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Future Scientific Missions for STS

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FUTURE SCIENTIFIC MISSIONS FOR STS

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ABSTRACT

As the Space Transportation System (STS) transitions to a fully operational system, the opportunities for flying new astrophysics missions in the late eighties and early nineties have greatly increased. Current NASA studies include the analysis of Space Platforms and Space Stations which could become operational systems in the nineties. The Space Shuttle gives the scientific community the capability to fly new astrophysics missions, obtain valuable scientific data, and provide payloads that can transition to Space Platforms and Space Stations. The purpose of this paper is to describe some scientific payloads that are being studied by NASA at the Marshall Space Flight Center (MSFC). Emphasis will be placed on showing how these scientific payloads can utilize the Space Shuttle, obtain new data, and through evolution form the nucleus for new astrophysics missions on a Space Platform or Space Station.

INTRODUCTION

During the late 1990's and early 1980's, astrophysics missions will require the use of more powerful scientific instruments such as the Solar Optical Telescope (SOT), Shuttle Infrared Telescope Facility (SIRTF), Pinhole Occulter Facility (POF), and Starlab, in order to understand and study the diverse astrophysical phenomena that will be unveiled. In addition to these large scientific facilities, there is also a need for more modest facilities that can be quickly carried into space and returned with scientific data. This would allow more efficient utilization of the larger scientific observatories and serve to develop the critical mass needed to lay the foundations for new scientific payloads and satellites. With the "new start" decisions still to be made for the Space Station and Space Platform, and their potential launch dates slipped to the early 1990's, a requirement exists to evaluate the Space Shuttle and Spacelab hardware for accommodating new astrophysics missions. The payloads and data obtained from these missions could be used to form the foundation for new astrophysics missions on a Space Platform or Space Station.

The references give recommendations of the Science Working Groups that have been formed from the scientific community to assist in the definition of the various facilities. Also included are results from definition studies, most of which were done inhouse at the MSFC. In addition, a new program is now being studied by NASA entitled Capabilities for Opportunity Payload Experiments (COPE). The purpose of this program is to fill unoccupied Space Shuttle cargo capacity with relatively small payloads that can be quickly and simply prepared for flight. This new program also utilizes the Space Shuttle for science and application missions and will be described in this paper.

ASTROPHYSICS MISSIONS FOR STS

NASA and the Marshall Space Flight Center are currently studying the following astrophysics missions that will be initially flown on the STS and then could easily transition to a

Space Station or Space Platform. Following is a list of these missions which are described in this report:

- Very Long Baseline Interferometer (VLBI)
- Advanced Solar Observatory (ASO)
- Pinhole Occulter Facility (POF)
- Solar Terrestrial Observatory (STO)

Very Long Baseline Interferometer

Infrared and radio astronomy observations in the decade of the 1990's will be provided by two major Spacelab instruments, the Shuttle Infrared Telescope Facility (SIRTF) and a large antenna system designed to significantly extend the aperture synthesis technique of Earth-based very long baseline interferometry technique (orbiting VLBI).

At the longer (radio) wavelengths milliarcsecond resolution has already been surpassed with intercontinental VLBI. However, in most objects, there remains spatial structure that is unresolved. For example, virtually every active galactic nucleus has angular structure that cannot be resolved, even with the best VLBI network currently available (offering a resolution of 10^{-4} arcsec). VLBI measurements have reached the limits imposed by the size of the Earth.(1)

The capability to assemble large structures in space and the existence of advanced technology for maintaining precise baselines and accurate pointing of large systems will make possible interferometers in space.(2, 3)

Radio interferometry observations of celestial sources are routinely performed on Earth by using atomic frequency standards to synchronize radio telescopes that may be separated by as much as intercontinental distances. Angular resolution better than a milliarcsecond, four orders of magnitude superior to that of Earth-based optical telescopes, has been achieved. By placing one or more of the observing elements in Earth orbit and making observations in concert with those on the ground, significant advantages over purely ground-based systems may be obtained. Among these advantages are improved angular resolution, improved coverage of the celestial sphere, more accurate radio maps, and more rapid mapping.

A Space VLBI Program

The Astronomy Survey Committee of the National Academy of Sciences has recommanded that a space VLBI antenna be launched in low Earth orbit during this decade.(4) To achieve a permanent VLBI system in space, three natural phases can be identified (see Figure 1). Each phase utilizes the expected evolution in the capabilities of space systems.

An initial step would be to utilize the capability of the Space Shuttle to demonstrate orbiting VLBI by deploying a large retrievable antenna attached to the Shuttle. This mission could be part of the Large Deployable Antenna Flight Experiment that has been under active study by MSFC and aerospace contractors during the past several years.(5, 6) An artist's concept of one possible antenna is shown in Figure 2. During the mission, about three days would be devoted to VLBI observations. An alternative system now under study at MSFC is a 15 meter antenna aboard the Shuttle that could later be used on the Space Platform or perhaps on an Explorer class mission.

A VLBI terminal aboard a Space Platform or Space Station could carry out observations for extended periods using essentially the same science package previously demonstrated on the Shuttle. Figure 3 illustrates the Platform concept with a 15 meter VLBI antenna attached to one of the ports.

During this time frame an alternative or perhaps concurrent flight configuration might be a 15 meter free flyer in the Explorer class but placed at a higher (5000 km) altitude.

Both Platform and free flyer VLBI observations are naturally complementary to a dedicated ground-based VLBI array. A single space VLBI terminal improves both the resolution and density of u-v coverage by large factors and significantly increases the sky coverage available.

The Advanced Solar Observatory

The Advanced Solar Observatory (ASO) is a proposed long duration space observatory which would be placed on a Space Shuttle serviced Space Station or Space Platform. Because of the large instrument apertures made possible by the size and weight carrying capacity of the Space Shuttle, the ASO will allow the sun to be studied with unprecedented resolution and sensitivity and will provide new insights into virtually every major problem confronting solar physicists.

In addition to the advantage in resolving power, sensitivity and spectral and temporal resolution, the Advanced Solar Observatory offers the enormous advantage of simultaneous observation in all temperature domains (by virtue of complete simultaneous wavelength coverage) of importance in the solar atmosphere.

The Advanced Solar Observatory is conceived as a comprehensive collection of high resolution instruments capable of observing the full spectral range of electromagnetic radiation emitted by the sun. The ASO will consist of four major instrument groupings or facilities:

- A High Resolution Solar Telescope Cluster (HRSTC)(see Figure 4)
- A Pinhole Occulter Facility (see Figure 5)
- A Solar High Energy Facility
- A Solar Low Frequency Radio Facility

The solar physics community proposes to develop this comprehensive observatory by an evolutionary process, by first developing and deploying on Spacelab (the Space Shuttle attached laboratory) a core of full scale, but simplified, ASO component instruments. These Spacelab instruments will later evolve into the mature long duration Advanced Solar Observatory. This process has already begun, with the initiation of the development of the Solar Optical Telescope (SOT), the first component of the High Resolution Solar Telescope Cluster (see Figure 4).

The Configuration of the Advanced Solar Observatory

The configuration of the Advanced Solar Observatory, as it might appear deployed in space, is illustrated in Figure 6. The individual components of the Advanced Solar Observatory which will be developed initially as individual Spacelab facilities have in most cases, been studied in some depth by previous NASA Definition Teams; consequently, the configuration of the individual ASO component instruments can be specified in some detail.(7, 8)

Because of the great luminosity of the sun, operations in the Space Shuttle attached "Sortie" or Spacelab mode, which can support observing programs of up to 10 days duration, can be highly productive for solar physics. Therefore, the ASO can be developed by utilizing a unique evolutionary approach; whereby its major components such as the SOT, the SSXRT, and the POF, etc., are first built and deployed as Spacelab facilities. Furthermore, several Spacelab flights of a developmental version of the ASO, consisting of the HRSTC and POF, would not only constitute a major scientific opportunity for solar research, but would also constitute an important engineering test of the ASO design. The Science Definition Team believes that this evolutionary approach will prove to be cost effective because of the built in (and scientifically valuable) testing which the Shuttle attached operations represent; and will allow scientifically productive and innovative observations (such as will be achieved by the SOT when it commences operation in 1989) to be undertaken sooner than would be possible with a more conventional developmental program.

Pinhole Occulter Facility

The Pinhole Occulter Facility (POF) will observe solar phenomena sources with an unprecedented angular resolution of 0.2 arcseconds. It achieves this by using coded-aperture imaging over a 50 m baseline, with a deployable boom used to separate an aperture mask from position-sensitive X-ray detector arrays. The existence of a remote occulting mask will make it possible to have large-diameter telescopes for white-light and ultraviolet observations of the corona. The strawman configuration of the POF has been defined by the Science Working Group (9, 10) and consists of four separate telescopes or position-sensitive counters mounted on a "detector plane"; each looks toward the target through its own portion of the "occulter plane." A self-deployable 50 m boom separates the two, and a standard NASA pointing-control actuator (e.g., the IPS) points the whole facility towards its target. A precision aspect and internal alignment system provides the information necessary to operate the pointing-control system; the absolute pointing must be within a few arcseconds of the desired direction. The high-resolution X-ray imaging system requires absolute reference to celestial coordinates to a fraction of its angular resolution.

The POF represents a first attempt to use the structural stability of the space environment to build high-resolution optical systems with very large baselines. The key technical elements in the feasibility of such a program are the aspect sensing and the control of the pointing direction of the large structure. The former depends upon star-tracker technology and the latter upon the development of precise control logic that can compensate for the inherent flexibility of a large structure.(11)

The Pinhole Occulter Facility can easily transition from a Space Shuttle sortie mode of operation to a key element of the Advanced Solar Observatory (ASO) in either a Space Platform or Space Station mode of operation. Figure 7 shows one concept under study at MSFC for a Space Shuttle sortie mission dedicated to the study of solar physics. In this mode of operation, the POF would be flown together with the Solar Optical Telescope (SOT) on a Space Shuttle mission. The advantage of flying in this mode is that the Space Shuttle will be available prior to Space Platform operations. If the STS can accommodate both of these facilities, then this mode of operation would give the solar scientific community valuable data, verification and improving on the experimental techniques learned by the solar community during the Skylab missions. In Skylab, scientists were able to carry out coordinated, multi-instrument observations of the sun, with the on-board scientist-astronaut able to key the observations to transient solar events.

Another step in the evolution of the POF would be to fly on a Space Station or Space Platform as shown in Figure 6. A POF aboard either of these facilities could carry out solar observations using essentially the same configuration previously demonstrated on the Space Shuttle.

Solar Terrestrial Observatory

The Space Plasma Physics science community has been one of the great advocates for the use of the Shuttle as a scientific platform for the examination of the near-Earth plasma environment and its interaction with the Earth's atmosphere. The Solar Terrestrial Observatory (STO) Science Study Group was established in 1979 to formulate a scientific strategy for the development of a Solar Terrestrial Observatory(12, 13) as an interdependent problem-oriented combination of solar, magnetospheric, and atmospheric instruments. In the scenario formed by the STO Science Study Group, the STO would be mounted on a long-lived Space Platform, carried into orbit, and serviced by the Space Shuttle (see Figure 8). The proposed strategy focused on investigations of the physical processes that interlink the major regions of solar-terrestrial space. In reviewing that strategy, one quickly concludes that the STO objectives can be met, and in many ways enhanced, by using a Shuttle-serviced manned Space Station. This conclusion is reinforced by the results of earlier workshops devoted to manned Space Stations.(14, 15)

The background leading up to the STO provides a solid foundation on which to build such a program. The historical process of coordinated observations on satellites, Skylab, and ground-based observatories, coupled with the capability to perform selective "laboratory-like" perturbation experiments from a long-duration orbiting laboratory, will help to provide the necessary ingredients to achieve the aggressive goals of the STO. Observations and studies of solar features and Earth atmospheric features are required to begin to understand the underlying physics. The instruments and techniques required to optimize these studies will be developed and perfected over the next several years using the Space Transportation System (STS). In the same way, active instruments designed to create energetic plasmas and waves will be developed to investigate the processes through which energy is conducted into the natural earthspace environment and thence into the Earth's atmosphere. Free-flying satellites and probes will also be required to permit measurements at distances away from the primary source and at multiple points to determine spatial and temporal variations.

The solar instruments provide required data on solar variability in multiple spectral regimes. The atmospheric instruments will collect data on the dynamics of the Earth's atmosphere, which are in turn correlated with solar variability information. Finally, the space plasma instruments will be used to examine (actively and passively) the mechanisms by which energy is transferred through the magnetosphere and ionosphere. These instruments will be designed to fly initially on Shuttle/ Spacelab, and taken together, provide the capabilities required by an early STO. Many of the instruments which are needed to begin the early STO are already under definition and/or development for STS missions and can easily transition to a permanent orbiting facility.

Capability for Opportunity Payloads/ Experiments (COPE)

A new program is now being studied by NASA to fill unoccupied Space Shuttle cargo capacity and to reduce the current, relatively long periods of time to manifest a payload aboard the Space Shuttle to a period from six months to two years before a flight. A set of "icebreaker" payloads is under consideration for the first COPE mission, tentatively scheduled for STS-14. The carrier for the project will span the width of the payload bay, about 15 feet, and will be about a meter in width. The carrier and payloads will be limited to one-quarter of the Shuttle's cargo bay in terms of weight, volume, data, and power requirements. The COPE program has three major objectives: develop a payload of opportunity carrier, select icebreaker payloads/mission(s), and simplify the payload integration process. Figure 9 shows three candidate icebreaker payloads installed on one of the COPE carrier concepts. The COPE concept shows another way that science and commercial payloads can be flown on the Space Shuttle. The combination of a low-cost pricing policy, coupled with frequent flights and six-month integration schedules will insure more effective utilization of the Space Shuttle and serve as a catalyst for new science and application missions.

A pricing policy is still being worked out by NASA to develop an innovative method to make the program attractive to users and get payloads into orbit.

CONCLUSION

As the STS (Space Shuttle/Spacelab) transitions to a fully operational system, the opportunities for flying new astrophysics missions in the late eighties and early nineties will be greatly increased. The scientific payloads and missions described in this paper, including the VLBI, POF, and elements of the ASO and STO, can readily be accommodated on the Space Shuttle.

Without these interim missions, there could be long periods of time in which the scientific community would not be able to obtain new data to understand the diverse astrophysical phenomena that has been revealed to date. Flying these astrophysics missions on the Space Shuttle will maintain the interests of the scientific community, allow serial development of powerful scientific instruments, learn and perfect experimental techniques through manned involvement, and provide a smooth transition for Space Platform and Space Station missions.

REFERENCES

1. "Radio Telescopes Bigger Than The Earth," B. F. Burke, Astronautics and Aeronautics, Vol. 70, No. 10, p. 44, October 1982.

2. Shuttle VLBI Experiment: Technical Working Group Summary Report, NASA TM-82491 (Samuel H. Morgan and D. H. Roberts, eds.), NASA, G. C. Marshall Space Flight Center, July 1982.

3. "Concepts for Large Interferometers in Space," S. H. Morgan, M. E. Nein, B. G. Davis, D. H. Roberts, and W. H. Traub, AIAA/SPIE/OSA Conference Proceedings: Technology for Space Astrophysics: The Next 30 Years, Danbury, CT, October 1982.

4. Astronomy and Astrophysics for the 1980's, Report by the Astronomy Survey Committee, National Academy of Sciences, National Academy Press, Washington, DC, 1982.

5. Deployable Antenna Flight Experiment Definition Study, Final Report, Grumman Aerospace Corp., Bethpage, NY, March 1982.

6. Deployable Antenna Flight Experiment Definition Study, Final Report, Harris Government Electronics Systems Division, Melbourne, FL, March 1982.

7. "The Advanced Solar Observatory," Arthur B. C. Walker, Jr., AIAA 21st

Aerospace Sciences Meeting, Reno, NV, January 10-13, 1983.

8. Advanced Solar Observatory Study Report, Interim Report of the Science Study Group, October 1982.

9. "Pinhole Occulter Facility - Executive Summary," NASA TP-2089, 1982.

10. Studies with the Pinhole Occulter Facility, AIAA-83-0513, E. Tandberg-Hanssen and J. Dabbs, NASA-Marshall Space Flight Center, AL; and H. Hudson, Univ. of California, San Diego, LaJolla, CA; and M. Greene, Univ. of Alabama, Huntsville, AL, AIAA 21st Aerospace Sciences Meeting, Reno, NV, January 10-13, 1983.

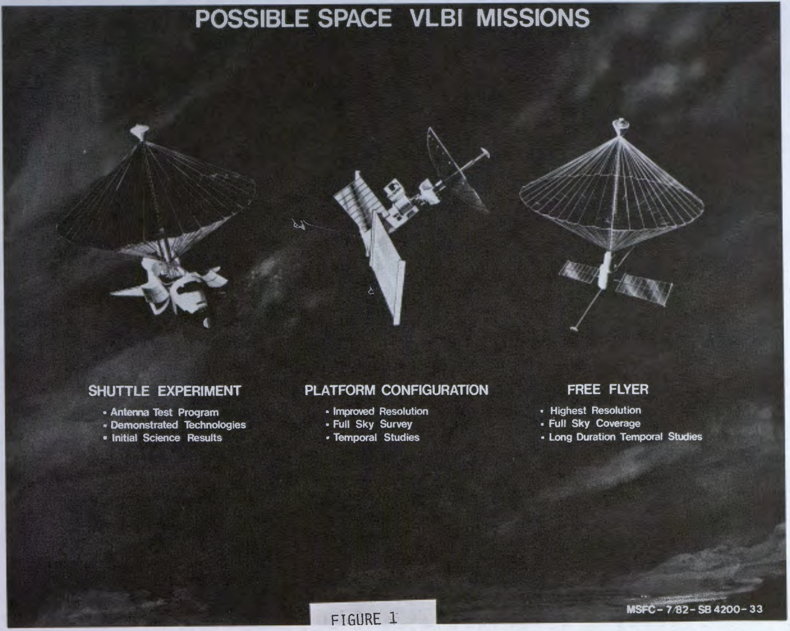
11. "Pinhole Coronagraph Pointing Control System Integration and Noise Reduction Analysis," Final Report, NASA Contract NAS8-34529, Michael E. Greene, 1981.

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

13. The Solar Terrestrial Observatory for Future Space Station Program, AIAA-83-0512, W. T. Roberts, NASA-Marshall Space Flight Center, AL, AIAA 21st Aerospace Sciences Meeting, Reno, NV, January 10-13, 1983.

14. "NASA Workshop on Solar Terrestrial Studies from a Manned Space Station," NASA CP-2024, NASA-Marshall Space Flight Center, AL, February 1977.

15. "UAH/NASA Workshop on Space Science Platform," University of Alabama in Huntsville, 1978.



POSSIBLE SPACE VLBI MISSIONS

SHUTTLE EXPERIMENT

- Antenna Test Program
- Demonstrated Technologies
- Initial Science Results

PLATFORM CONFIGURATION

- Improved Resolution
- Full Sky Survey
- Temporal Studies

FREE FLYER

- Highest Resolution
- Full Sky Coverage
- Long Duration Temporal Studies

MSFC-7/82-SB 4200-33

FIGURE 1

STS ORBITAL VLBI DEMONSTRATION

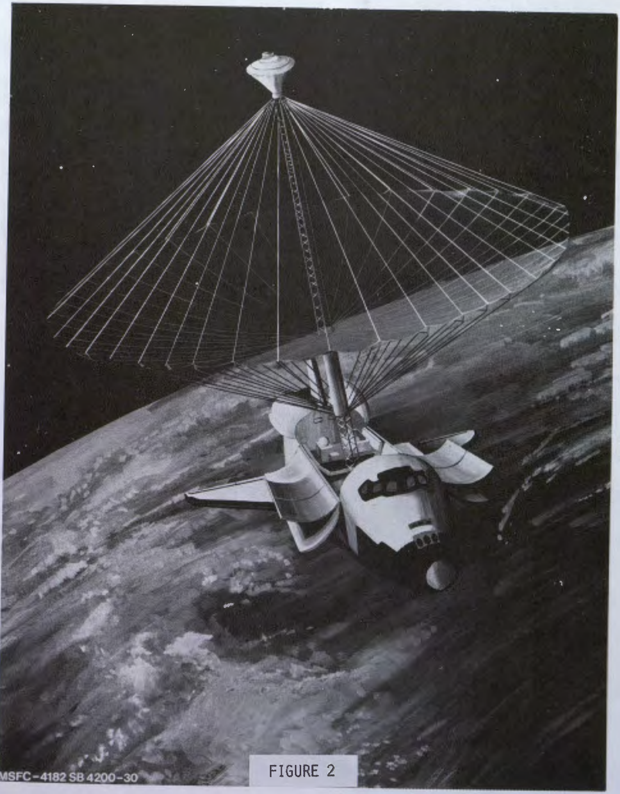


FIGURE 2

ORBITING VLBI: PLATFORM CONFIGURATION

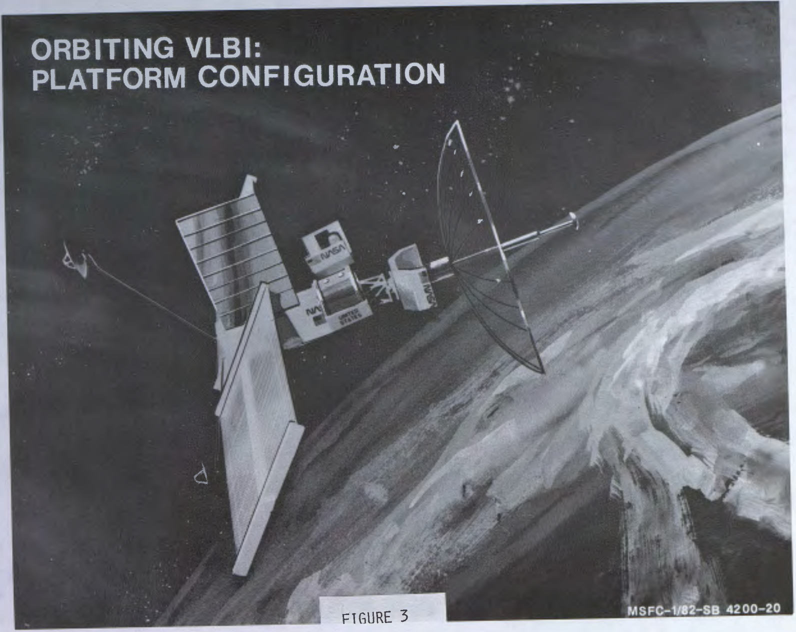


FIGURE 3

SOLAR OPTICAL TELESCOPE

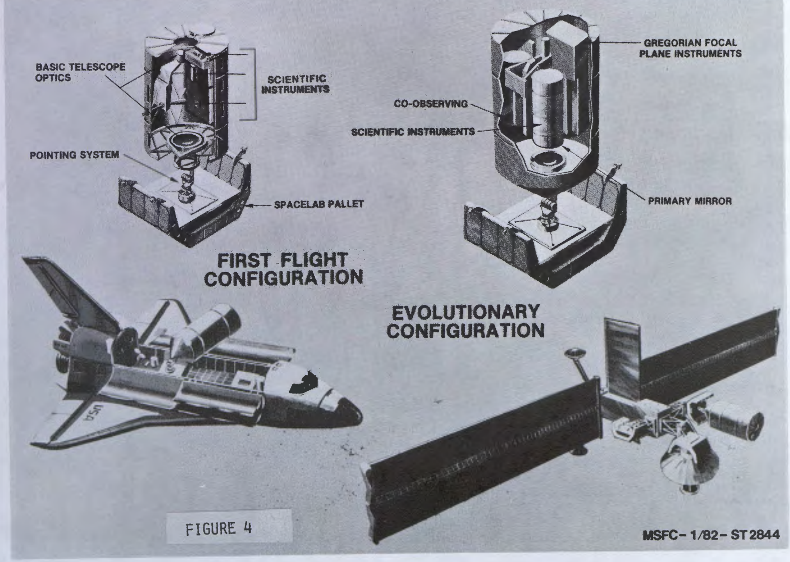


FIGURE 4

MSFC- 1/82- ST 2844

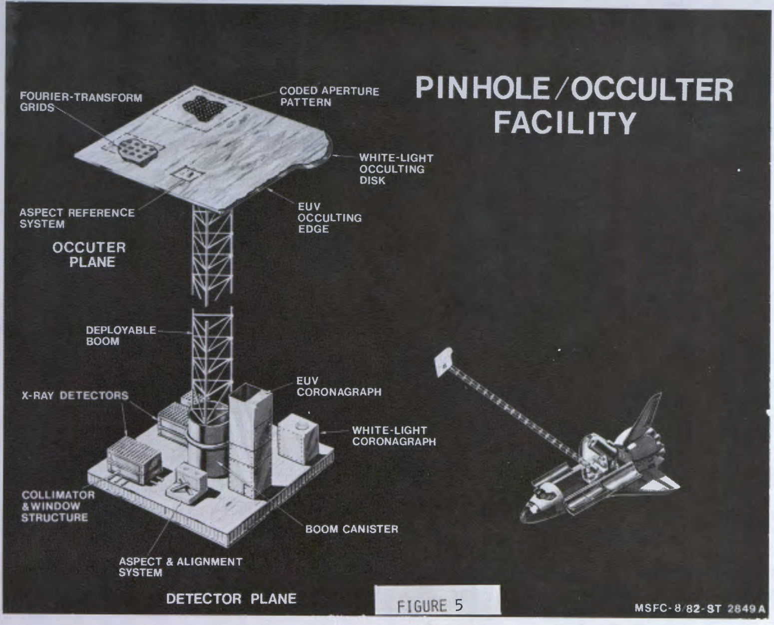
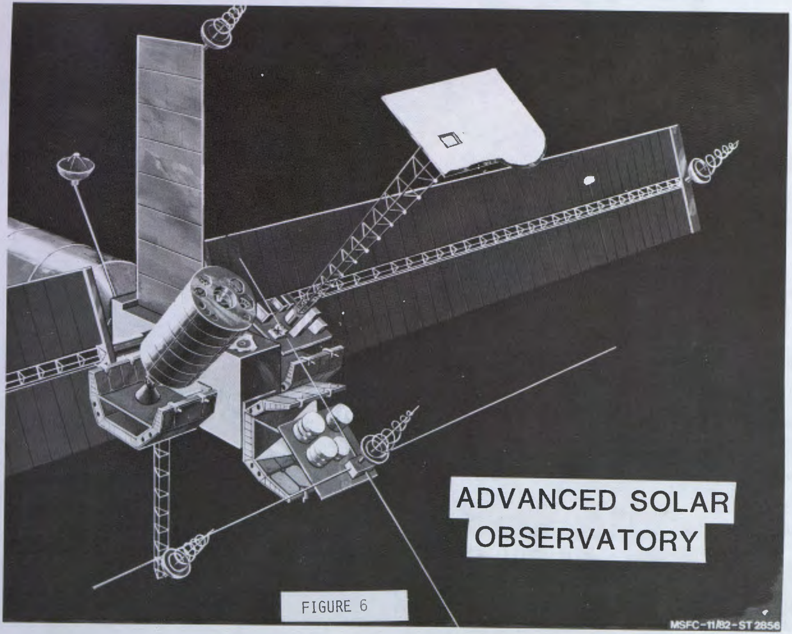

PINHOLE/OCCULTER FACILITY
FOURIER-TRANSFORM GRIDS
CODED APERTURE PATTERN
WHITE-LIGHT OCCULTING DISK
ASPECT REFERENCE SYSTEM
EUV OCCULTING EDGE
OCCUTER PLANE
DEPLOYABLE BOOM
X-RAY DETECTORS
EUV CORONAGRAPH
WHITE-LIGHT CORONAGRAPH
COLLIMATOR & WINDOW STRUCTURE
BOOM CANISTER
ASPECT & ALIGNMENT SYSTEM
DETECTOR PLANE
MSFC-8/82-ST 2849 A

FIGURE 5



ADVANCED SOLAR OBSERVATORY

FIGURE 6

MSFC-11/82-ST 2856

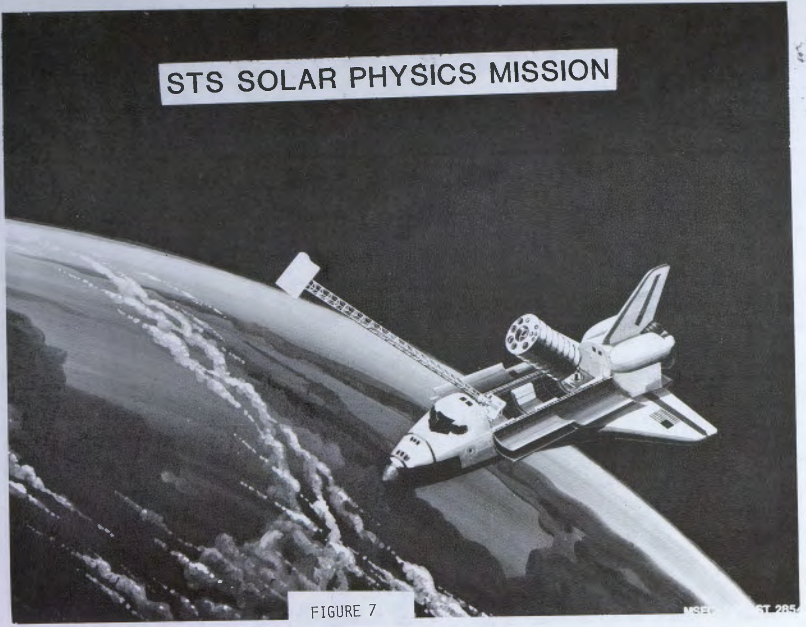
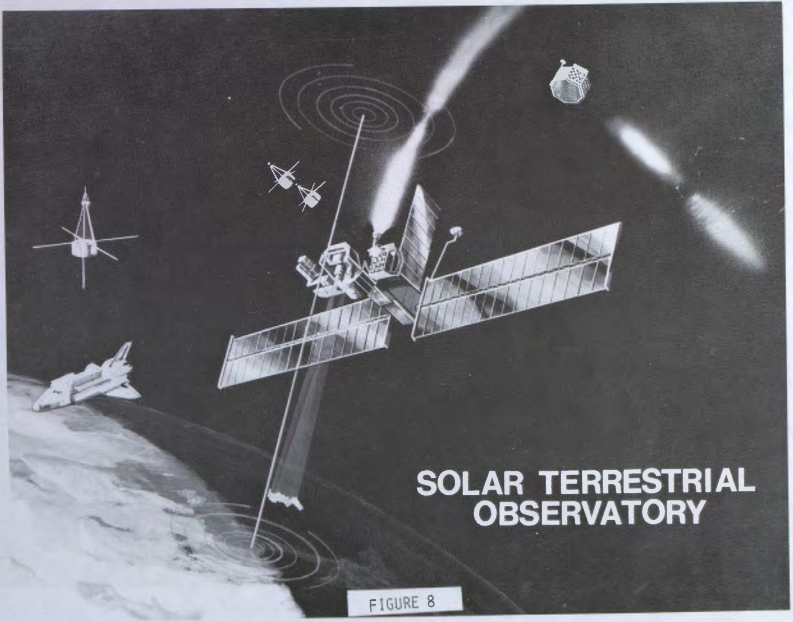


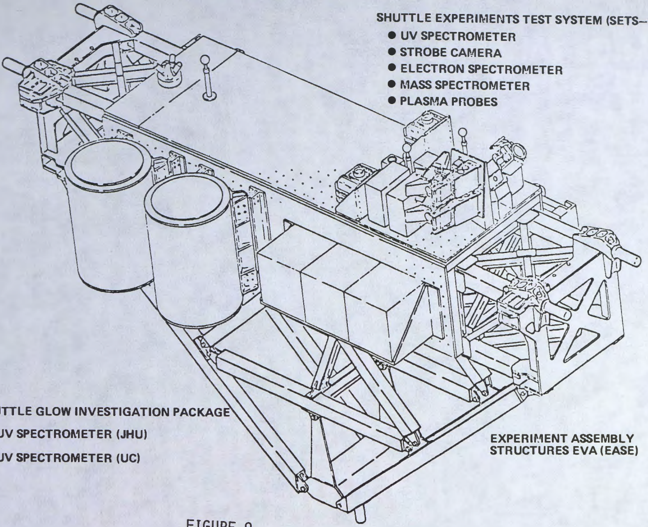
FIGURE 7



SOLAR TERRESTRIAL OBSERVATORY

FIGURE 8

ICEBREAKER PAYLOAD COMPATIBILITY ANALYSIS



SHUTTLE EXPERIMENTS TEST SYSTEM (SETS–1)

- UV SPECTROMETER
- STROBE CAMERA
- ELECTRON SPECTROMETER
- MASS SPECTROMETER
- PLASMA PROBES

SHUTTLE GLOW INVESTIGATION PACKAGE

- UV SPECTROMETER (JHU)
- UV SPECTROMETER (UC)

EXPERIMENT ASSEMBLY STRUCTURES EVA (EASE)

FIGURE 9