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SCIENCE AND APPLICATION PAYLOADS IN THE 90's

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ABSTRACT

During the 90's with the operation of the Extended Duration Orbiter (EDO), Space Station Freedom (SSF), large platforms in polar and geosynchronus orbits around the Earth, and supporting systems and technology, an infrastructure will exist that will offer a wide range of opportunities for science and applications payloads. The Marshall Space Flight Center (MSFC) is in a unique position of studying for NASA science missions for all of these systems. This paper will discuss a variety of payloads being studied for NASA at the MSFC that are scheduled for flight in the 90's, in support of space science and Mission to Planet Earth. These science payloads such as the Controls, Astrophysics and Structures Experiment in Space (CASES), Advanced Solar Observatory (ASO), Laser Atmospheric Wind Sounder (LAWS), and Lightning Imaging Sensor (LIS), etc. will fully utilize the capabilities of the EDO, SSF, Earth Observation System (EOS), and Earth Science Geostationary Platform (ESGP). Emphasis will be placed on showing how these scientific payloads can fully exploit the great potential of these new capabilities for exciting new science and application missions.

INTRODUCTION

During the late 1990's science missions will require the use of more powerful science instruments and facilities such as the Controls, Astrophysics, and Structures Experiment in Space (CASES), Pinhole Occulter Facility (POF), and Laser Atmospheric Wind Sounder (LAWS). These instruments will take full advantage of the infrastructure that will be in-place during the 1990's: Extended Duration Orbiter (EDO), Space Station Freedom (SSF), Earth Observing System (EOS), and the Earth Science Geostationary Platform (ESGP). The synergism from this infrastructure and scientific payloads will not only obtain valuable scientific data, but provide the foundation for the scientific and application missions for the next century. In addition, due to the long periods of time required to build the "Great Observatories" such as HST and AXAF, considerable work needs to be done in the 90's for the observatories of the 21st century. The purpose of this paper is to provide an overview on some of the science and applications payloads that MSFC is developing for NASA, and provide reference material for interested people to obtain more detailed information. The author of this paper is indebted to the members of the Space Science and Applications Group, PS02, at MSFC for their assistance in writing this paper and managing these programs.

CONTROLS, ASTROPHYSICS, AND STRUCTURES EXPERIMENT IN SPACE (CASES)

MSFC is presently managing for NASA (Codes E and R) a very interesting STS mission entitled Controls, Astrophysics, and Structures Experiment in Space (CASES). Langley Research Center will support MSFC in the experiment definition and manage the Guest Investigators Program. The CASES project is currently in a Phase B status, being studied by the Lockheed Missiles and Space Company (LMSC) and Teledyne Brown Engineering (TBE). The CASES experiment will be flown as shown in Figure 1, utilizing Spacelab components and the STS. The CASES would also benefit from long duration missions and could effectively utilize the capabilities of the Extended Duration Orbiter. The technology benefits from CASES would provide a firm foundation to develop the Pinhole Occulter Facility (POF) as a space station attached payload, and support other advanced astrophysics missions. CASES will investigate critical control technology that is needed to stabilize and point large flexible structures in space. The control of a deployable 32-m boom, of a design identical to the one used in the Solar Array Flight Experiment program, will be implemented using small cold-gas thrusters for pointing. Angular momentum exchange devices will be used for active damping to suppress vibrations. Since the boom is rigidly attached to the orbiter, the orbiter/boom system may be pointed to a predetermined target for a period of at least 30 minutes. In addition, tracking and slewing of the orbiter at small angular rates will be demonstated. A significant advantage of this control method is that the orbiter can be stabilized for significant periods of time with very low g levels.

The CASES will also accomodate an astrophysics/solar hard x-ray imaging experiment. This experiment will address important issues in high energy astronomy, such as the identification and characterization of the energy source seen at the galactic center and the energy release mechanisms in solar flares. Imaging of hard x-rays is accomplished by aperture plates placed at the tip of the boom. This provides coded aperture imaging on position sensitive proportional counter arrays placed in the cargo bay at the base of the boom. The large separation between masks and detectors makes possible high spatial resolution.

SPACE STATION FREEDOM

The Space Station Freedom (SSF) will provide science and application payloads with many opportunities, in future U.S. space activities, by providing a large-scale permanent space facility. This facility will provide structural support, electrical power, data processing, communications and manned resources. Internal (i.e., pressurized volume) payloads will be devoted to materials processing and life science research. The attached payloads externally mounted on the Space Station truss may include astronomy, and solar physics telescopes, earth science instruments, active space physics experiments,and cosmic ray experiments. NASA and the MSFC are currently studying the following science and application payloads for the SSF: Pinhole Occulter Facility (POF), Advanced Solar Observatory (ASO), Laser Atmospheric Wind Sounder (LAWS), Lightning Imaging Sensor (LIS), High Resolution Microwave Spectrometer Sounder (HIMSS), the Tropical Rainfall Measurement Mission (TRMM), and the Neutral Environment With Plasma Interactions Monitoring System (NEWPIMS).

PINHOLE OCCULTER FACILITY (POF)

The Pinhole Occulter Facility (POF) is an important solar observatory. The POF has been conceived as a stand-alone facility suitable for advanced studies of solar active regions, the solar corona, and cosmic X-ray sources. The POF payload is a potential candidate for continuous operation on SSF. The POF consists of a boom, deployed on-orbit to about 32-m (105 feet) in length, which separates an occulter plane (mask) from a detector plane. The long baseline is also used to provide external occulting for white light and ultraviolet coronal instruments. The x-rays will be imaged to sub-arc-second resolution and in higher energies than previously possible. Coronal observations will be with higher spatial resolution, lower scattered background radiation, and to a lower depth in the solar corona than was before possible. Figure 2 shows the POF attached to SSF. An accommodation study of the POF on SSF was completed in 1988 for NASA/MSFC by the Teledyne Brown Engineering (TBE) Company. The CASES payload, previously described, should serve as a valuable pathfinder for the POF both from a science and technology viewpoint.

ADVANCED SOLAR OBSERVATORY (ASO)

The Advanced Solar Observatory (ASO) is a solar physics observatory that may be implemented in the future on Space Station Freedom. The ASO takes advantage of the unique resources provided by SSF to host instruments of large mass and volume, the ability to coordinate observations from multiple instruments, maintenance and servicing functions, and the ability to perform instrument modifications and upgrades while on orbit. The objectives of the Advanced Solar Observatory, are to significantly advance the study of the Sun to determine and understand the fundamental processes which drive solar dynamic phenomena. Development continues on a comprehensive set of solar telescopes and instruments which permit simultaneous and coordinated measurements across the energy spectra ranging from gamma rays and energetic neutrons, soft x-rays, extreme-ultraviolet and ultraviolet, visible light, and low-frequency radio emissions. The ASO on SSF (See Figure 2) will host a high energy facility, POF, a multi-telescope high resolution telescope cluster, and the low-frequency radio facility. A ground based command and data facility will be used to coordinate measurements taken from SSF instruments with data taken from other free flying and ground based solar instruments.

A NASA/MSFC funded study in 1989 with Teledyne Brown Engineering (TBE) has defined requirements for the ASO on SSF, and confirmed the assessment that the ASO can be accommodated on SSF.

LASER ATMOSPHERIC WIND SOUNDER (LAWS)

LAWS represents a major step toward the goal of making routine global wind profile measurements from space. Its purpose is to improve our understanding of the atmospheric wind field by investigating many interdisciplinary scientific questions from a polar orbiting platform of the Earth Observing System (EOS) (See Figure 3) or from Space Station Freedom. Wind profiles obtained by the LAWS system will provide research information essential for advancing the skill of numerical weather prediction, furthering our knowledge of large-scale atmospheric circulation and climate dynamics, and improving our understanding of global biogeochemical and hydrologic cycles. LAWS is a facility instrument on the EOS and has also been accepted for concept definition as an attached payload on Space Station Freedom (SSF).

The system technology required for space-based operation is the coherent CO_2 Doppler lidar technique. This system, operating in the eye-safe infrared wavelength (9 to 10 um) has been used successfully in ground-based and airborne wind measurement systems. The space system currently envisioned consists of a pulsed, frequency-controlled CO_2 laser transmitter, a continously scanning transmit-and-receive telescope, a heterodyne detector, and a signal processing system. Initial studies have shown that this instrument concept for LAWS can be accommodated on both the EOS polar orbiting platform and Space Station Freedom.

A LAWS science team was selected in early 1989 composed of scientists active in the fields of atmospheric dynamics and laser technologies. General Electric and Lockheed were selected for parallel studies in early 1989 by NASA to define a LAWS configuration for both the EOS polar platform and SSF. Both concepts will be studied in detail by NASA in order to select the optimum system for direct measurement of wind profiles around the Earth.

TROPICAL RAINFALL MEASUREMENT MISSION (TRMM)

The Tropical Rainfall Measurement Mission (TRMM) is a proposed flight of several instruments on either a free flyer or SSF to obtain tropical rainfall data over a period of at least three years. The TRMM is being proposed as a joint U.S.-Japan mission for the study of tropical rainfall systems and their impact on global weather cycles. TRMM would include the first precipitation radar ever flown in space, which would be provided by Japan. MSFC has completed a SSF accommodations study for NASA of the TRMM payload (a radar, at least one microwave radiometer, and a visible and infrared cloud imager - (Figure 5). The study concluded that TRMM could be accommodated by SSF. For the purposes of the study it was assumed that all of the instruments would be mounted on a Spacelab pallet. The pallet would be pointed by a payload positioning system with a 45° offset to avoid a possible gimbal-lock situation.

A separate activity at Goddard Space Flight Center has addressed the possibility of flying TRMM on a multimission spacecraft. Recently a decision was made by NASA to fly the initial TRMM on a free flyer spacecraft launched by a Japanese H-2 rocket. Japan will also provide a single frequency radar for TRMM that uses an electrical scanner. After this mission the TRMM payload may transition to SSF.

NEUTRAL ENVIRONMENT WITH PLASMA INTERACTIONS MONITORING SYSTEM (NEWPIMS)

Space Station Freedom (SSF) will be a complex and busy structure in space. It will serve as a vehicle fueling and repair facility. Proximity operations will include the Space Shuttle and the Orbital Manuevering Vehicle, that could present significant perturbations to the ambient environment. Additionally, the operations on the SSF may be affected in yet undefined ways by the space environment.

Operationally, the large size of SSF and the inclusion of many high-current electrical paths, and numerous simultaneous communications links could produce many unknown environmental perturbations. As a result, the environment of SSF needs to be verified during construction, and as operations commence and continue.

Users of SSF will have a critical need for knowledge of the actual environment within which external instrument measurements will be made. Telemetry and sensor signals may be masked by the noise, leading to false conclusions due to defective data. Thus, a continous, ongoing data base is critically needed that characterizes the environmental parameters of and around SSF as functions of time and location.

In response to the above needs, a system to provide comprehensive environmental measurements at multiple locations on SSF is planned. This system called the Neutral Environment With Plasma Interactions Monitoring System (NEWPIMS) will have at least a twofold function: to monitor the impact of the Space Station on the environment and vice versa, and to supply a database to users that can be employed to unfold natural from induced changes in environmental parameters at the Station.

The NEWPIMS Science Study Team has defined a suite of instruments needed to provide the measurements necessary to define the external environment around the Space Station. A brief definition of each instrument and its measurement capabilities is provided in reference 7 to show the environment parameters covered.

EARTH SCIENCE GEOSTATIONARY PLATFORMS (ESGP)

The ability to continuously dwell over a specific region of the Earth to study multi-discipline Earth Science processes makes the Earth Science Geostationary Platforms (ESGP) especially important in providing a dynamical understanding of the physical processes that control natural and man-influenced global changes. From geostationary orbit (22,300 miles above Earth), the complete diurnal cycle of land, ocean, and atmospheric phenomena can be observed at any time scale without aliasing.

Drawing on their experience as Earth scientists, the ESGP Science Steering Committee has identified a wide range of specific processes that are integral to the Mission to Planet Earth objectives and require measurement from geostationary orbit. A subset of these phenomena and processes include: precipitation and lightning; mesoscale atmospheric and oceanic circulations; coastal processes including tides; environemental pollution; volcano eruption and earthquake occurrence; oceanic phytoplankton blooms; water vapor sources, sinks and structure; solar flux and solar constant; atmospheric trace gases; diurnal terrestrial ecosystem processes; cloud evolution and severe storms; and the Earth system radiation balance.

Three U.S. Earth Science geostationary platforms and two foreign provided geostationary platforms are being proposed in the Mission to Planet Earth initiative. The initial U.S. platform is expected to weigh approximately 4,600 kg (10,000 lbs.) and carry about 1,400 kg (3,000 lbs.) of scientific instruments. Candidate instruments include facility instruments (those which provide information useful to multiple disciplines), principal investigator instruments (those provided by individual scientists to address specific discipline processes), and NOAA operational instruments. Platform concept studies are currently being conducted by Lockheed Missiles and Space Company (LMSC); their subcontractors, Ford Aerospace and Computer Sciences Corporation; and by the Marshall Space Flight Center (MSFC) inhouse team. Science instrument concepts are already being studied by NASA Centers, NOAA, Universities, and instrument contractors. Launch of the first ESGP is currently planned for the late 1990's.

CONCLUSION

The infrastructure planned for the 1990's will offer a wide range of opporturnities for science and application payloads. We have shown how the potential capability of the Extended Duration Orbiter (EDO); Space Station Freedom (SSF); and the polar, geostationary, and free flyer platforms of Mission to Planet Earth can be effectively utilized for exciting new science and application missions such as the CASES, POF, ASO, NEWPIMS, LAWS, and TRMM. The scientific and technological results from some of these payloads should be extremely useful in supporting the President's new initiatives.

Since considerable time is required to develop and deliver experiment hardware, now is the time to begin planning experiments and payloads to take advantage of the unique capabilities described in this paper. We at NASA/MSFC are confident that this infrastructure will meet the current and future needs of the scientific community and look forward to working with them to exploit these capabilities for the benefit of mankind.

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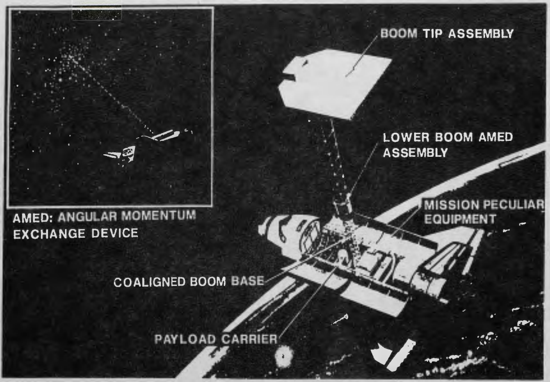

Figure 1. Control, Astrophysics, And Structures Experiments In Space (CASES)

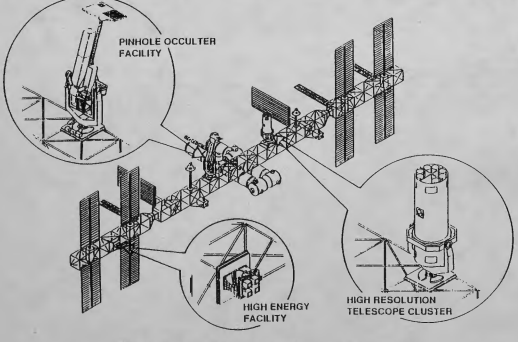

Figure 2. Advanced Solar Observatory (ASO)

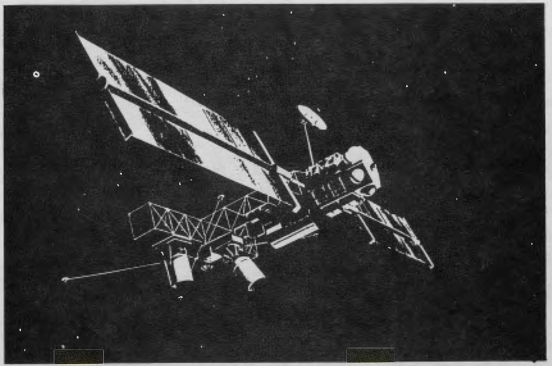

Figure 3. Laser Atmospheric Wind Sounder (LAWS)

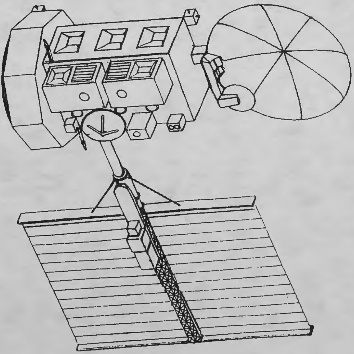

Figure 4. Earth Science Geostationary Platform (ESGP)