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.

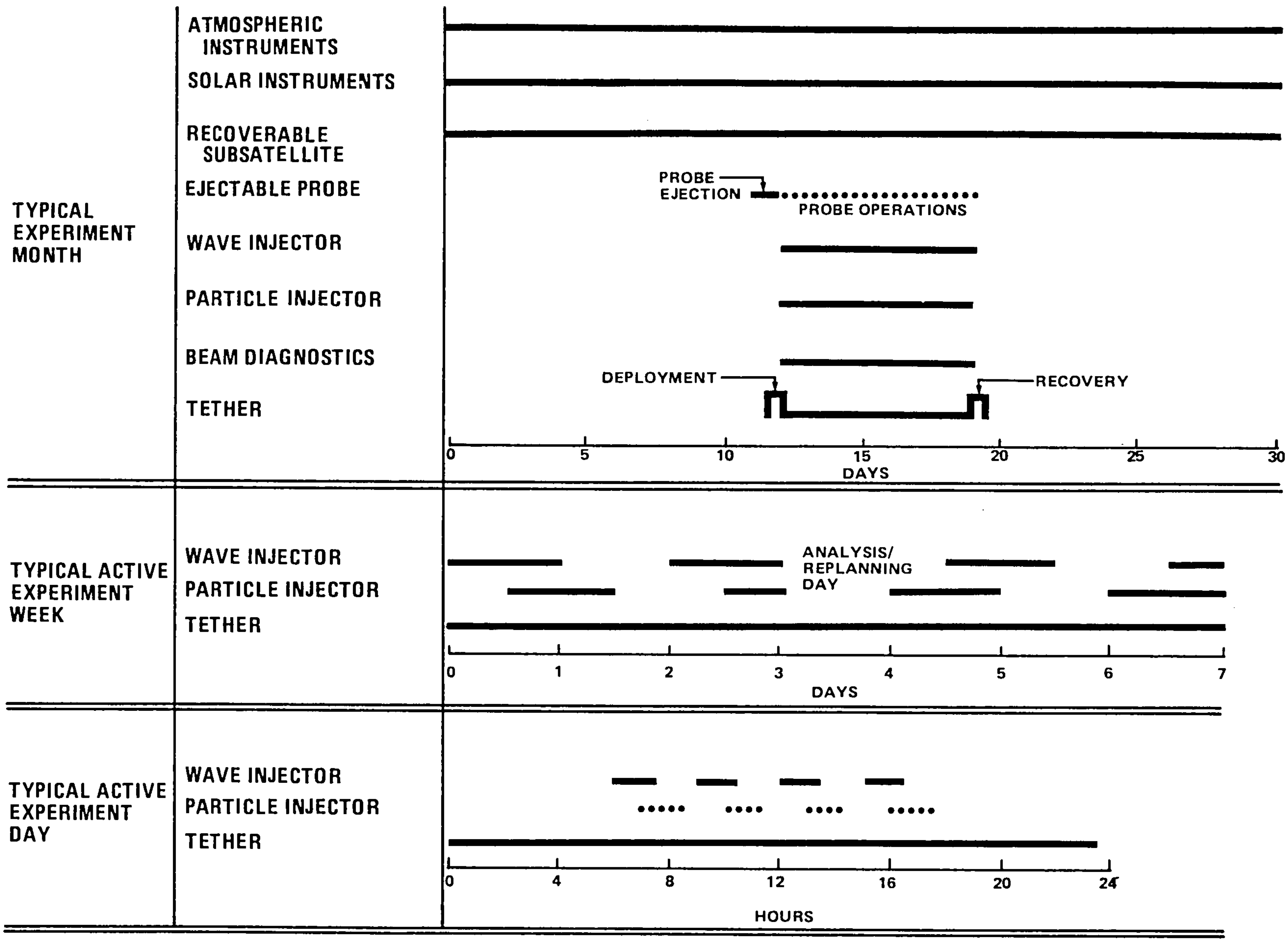
The following figure shows an example of a typical campaign mode of operation. On average these times will be scheduled well ahead and the general experiment scenario will be preplanned. Prior to the start of the campaign mode, the electrodynamic tether will be deployed and the ejectable probe(s) will 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.

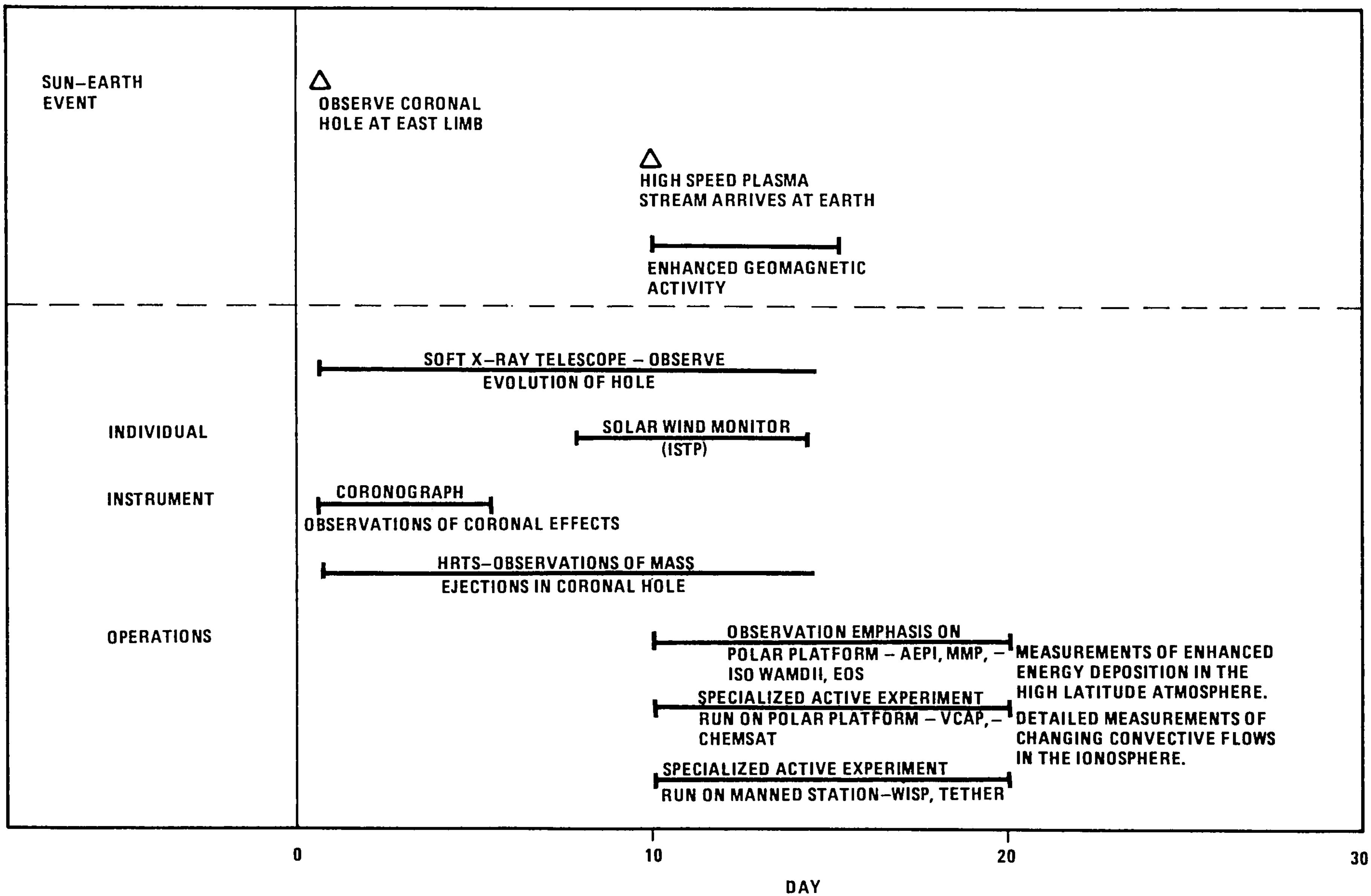
During the week (7 days) of the typical campaign mode of operation, one day will be devoted to analysis of the data acquired to that time, and to accommodate any replanning necessary for the remaining time. Likewise the daily experiment operations will be planned to be accomplished within one 12-hr shift 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

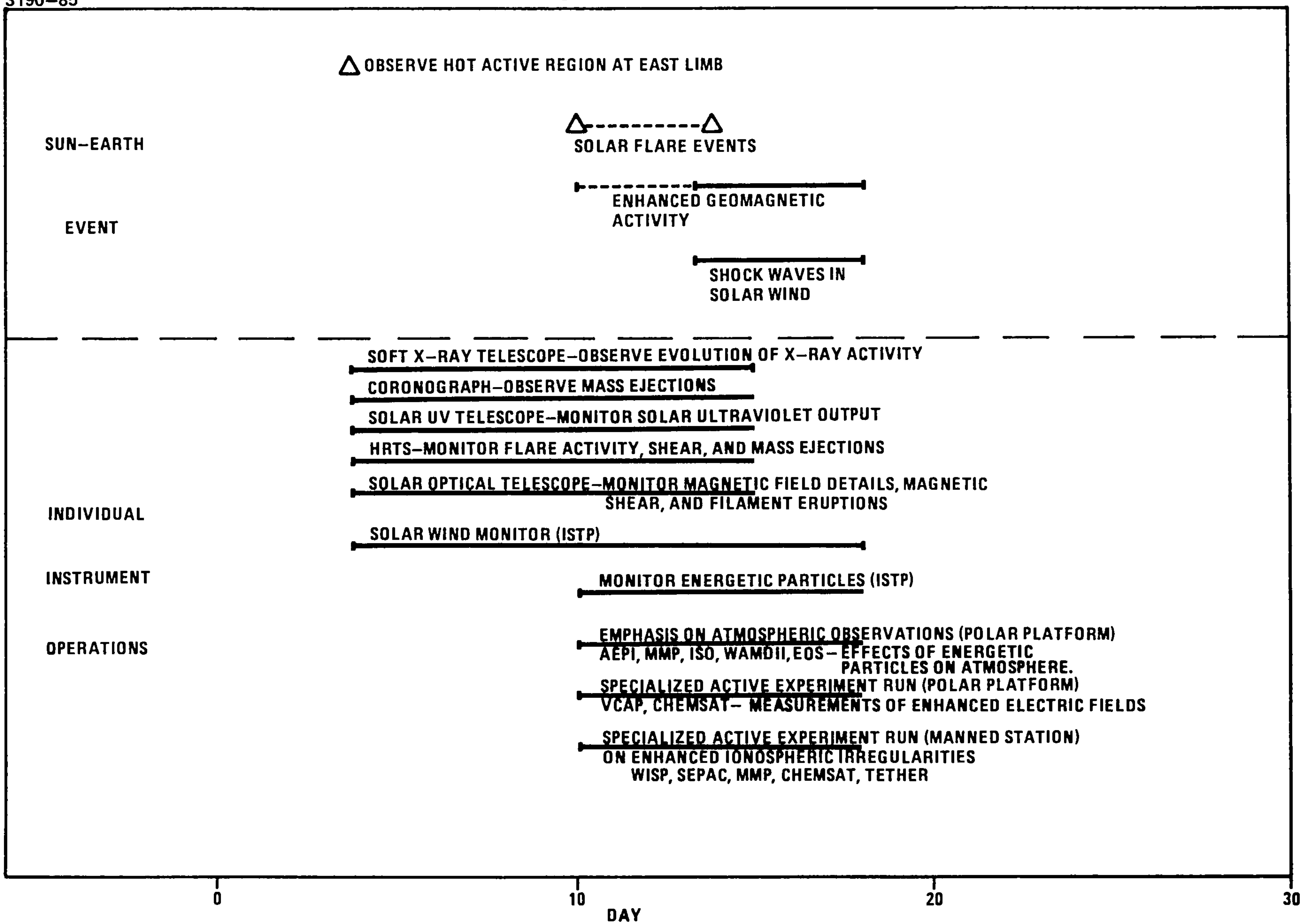


SOLAR TERRESTRIAL OBSERVATORY
SOLAR EVENT TRIGGERED CAMPAIGN MODE
CORONAL HOLE



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.