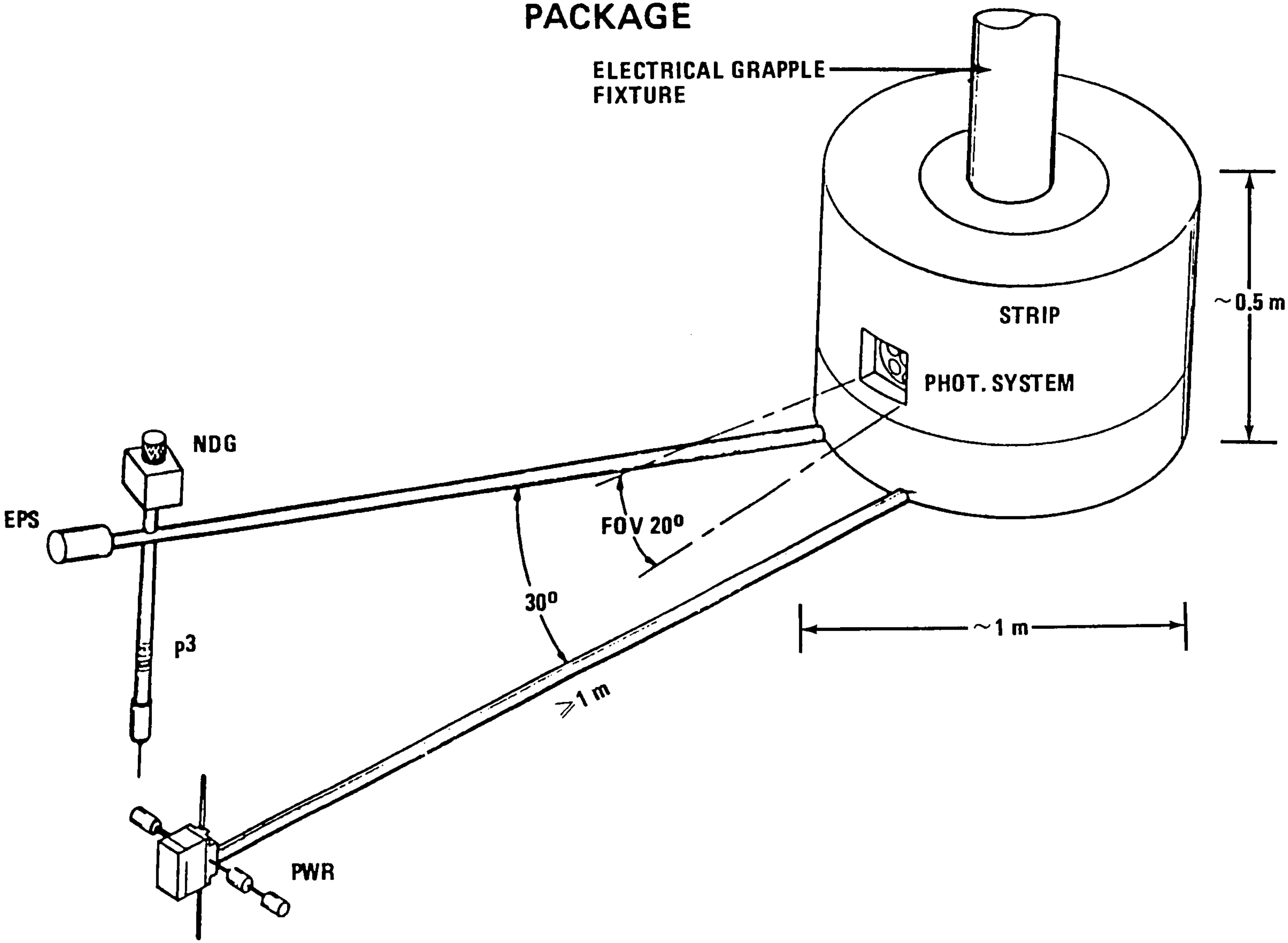
The 4 Mbs data rate may be sampled to accommodate lower (<64 kbs) data rate restrictions.

Instruments may also be useful for other active experiments and for monitoring the ambient environment of the Space Station.

Source of Information: PDR documents

For more information contact: Bill Roberts, PS02
NASA/MSFC
Huntsville, AL 35812
(205) 453-3430

THEORETICAL AND EXPERIMENTAL BEAM PLASMA PHYSICS PACKAGE



Title: RECOVERABLE PLASMA DIAGNOSTICS PACKAGE (RPDP)

Prepared by: Bill Roberts, NASA/MSFC

Short Description: The RPDP is an ejectable and recoverable satellite with flight and ground support systems so that it can be utilized in three modes: attached to an RMS; tethered; or as a subsatellite. The satellite is well instrumented with particle and field diagnostic as well as optical sensors to: investigate the dynamics of the natural environment or ejected perturbations from particle beams; measure the characteristics and propagation of electrostatic and electromagnetic waves; study wave particle interactions; study natural properties of the magnetosphere, ionosphere, and upper atmosphere.

Instrument Characteristics:

Mass:	580 kg (540 kg satellite, 40 kgm Space Station equipment)
Volume:	1.5 cubic meters
Power:	0.8 kW (when operated on RMS, 0.2 kW as a subsatellite)
Data Rate:	1.25 Mbs

General Comments:

Early versions flown on OSS-1 (1982) and Spacelab II missions (1985). The RPDP is scheduled for flight on Space Plasma Lab (1990, 1992).

Plan for the RPDP to free fly in a "station keeping" mode with Space Station, so that the periodic pickup and repositioning will be done by the STS or OMV. The RPDP has no maneuvering capability.

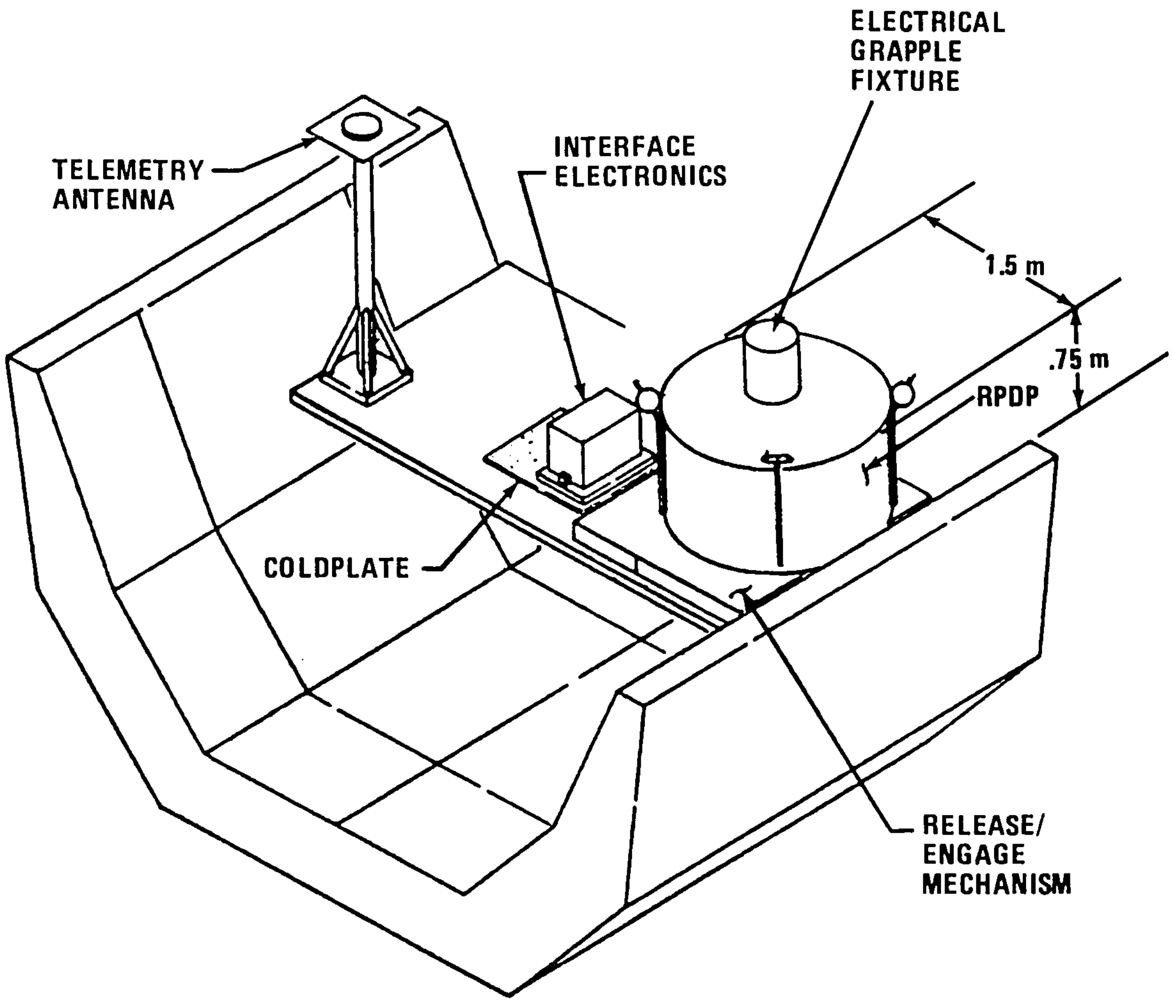
Range from Space Station should be within 200 km for active experiments (although the RPDP could drift up to one orbit differentially).

Data routed through Space Station. (Ground stations can be used 200 km range).

Source of Information: RPDP fact sheet

For more information contact: Bill Roberts, PS02
NASA/MSFC
Huntsville, AL 35812
(205) 453-3430

RECOVERABLE PLASMA DIAGNOSTICS PACKAGE ASSEMBLY MOUNTED ON A PALLET



Title: ELECTRODYNAMIC TETHER

Prepared by: Bill Roberts, NASA/MSFC

Short Description: The Electrodynamic Tether consists of a satellite deployed to a distance of 20 km by an electrically conducting tether. The Space Station hardware consists of a 12 m deployment boom, satellite cradle, tether reel and motor, and other tether support systems. The Electrodynamic Tether will be used to perform a variety of wave experiments by exciting a wide spectrum of low frequency waves in the ionospheric plasma. The system can also be used to artificially generate and study field aligned currents and associated plasma effects. Hydromagnetic waves generated by the passage of the system through the space plasma are of particular interest in space plasma research.

Instrument Characteristics:

Mass:	2600 kgm (includes 500 kgm for satellite)
Volume:	8 cubic meters (includes 1 cubic meter for satellite)
Power:	1.6 kW (1.5 kW for peak operation of the deployer operating for up to 10 hours for each deployment)
Data rate:	64 Kbs
Campaign period:	6 days

General Comments:

Early versions of the Electrodynamic Tether will be flown on STS missions beginning in the late 1980s. It is expected that the tether will also be flown in the "atmospheric mode" before 1990, where a 100 km tether will be deployed down (earthward from the STS).

The tether mission will be a part of the STO "campaign mode" wherein the tether is deployed for one week per month (average), and then retrieved.

Servicing of the satellite is expected to be required after every retrieval.

Items to be serviced include the satellite batteries and gas for satellite thrusters. The tether material should be routinely inspected for material degradation.

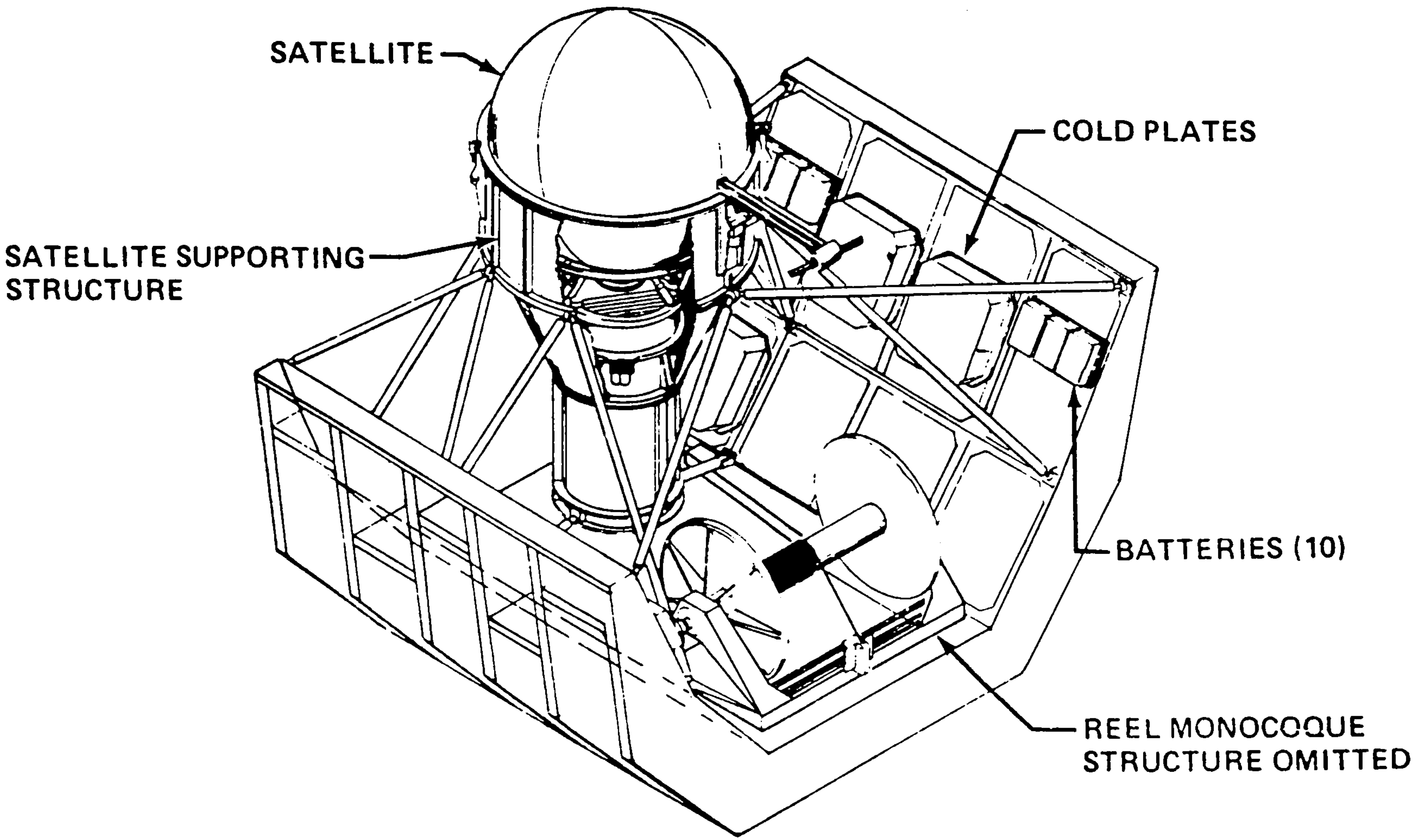
Data will be through Space Station.

Source of Information: TSS Project Documents

For more information contact: Bill Roberts
PS02, NASA/MSFC
Huntsville, AL 35812
(205) 453-3430

PALLET MOUNTED TETHERED SATELLITE SYSTEM

TSS CONFIGURATION



Title: IMAGING SPECTROMETRIC OBSERVATORY (ISO)

Prepared by: Bill Roberts, NASA/MSFC

Short Description: The objectives of this instrument are to measure the spectral signatures of a large range of minor constituents, metastable, and excited species of both atomic and molecular ions, and neutrals in the atmosphere (from the stratosphere to the upper thermosphere). The instrument is composed of five identical spectrometers, each restricted to a given spectral range between 20 and 1200 nanometers designed for high speed operation as an imaging device. Each module is an imaging scanning spectrometer with coincident 0.5 x 0.007deg field-of-view.

Instrument Characteristics:

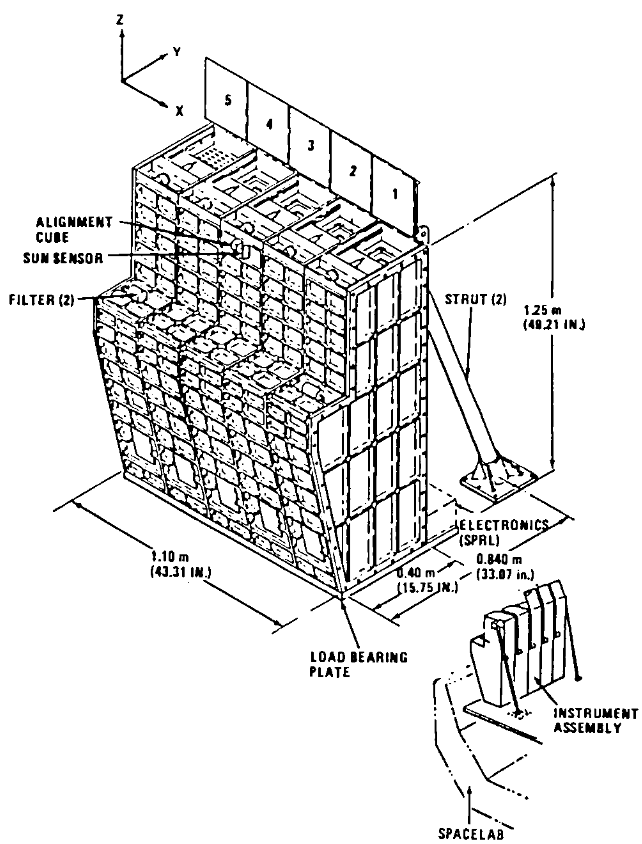
Mass:	250 kgm
Volume:	1 cubic meter
Power:	0.2 kW
Data rate:	2.0 Mbs peak, 125 Kbs average

General Comments:

Heritage is from Spacelab I flown in 1983 with reflights scheduled on Earth Observations Missions (1986, 1988). Instrument is presently fixed-mounted with pointing at nadir or limb using mirror system. Future flights desire mounting on a pointing system. Instrument should be mounted to provide a clear field-of-view from Earth nadir to limb.

Source of Information: ISO fact sheet.

For more information contact: Bill Roberts, PS02, NASA/MSFC, Huntsville, AL 35812.



Title: ATMOSPHERIC EMISSION PHOTOMETRIC IMAGING (AEPI)

Prepared by: Bill Roberts, NASA/MSFC

Short Description: The AEPI consists of a dual channel, low light level video system with a filter wheel to isolate the emissions of interest, mounted on a stabilized, two-axis gimbal system for pointing and control. The objectives are to produce images of various atmospheric emissions to: investigate ionospheric transport processes; observe induced emissions from artificial particle injection; measure electron impact cross sections of atmospheric species; study natural aurora at high spatial and temporal resolutions and in the ultraviolet.

Instrument Characteristics:

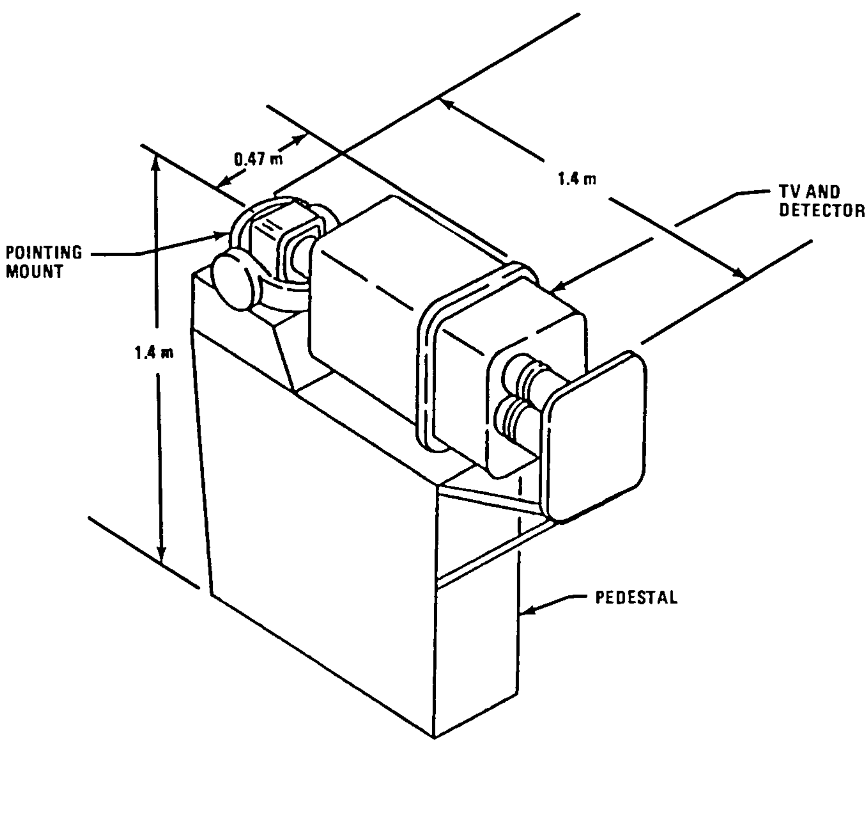
Mass:	200 kg
Volume:	1 cubic meter
Power:	0.35 kW
Data rate:	300 Kbs plus 1 video channel.

General Comments:

Heritage is from Spacelab I flown in 1983 and reflights scheduled on Earth Observation Missions (1986) and Space Plasma Lab (1992). The instrument provides its own pointing mount. Instrument requires a clear field-of-view from Earth nadir to limb, in all directions.

Source of Information: AEPI fact sheet

For more information contact: Bill Roberts, PS02, NASA/MSFC, Huntsville, AL 35812



Title: MAGNETOSPHERIC MULTIPROBES (MMP/Chemsat)

Prepared by: Jim Burch, SwRI

Short Description: The Multiprobes (MMP) are a set of ejectable, self-contained, limited-lifetime free flyers which are designed to make plasma diagnostic measurements at multiple locations within telemetry range of the Space Station's co-orbiting platform and polar platform. When configured as CHEMSATS, one or more MMP's will conduct chemical releases as tracers or modifiers of the local plasma and field environment, while diagnostic measurements are made from other MMP's and from the nearby platform. The probes will be battery powered and will have lifetimes of a few days to several weeks. Up to 12 probes would be placed on the co-orbiting platform and the polar platform every six months and two years, respectively, for use in the campaign mode of operation.

Instrument Characteristics:

Mass:	Carrier and ejection mechanism for each probe: 160 kg; individual probe: 160 kg
Dimensions:	Carrier and ejection mechanism for each probe: 1.1 m diameter; 1.3 m height. Individual probe: 0.9 m diameter; 0.5 m height.
Power:	1000 Watts on platform; 500 Watts on each probe (from self-contained battery)
Data Rate:	400 kb/s per probe

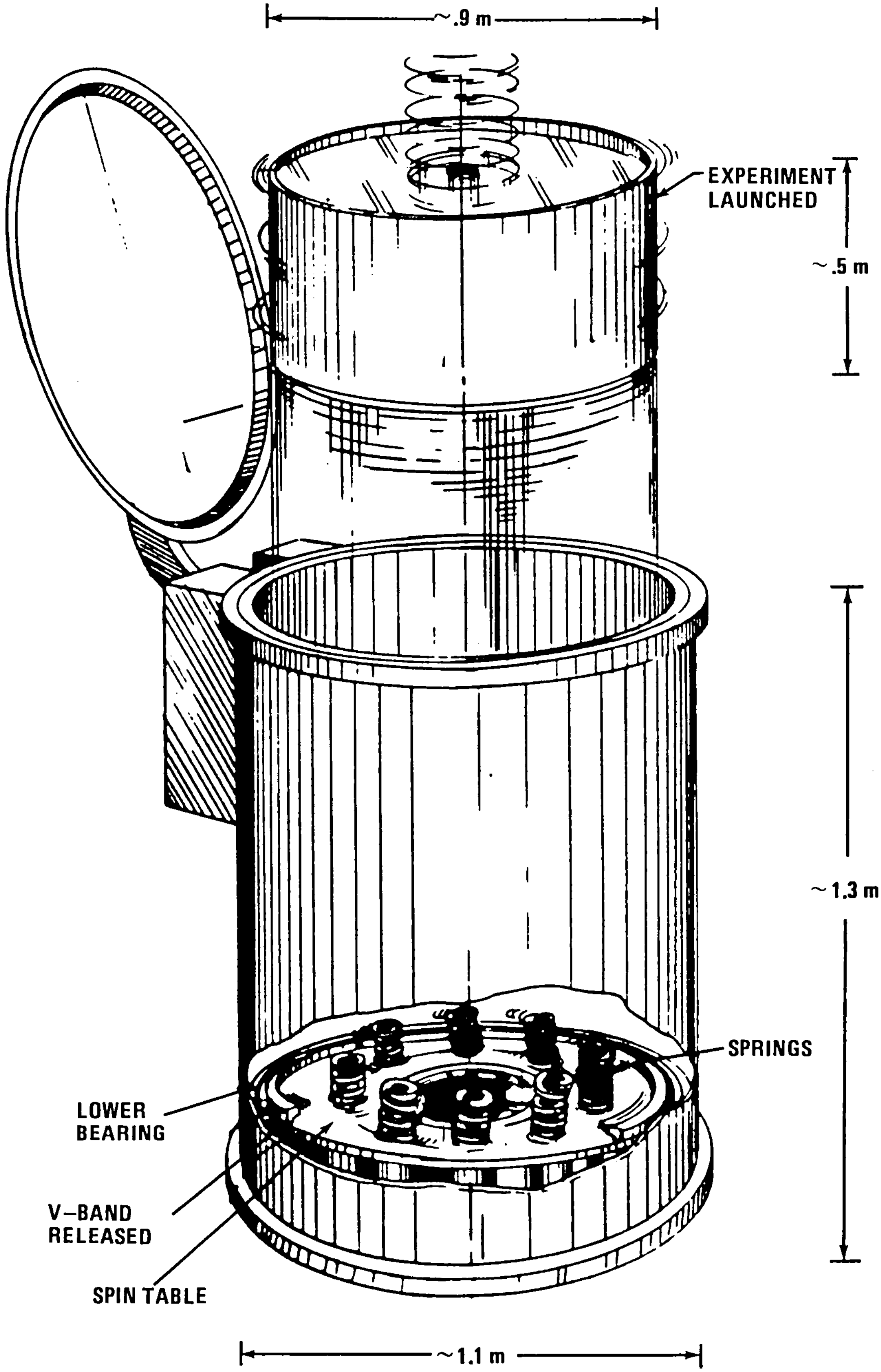
General Comments:

The MMP system is being developed by Wallops Flight Center. A single-probe Shuttle mission is tentatively scheduled for late 1987 and a four-probe mission for late 1989.

Data routed through Space Station Platforms.

For more information, contact: Dr. Jim Burch
Southwest Research Institute
P.O. Drawer 28510
San Antonio, TX 78284

EJECTION OF MULTIPROBE FROM CARRIER



Title: WIDE ANGLE MICHELSON DOPPLER IMAGING INTERFEROMETER (WAMDII)

Prepared by: Bill Roberts, NASA/MSFC

Short Description: The WAMDII is a specialized type of optical Michelson interferometer working at sufficiently long path difference to measure Doppler shifts and to infer Doppler line widths of naturally occurring upper atmospheric Gaussian line emissions. The instrument is intended to measure vertical profiles of atmospheric winds and temperatures within the altitude range of 85 km to 300 km. The WAMDII consists of a Michelson interferometer followed by a camera lens and an 85 x 106 CCD photodiode array. Narrow band filters in a filter wheel are used to isolate individual line emissions and the lens forms an image of the emitting region on the CCD array.

Instrument Characteristics:

Mass:	100 kgm
Volume:	0.4 cubic meters
Power:	0.2 kW
Data rate:	324 kbs

General Comments:

Heritage is from an instrument being designed for flight on a future STS mission.

Instrument requires accurate knowledge of the angle between the look-direction and the spacecraft velocity vector to an accuracy of 0.03 degrees.

Field-of-view is rectangular of dimensions 6.0° x 7.5°.

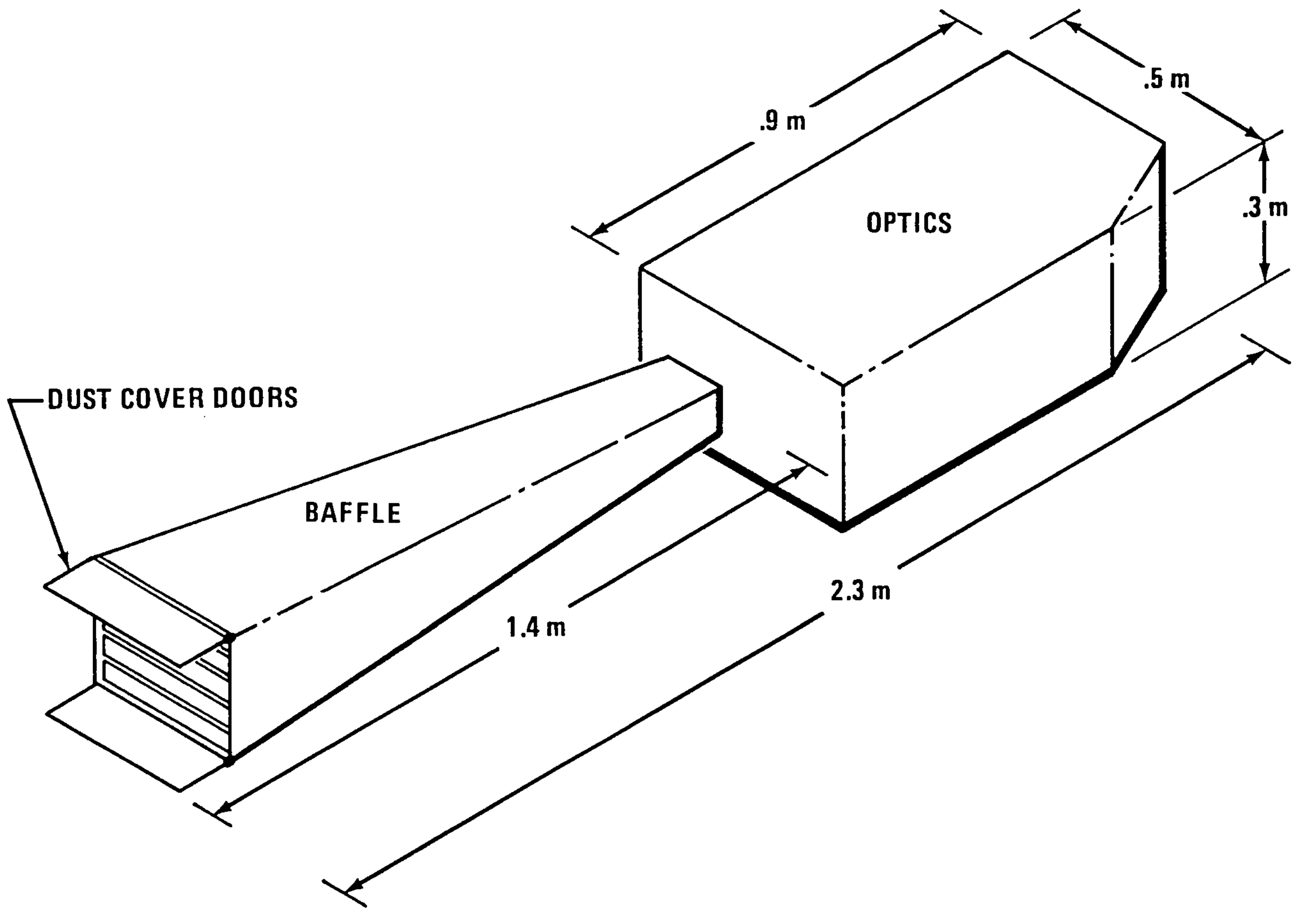
Requires pointing accuracy of 0.5°.

Other targets include auroral forms, airglow irregularities, chemical releases, particle beam injections, and emissions stimulated by wave injections.

Source of Information: Experiment Requirements Document

For more information, contact: Bill Roberts
PS02, NASA/MSFC
Huntsville, AL 35812
(205) 453-3430

WIDE ANGLE DOPPLER IMAGING INTERFEROMETER OPTICS



Title: VEHICLE CHARGING AND POTENTIAL (VCAP)

Prepared by: Bill Roberts, NASA/MSFC

Short Description: The instrumentation of the VCAP includes a small electron accelerator capable of operating in a pulsed mode with firing pulses ranging from 600 nanoseconds to 107 seconds (100 milliamps at 1000 volts), a spherical retarding potential analyzer-Langmuir probe, and charge current probes. This instrumentation will support studies of beam plasma interactions and the electrical charging of the spacecraft. Active experiments may also be performed to investigate the fundamental processes of artificial aurora and ionospheric perturbations. In addition, by firing the beam up the geomagnetic field lines of force (away from the Earth) investigations of parallel electrical fields may be performed.

Instrument Characteristics:

Mass:	100 kilograms
Volume:	0.3 cubic meters
Power:	0.3 kilowatts
Data rate:	100 Kbps

General Comments:

Instrumentation originally flown on OSS-1 and Spacelab II missions.

The VCAP will be operated during STO campaign modes to support magnetosphere/ionosphere investigations.

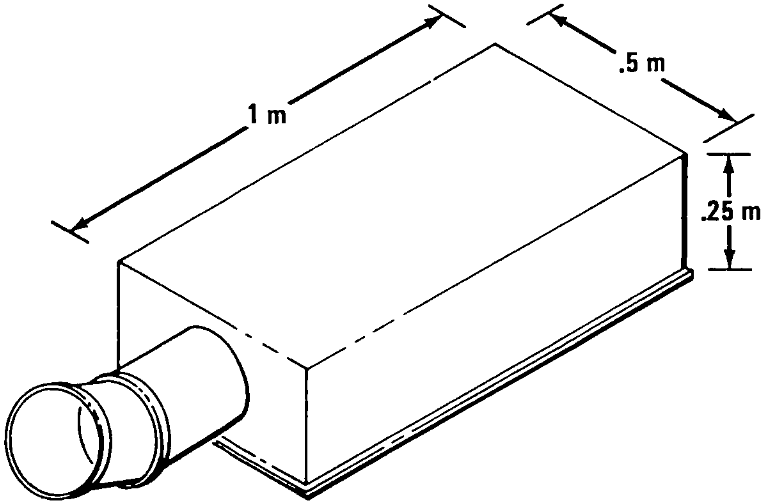
Coordinated experiments between the polar platform and the manned Space Station will occasionally be performed.

Coordinated investigations with other polar platform instruments will be performed.

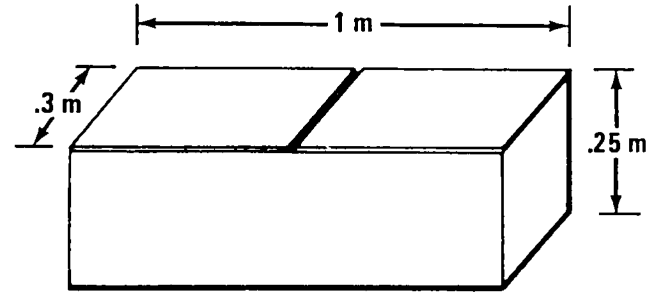
Source of Information: VCAP Information Sheets

For more information, contact:
Bill Roberts
PS02, NASA/MSFC
Huntsville, AL 35812
(205) 453-3430

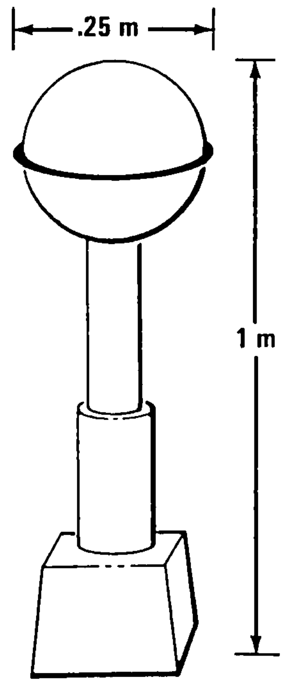
VEHICLE CHARGING AND POTENTIAL EXPERIMENT PACKAGES



FAST PULSE ELECTRON GUN



CHARGE CURRENT PROBE



SPHERICAL PROBE

INITIAL PLACEMENT OF STO INSTRUMENTS

The current plans for the placement of STO instruments on the IOC Space Station will make use of each of the currently planned Space Station elements — the manned Space Station, the polar platform, and the co-orbiting platform. Table 1 provides a designation of the instrument placement on each element along with a summary of the mass, volume, power, and data requirements which these instruments will impose.

The solar instruments will be placed on the manned Space Station and will operate continuously, making observations fo the Sun. Of particular importance is the need to obtain continuing information of the total radiative output of the Sun (so called solar constant). Changes of a fraction of a percent in solar radiation would have a significant effect on Earth's energy input and thus the long-term climatic conditions. The ultraviolet portion of the solar spectrum has a particularly dramatic effect on the chemistry of Earth's middle atmosphere. Long-term monitoring of this portion of the solar spectrum will be accomplished by the use of an ultraviolet irradiance monitor. Measurements of coronal changes, soft X-ray emissions, and mass ejections will also provide data on solar energetic events which will trigger periodic operations of the Solar Terrestrial Observatory in the campaign mode. These modes of operation will be invoked to study the coupling of active events on the Sun into Earth's environment.

Also, the large active instruments will be on the manned Space Station. These instruments include large electron and plasma accelerators, with associated beam plasma diagnostic monitors, high power wave injectors, and an electrodynamic tether system. The accelerators are used to investigate beam plasma interactions, ionospheric modifications, plasma propagation and ionization, and stimulated emissions. These accelerators operate in a pulsed mode with firing durations of about 5 sec at low power (<5 kW) ranging to 0.1 sec at high power (<40 kW). A number of particle and field diagnostic instruments are included to support the assessment of the effects of the beam on the ambient environment, on the Space Station, and on the beam itself. These instruments include ion spectrometers, electron detectors, wave detectors, neutral particle detectors, photometers, and a low light level imager. One particular group of instruments will be built for mounting on the RMS. These instruments will be moved radially along the accelerated beam to measure beam properties and their variations at different positions along the beam. The RMS mounted instruments will require that the crewman, using the Space Station RMS, pick up the diagnostic package and control its position and operations during selected firings of the accelerators. This package may also have a use for measuring the interactions of the ambient plasma with the Space Station, and the flow of the plasma around the Space Station. In addition, the RPDP makes similar measurements at various ranges remote from the Space Station.

The wave-injection instruments are also on the manned Space Station, and are used for studies of wave-particle interactions, wave propagation, and ionsopheric sounding. The instrument radiates energy from a long dipole antenna which is deployed during the operations campaigns and can be retracted at all other times. The antenna length will normally be deployed to 150 m per element (300 m tip-to-tip) but may achieve 1000 m tip-to-tip when fully deployed. This instrument may be used in the high frequency mode to perform soundings to study the propagation of ionospheric disturbances and topside ionospheric structures. The instrument is also

SOLAR TERRESTRIAL OBSERVATORY
PROPOSED INITIAL PLACEMENT OF INSTRUMENTS

3770–85

MANNED STATION	MASS	VOLUME	POWER	DATA RATE	COMMENT
CORONOGRAPH	250 KG	3.0 M^3	.1 KW	100 KBPS	
TOTAL IRRADIANCE MONITOR	20 KG	0.03 M^3	.015 KW	.2 KBPS	
UV IRRADIANCE MONITOR	135 KG	0.5 M^3	.7 KW	.5 KBPS	
HRTS	330 KG	2.5 M^3	.25 KW	3.2 KBPS*	* PLUS FILM AND TV
SOFT X–RAY TELESCOPE	170 KG	1.0 M^3	.1 KW	100 KBPS*	*PLUS TV
WAVE INJECTOR	1200 KG	6.0 M^3	25 KW*	10 MBPS	*MAXIMUM POWER (WILL GROW)
PARTICLE INJECTOR	600 KG	3.0 M^3	1.5 KW	512 KBPS*	*DATA PLUS VIDEO & ANALOG
PLASMA MONITORS	36 KG	0.1 M^3	70 WATTS	4 MBPS	DESIGNED FOR RMS MOUNT
RECOVERABLE PLASMA SATELLITE	580 KG	1.5 M^3	200 WATTS	1.25 MBPS	FREE FLYER
TETHER	2600 KG	8.0 M^3	1.6 KW*	64 KBPS	*PEAK POWER DURING DEPLOY.
TOTAL	5921 KG	26 M^3	30 KW*	17 MBPS*	*PEAK DEMAND
POLAR PLATFORM	MASS	VOLUME	POWER	DATA RATE	COMMENT
IMAGING SPECTROMETERS	250 KG	1.0 M^3	200 WATTS	2.0 MBPS*	*PEAK DATA RATE
PHOTOMETRIC IMAGER	200 KG	1.0 M^3	350 WATTS	300 KBPS*	*DATA PLUS VIDEO
IMAGING INTERFEROMETER	100 KG	0.4 M^3	200 WATTS	324 KBPS	
EJECTABLE PROBES	4000 KG	16.0 M^3	1.0 KW	400 KBPS*	*PER EJECTABLE PROBE
PARTICLE INJECTOR	100 KG	.3 M^3	300 WATTS	100 KBPS	
TOTAL	4650 KG	19 M^3	2050 WATTS	3.2 MBPS*	*PEAK DEMAND + VIDEO
CO–ORBITING PLATFORM	MASS	VOLUME	POWER	DATA RATE	COMMENT
EJECTABLE PROBES	4000 KGM	16.0 M^3	1.0 KW	400 KBPS*	*PER EJECTABLE PROBE

used to investigate plasma heating and other perturbations of interest and importance in space plasma physics. Wave experiments are also performed in coordination with the free-flying RPDP.

The final instrument mounted directly on the Space Station at IOC will be a long tether system. The initial tether system will be configured to perform electrodynamic experiments and will be deployed to a length of 20 km. The deployment will require about 8 hr and when deployed will operate in a variety of modes to support the specific experiments being performed. Since this is an electrodynamic tether, the tether line itself will be an electrical conductor. The tether will be retrieved at all times when not operating. The electrodynamic tether may be connected to the wave injector for use as a long antenna. The tether can be used to generate low frequency waves and to provide a path for electrical conduction during electron or ion accelerator operations. The tether can also be used as a collector of electrical power as the conducting tether line cuts through the Earth's magnetic field.

The recoverable plasma subsatellite (RPDP), although not connected directly to the manned Space Station, will fly in the vicinity of the station and will perform coordinated observations during campaign mode operations on the Station. This subsatellite will also provide data on ambient particle and field conditions at the Space Station orbit at all times. Periodic servicing, reboost, and repositioning of the satellite will either be performed from the manned Space Station (using the OMV capability) or as a special function of STS logistic flights to the manned Space Station. The satellite will contain a full complement of particle and field instruments as well as selected imaging and photometer systems. Operational control and data flow will be primarily through the manned Space Station although backup ground control is planned.

One STO instrument system is planned for placement on the Space Station co-orbiting platform — a system to eject small probes (multiprobes). These multiprobes will contain diagnostic detectors or chemical/gas release cannisters. (Other diagnostic plasma instruments could also be accommodated on the co-orbiting platform.) The ejectable probes are presently being designed to be contained in a single modular package containing multiple "throw away" rocket class probes. Each probe will host three to four instruments designed to measure electric and magnetic fields, ion constituent densities and temperatures, electron density and temperature, energetic charged particles, and neutral density. The probes will be battery powered and will have lifetimes of a few days to months. They will be ejected to support campaign mode operations, monitoring the ambient environment at multiple points in the magnetosphere/ionosphere, or supporting the active perturbation investigations by measuring the perturbation structure and propagation during accelerator firings and wave injections. A study is currently contemplated to include the capability for selected multiprobes to contain chemicals (CHEMSAT) which may be released to "paint" the magnetosphere for studies of magnetic field topology, the existence of magnetospheric electric fields, upper atmospheric winds, and critical velocity ionization. A set of 12 of these multiprobes (8 diagnostic, 4 CHEMSAT) would be placed on the coorbiting platform. Two to six of these probes would be ejected during, or immediately before, each of the STO operational campaign modes. Servicing missions to the co-orbiting platform will be required every 6 to 12 months to reload the packages with a new set of probes.

The polar platform will contain the atmospheric monitoring instruments. These instruments will operate full time except for the photometric imager which can only operate at full capacity during the night portion of the orbit. These instruments will continually monitor the dynamics of the upper atmosphere, aurora and airglow, and profiles of atmospheric constituents. The compilation of this data is necessary to assess the long term variability of the Earth's upper atmosphere as a function of solar activity, solar irradiation variability, and seasonal variability.

Measurements of aurora and airglow emissions provide information on excitations as a function of solar activity and magnetospheric activity. The photometric imager will provide imaging information on auroral forms and dynamics. The interaction of precipitating energetic particles into the Earth's upper atmosphere also provides information on the dynamics of the outer magnetosphere.

Spectrometers will monitor information from excited atmospheric species in the spectral range from 200 to 12,000 A. From this data, atmospheric composition may be monitored on a global scale. The doppler imaging interferometer provides information on atmospheric winds and temperatures in the mesosphere and lower thermosphere. The variation of this flow as a function of season and solar activity, when combined with information from the other atmospheric instruments, will provide better models of transport processes and energy coupling between the magnetosphere and the atmosphere.

A small accelerator system will also be flown on the STO polar platform. This accelerator will be used in a campaign mode similar to the active instruments on the manned station. It is envisioned that the accelerator instruments will be operated periodically to investigate parallel electric fields in the magnetosphere, for the creation of artificial aurora, and to perform magnetic field topology investigations.

The final STO instrument system to be flown on the polar platform at IOC will be the ejectable probes (multiprobes) similar to those planned for the co-orbiting platform. These probes will be primarily reserved for studies of high solar activity events, i.e., to gather data on the effects phenomena such as solar flares have on the magnetosphere/ionosphere. There will be a combination of both diagnostic probes and chemical/gas release probes (8 diagnostic, 4 CHEMSAT).

SERVICING AND REPAIR REQUIREMENTS

The following table provides some preliminary information on expected servicing and repair requirements for the Solar Terrestrial Observatory instruments on the IOC Space Station elements. The solar instrument requirements appear to be fairly straightforward. We are concerned, however, about possible contamination of optical surfaces from emissions and debris around the Space Station. If, in fact, the Space Station attitude is controlled by control moment gyros, and water/waste dumps are not permitted, the station environment may be expected to be fairly clean. Protection from STS dockings and periodic reboosts may be fairly easily accomplished with doors and shutters to protect optical surfaces. If, however, vacuum venting of debris and gases is allowed for the microgravity research and production facilities, the environment will be much less conducive to optical observations. This deleterious situation may be further compounded by frequent launch and retrieval of the OMV and eventually the OTV if provisions are not made for these systems to use cold gas or other benigh propulsive systems when in the vicinity of the Space Station.

SOLAR TERRESTRIAL OBSERVATORY
GENERAL SERVICING AND REPAIR REQUIREMENTS

	SERVICING		REPAIR	
MANNED STATION	WHAT	INTERVAL	WHAT	HOW
INSTRUMENT				
CORONOGRAPH	–	–	DOOR JAM COMPONENT FAILURE	UNJAM–EVA NOTE 1,2,3
TOTAL IRRADIANCE MONITOR	CALIBRATION	6 MONTH	DOOR JAM COMPONENT FAILURE	UNJAM–EVA NOTE: 1,2,3
UV IRRADIANCE MONITOR	CALIBRATION	6 MONTH	DOOR JAM COMPONENT FAILURE	UNJAM–EVA NOTE: 1,2,3
HRTS	FILM CHANGE	1 MONTH	DOOR JAM COMPONENT FAILURE	UNJAM–EVA NOTE: 1,2,3
SOFT X–RAY TELESCOPE	–	–	DOOR JAM COMPONENT FAILURE	UNJAM–EVA NOTE: 1,2,3
WAVE INJECTOR	–	–	ELECTRONICS FAILURE ANTENNA DAMAGE	NOTE: 1,2,3 REPLACE ELE.
PARTICLE INJECTOR	BATTERIES (SPARES) GAS FILAMENTS (SPARES)	3 MONTHS (INSPECT.) 6 MONTHS 6 MONTHS	ELECTRONICS FAILURE	NOTE: 1,2,3
PLASMA MONITORS	–	–	ELECTRONICS FAILURE	NOTE: 1,2,3
RECOVERABLE PLASMA SAT	OMV OR SHUTTLE REBOOST BATTERIES OPTICAL WINDOWS	6 MONTHS (2 PER YR) 6 MONTHS 6 MONTHS	ANTENNAS BOOMS ELECTRONICS	NOTE: 1,2,3
TETHER	BATTERIES PROPELLANT GAS FOR PLASMA CONTACTOR LANGMUIR PROBE CLEANING	2 MONTHS 2 MONTHS 2 MONTHS 2 MONTHS	MOTOR/REEL ELECTRONICS	NOTE: 1,2,3
POLAR PLATFORM				
INSTRUMENT				
IMAGING SPECTROMETERS	MIRROR CHANGEOUT	2 YEARS	COMPONENT FAILURE	NOTE: 1,3
PHOTOMETRIC IMAGERS	FILTER CHANGEOUT	2 YEARS	COMPONENT FAILURE	NOTE: 1,3
IMAGING INTERFEROMETER	–	–	COMPONENT FAILURE	NOTE: 1,3
EJECTABLE PROBES	RELOAD CANNISTERS	2 YEARS	–	–
PARTICLE INJECTOR	REPLACE RILAMENTS	2 YEARS	ELECTRONICS FAILURE	NOTE: 1,3
CO–ORBITING PLATFORM				
INSTRUMENT				
EJECTABLE PROBES	RELOAD CANNISTERS	6 MONTHS	–	–
DIGNOSTIC INSTRUMENTS	CLEANING PROBES	6 MONTHS	ELECTRONICS FAILURE	NOTE: 1,2,3

NOTES: 1. CHANGE COMPONENT IN PLACE
2. RETRIEVE AND REPAIR AT SPACE STATION
3. RETURN TO GROUND
} DEPENDS ON PROBLEM

The active instruments (wave injectors, particle injectors, and tethers) will probably require the greatest amount of periodic servicing and repair. These are relatively high power systems and the wear on subsystems such as batteries, power amplifiers, antennas, high voltage converters, and filaments will be relatively heavy. Likewise, periodic inspections fo the tether cable and the wave injector dipole antenna will be required to assure that these instrument elements are not worn or otherwise damaged as a result of frequent deployment and retrieval. Plans are made during the initial phase of the STO mission to routinely replace filaments and batteries until enough space lifetime data has been acquired to establish actual lifetimes for these systems. Replacement of gases for the plasma accelerator, propellant for the tethered satellite and gas for the tether plasma contactor will require a standard servicing function. The plasma monitors will probably need little servicing and only periodic repair to replace probes and electronic units.

The recoverable subsatellite will be flown in a station keeping orbit with the Space Station. Since the drag coefficient for the subsatellite will be different from that of the Space Station, the subsatellite will drift away. Periodic repositioning of the subsatellite will thus be required. This can be accomplished by having the STS — while on the way to the Space Station for logistics missions — capture the subsatellite with the RMS and reposition and release the satellite. Alternatively, an OMV missions will be required to capture and reposition the subsatellite. Also, occasional mission might be required to service and repair the subsatellite subsystems such as batteries, instruments, booms, and electronics.

Instruments on the polar platform will be locked to the expected two year intervals between missions. Thus, all servicing and repair functions will have to be tailored to that interval. A special study is needed to identify instrument components which have a mean time to failure of less than two years. Special modifications may have to be made to these instruments. The ejectable probes cannot be replaced as easily as those on the co-orbiting platform so that special care in experiment planning and timelining will be necessary.

The ejectable probes on the co-orbiting platform, however, are expected to be more accessible so that periodic missiosn can be scheduled to replace expended probes on this platform. Also, if there are additional diagnostic instruments on the co-orbiting platform, these may be repaired and serviced during these missions.

SOLAR TERRESTRIAL OBSERVATORY OPERATIONAL SCENARIOS

The STO is an event and comprehensive study-oriented combination of instruments with the goal of providing data to acquire a better understanding of the physical processes that couple the major regions of solar terrestrial space. The currently planned operational process to achieve this goal requires that near continuous monitoring of solar irradiance and solar active regions be established along with near continuous monitoring of atmospheric, ionospheric and magnetospheric constituents, and dynamics. In order to better understand the processes which couple the Earth-space regions, controlled, active experiments are planned which introduce perturbations that simulate or stimulate natural phenomena. These controlled experiments will be performed periodically during the STO mission and are referred to as campaign modes of operation. These campaign modes may be scheduled well ahead to perform a series of experiments to investigate specific physical processes. Alternatively, the campaign modes may be triggered by specific solar events which require experiments designed to investigate the evolution of naturally occurring processes. In this section we will attempt to provide examples of each type of these operational modes.

Some of the STO operational modes could be scheduled for times when the manned Space Station and the polar platform orbits converge on this same geomagnetic lines of force. Although this conjugate situation will only occur for a short time (seconds), the opportunity afforded for coordinated experiments between the manned station and the polar platform will be uniquely valuable.

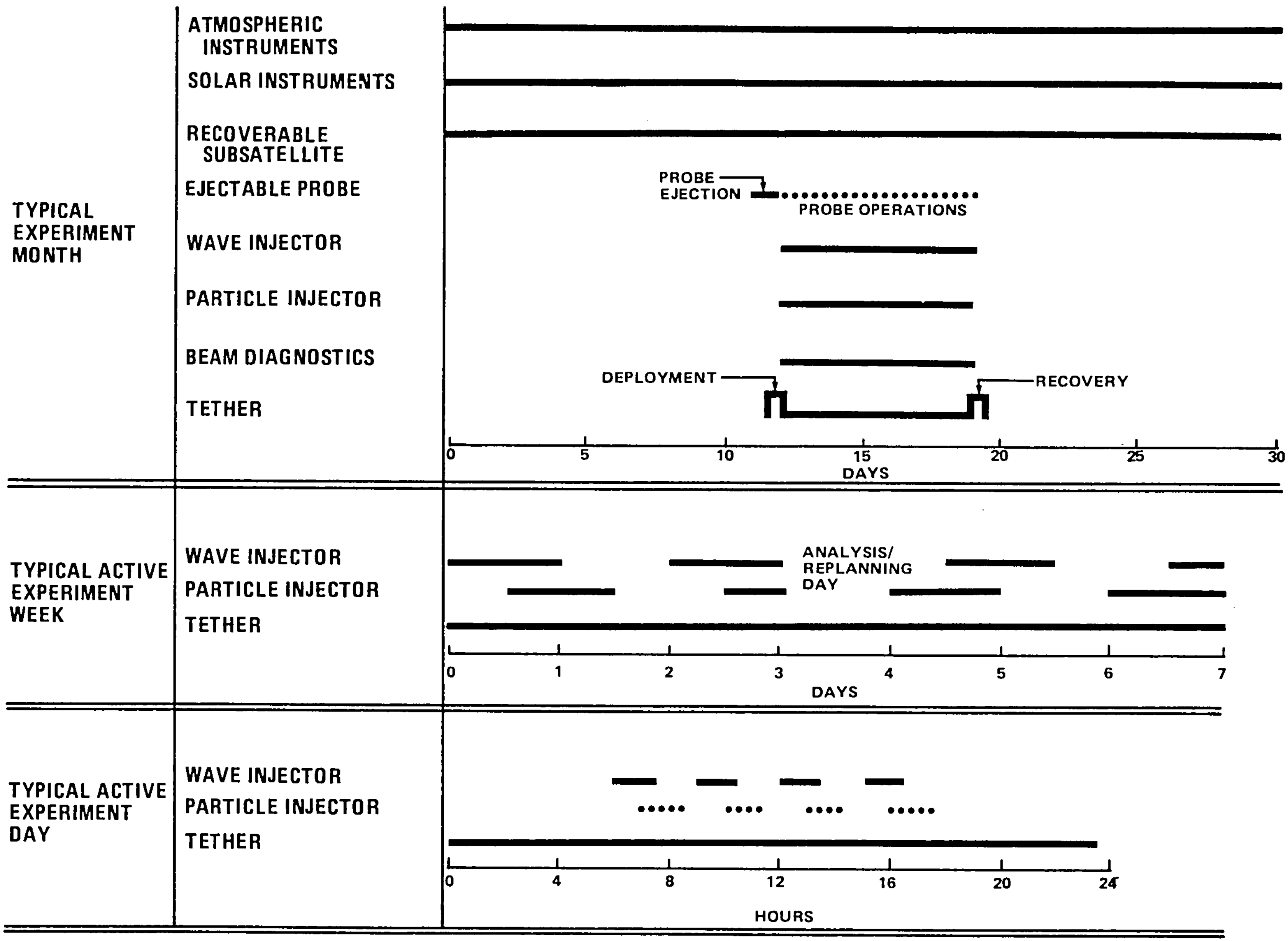
The following figure shows an example of a typical campaign mode of operation. On average these times will be scheduled well ahead and the general experiment scenario will be preplanned. Prior to the start of the campaign mode, the electrodynamic tether will be deployed and the ejectable probe(s) will be released (from the co-orbiting and/or polar platform). The tether diagnostics will be operated for the full time that the tether is deployed, but the use of the electrodynamic mode operations will be performed in conjunction with the wave injector and the particle accelerators. Wave injection and particle accelerator operations will require some coordinated operations and some non-coordinated operations. For example, off-on modulation of the electron accelerator will generate waves which may be detected by the wave injector instruments. This would be an opportunity to perform coordinated investigations of the use of the electron beam as a virtual antenna. Likewise the wave injector using the high frequency sounding techniques is needed to detect and monitor ionospheric disturbances caused by the operation of the particle injectors. Numerous other examples of coordinated experiments involving the simultaneous operation of the wave injectors and the particle accelerators could be discussed. Typically the wave injector operations will have a duration of about one complete orbit (90 minutes) whereas the typical duration for a particle injection experiment is about 5 minutes.

There are also classes of investigations in which the wave injectors and the particle accelerators do not want the disturbances caused by the other system. Time is therefore scheduled for WISP only, and for SEPAC only, operations.

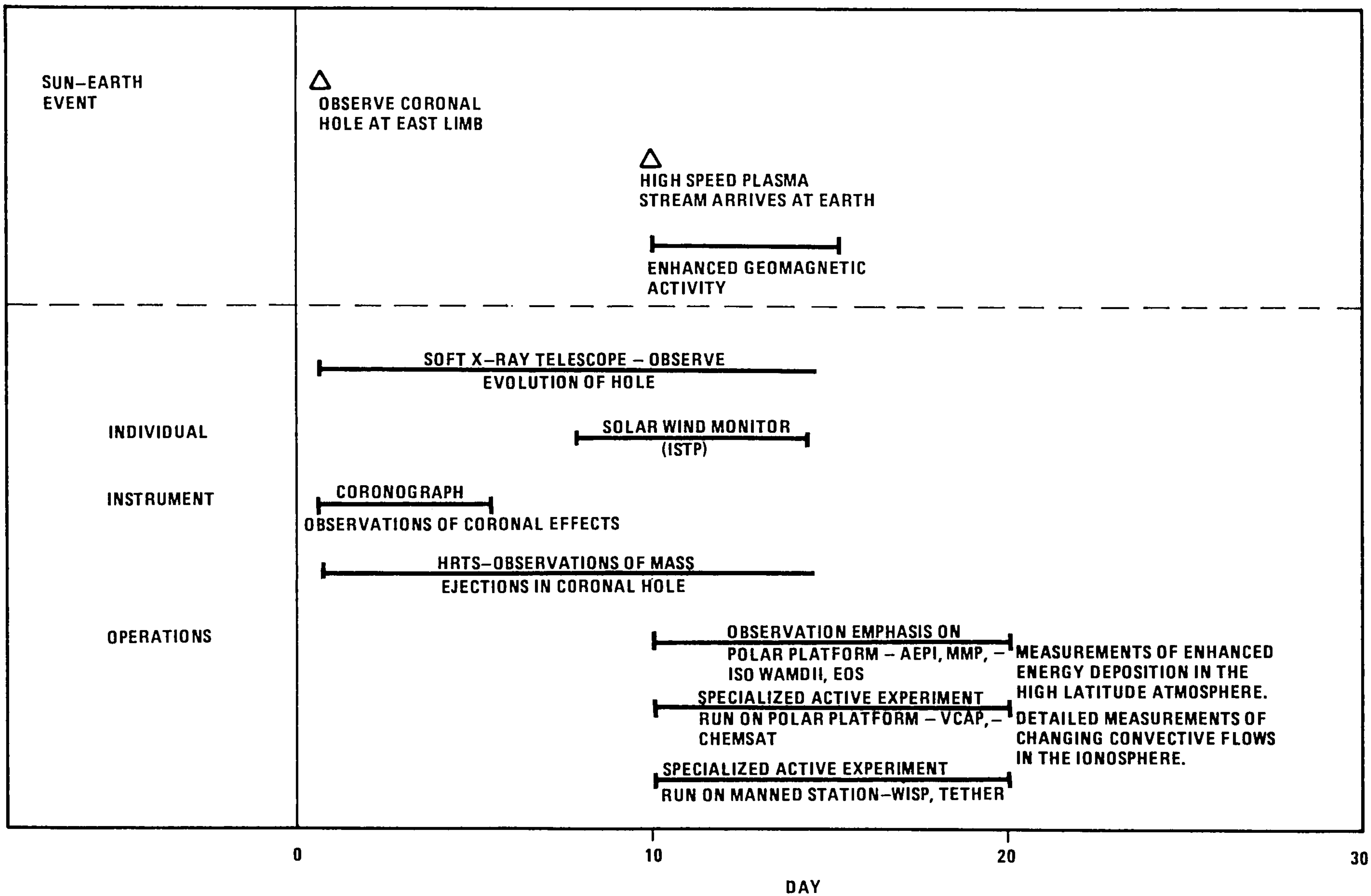
During the week (7 days) of the typical campaign mode of operation, one day will be devoted to analysis of the data acquired to that time, and to accommodate any replanning necessary for the remaining time. Likewise the daily experiment operations will be planned to be accomplished within one 12-hr shift each day. This will leave adequate flexibility for the analysis and any required replanning for the following days' activities. This operational scenario has been derived as a result of our Shuttle/Spacelab experience which demonstrated the need for analysis and replanning time, and also demonstrated the loss of effectiveness of the flight and ground operations personnel resulting from shifts exceeding 9 to 12 hr.

The next two figures show examples of the second class of STO campaign mode operations — solar event triggered campaign modes. Both figures show that a particular type of solar event (i.e., a solar flare or coronal hole) is observed on the Sun, and this triggers the subsequent operational scenarios. The solar instruments will be operated in a high data rate mode as will the atmospheric instruments. Data from other programs will also provide critical information during these times. Data from the International Solar Terrestrial Program (ISTP) satellites will be particularly important for solar wind and magnetospheric data. Data from the Upper Atmospheric Research Satellite (UARS) and the Earth Observing System (EOS) will also be very

TYPICAL (NON SUN–EARTH EVENT TRIGGERED) STO CAMPAIGN MODE

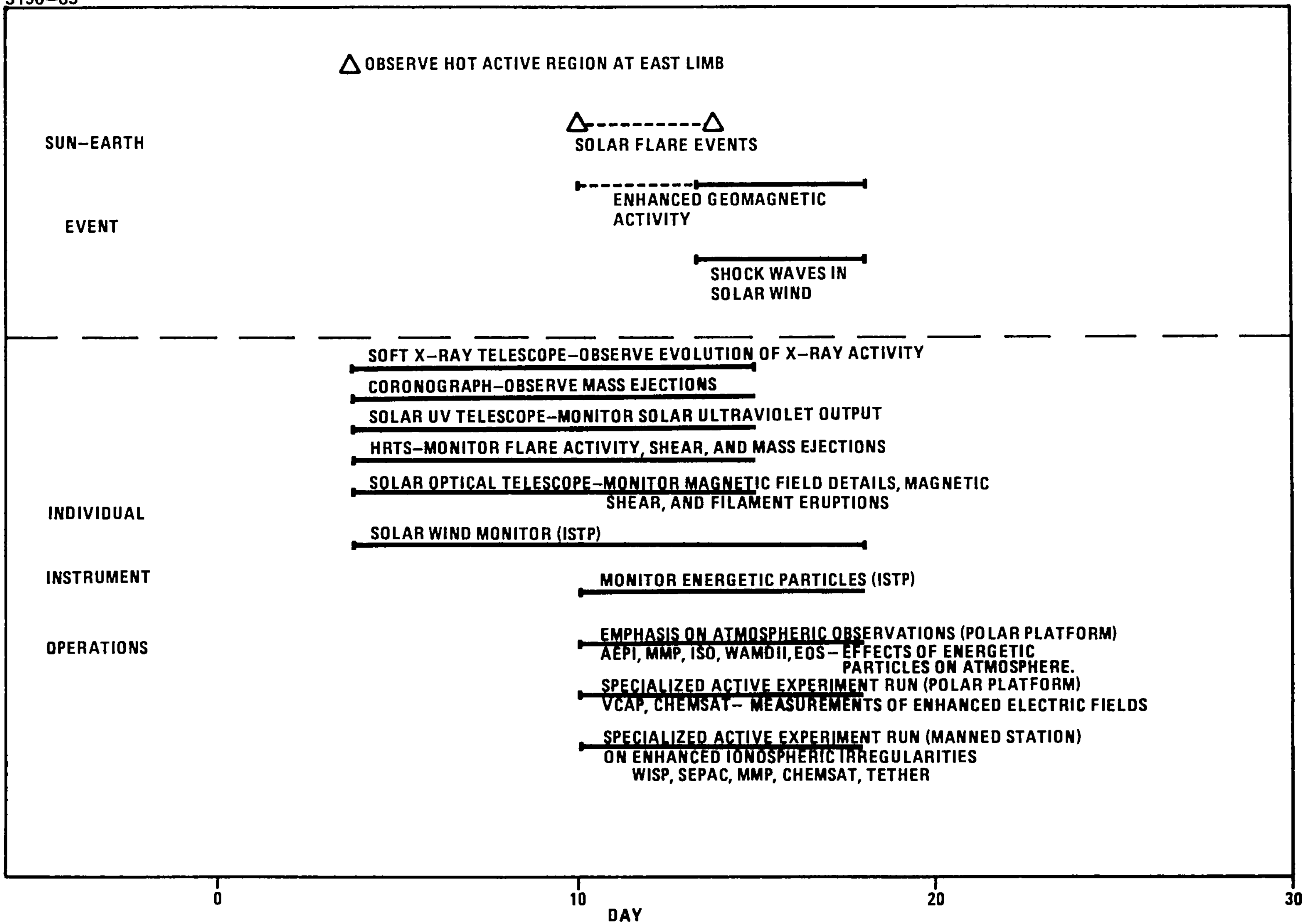


SOLAR TERRESTRIAL OBSERVATORY
SOLAR EVENT TRIGGERED CAMPAIGN MODE
CORONAL HOLE



SOLAR TERRESTRIAL OBSERVATORY
SOLAR EVENT TRIGGERED CAMPAIGN MODE
SOLAR FLARE

3190–85



useful to determine atmospheric effects. Ejectable diagnostic and chemical release probes may be deployed from the polar platform or co-orbiting platform to aid in the investigations of particle and field effects in the magnetosphere/ionosphere system. Likewise the particle accelerators could be used to detect and investigate the occurrence of parallel electric fields. The wave injector would be very useful in mapping traveling ionsopehric disturbances resulting from the deposition of energy into the auroral zone and other sources.

These campaign modes, unlike the typical campaign mode discussed earlier, will require full operations 24 hr per day. This does not say that all instruments will be continuously operated, but rather that the operational scenario will accommodate single and coordinated operations of all the STO instruments and experiments 24 hr per day. In this way, the flight and ground crews will be available to perform detailed experiments and support continuous monitoring of the evolution of the natural events as they occur.

REFERENCES

1. "Solar Terrestrial Observatory," Final Report of the Science Study Group, October 1981.

2. "NASA Workshop on Solar Terrestrial Studies from a Manned Space Station," NASA CP-2024, February 1977.

3. "Guntersville Workshop on Solar Terrestrial Studies," NASA CP-2037, October 1977.

4. "Solar Terrestrial Observatory," Preliminary Design and Analysis Study, NASA/MSFC, March 1982.

5. "Space Station Summer Study Report," SESAC Task Force on Scientific Uses of Space Station, NASA Heacquarters, March 21, 1985.

Field	Value
1. REPORT NO.	NASA CP-2411
2. GOVERNMENT ACCESSION NO.	
3. RECIPIENT'S CATALOG NO.	
4. TITLE AND SUBTITLE	Solar Terrestrial Observatory Space Station Workshop Report
5. REPORT DATE	January 1986
6. PERFORMING ORGANIZATION CODE	
7. AUTHOR(S)	W. T. Roberts, Editor
8. PERFORMING ORGANIZATION REPORT #	
9. PERFORMING ORGANIZATION NAME AND ADDRESS	George C. Marshall Space Flight Center Marshall Space Flight Center, Alabama 35812
10. WORK UNIT NO.	M-505
11. CONTRACT OR GRANT NO.	
12. SPONSORING AGENCY NAME AND ADDRESS	National Aeronautics and Space Administration Washington, D.C. 20546
13. TYPE OF REPORT & PERIOD COVERED	Conference Publication
14. SPONSORING AGENCY CODE	
15. SUPPLEMENTARY NOTES	Prepared by Program Development.

16. ABSTRACT

In response to a need to develop and document requirements of the Solar Terrestrial Observatory at an early time, a mini-workshop was organized and held at the Marshall Space Flight Center on June 6, 1985. The participants at this workshop set as their goal the preliminary definition of the following areas:

1) Instrument descriptions
2) Placement of instrumentation on the IOC Space Station
3) Servicing and repair assessment
4) Operational scenarios

This report provides a synopsis of the results of that workshop.

Field	Value
17. KEY WORDS	Space Station Space Platform Science Operations Solar Terrestrial Physics
18. DISTRIBUTION STATEMENT	Unclassified - Unlimited Subject Category 46
19. SECURITY CLASSIF. (of this report)	Unclassified
20. SECURITY CLASSIF. (of this page)	Unclassified
21. NO. OF PAGES	39
22. PRICE	A03

For sale by National Technical Information Service, Springfield, Virginia 22161

NASA-Langley, 1986

National Aeronautics and
Space Administration
Code NIT-4

Washington, D.C.
20546-0001