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APPLICATIONS SPACELAB MISSIONS

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ABSTRACT

The plans of the Office of Space and Terrestrial Applications for Shuttle/Spacelab missions are presented. The current program contains a dedicated low-gravity mission (Spacelab 3 Mission) and several minor missions planned for flight during 1980-1982. These minor missions have either Materials Processing or Earth Viewing emphasis. Several representative experiments are used to illustrate the Applications Spacelab Program.

INTRODUCTION

For purposes of this paper, the term "Spacelab" shall be inclusive of payloads which remain attached to the Shuttle/Orbiter during flight.

The Applications Spacelab Program, managed by the Office of Space and Terrestrial Applications (OSTA), emphasizes experiments in the areas of Resource Observations, Environmental Observations, Materials Processing in Space, and Communications. The Program also includes the flight of experiments in the area of Advanced Technology. This paper presents an overview of the planned and approved missions.

The first of our two approved missions is the "OSTA-1," which will fly on STS-2 as the first payload for the Shuttle. The other approved Applications mission is "Spacelab 3," a low gravity mission which will use the entire Orbiter cargo capability. It will be the first Spacelab mission in which experiment objectives are prime. On the earlier Spacelab missions, the engineering verification of the Spacelab is the prime objective.

Other Spacelab missions whose flight requirements are being analyzed will, during 1981, fly: 1) the "Solar Array Experiment," a large space structure, 2) a "Large Format Camera" which will provide stereoscopic geological observations and 3) a "Materials Experiment Assembly" which will transition materials processing rocket experiments to the shuttle. These smaller missions will probe the concept of "payloads of opportunity."

THE OSTA-1 MISSION

In late 1976, we completed a broad solicitation for experiments to be conducted during the Orbital Flight Test Program (the first six Orbiter flights). The result in Applications, is OSTA-1 (Fig. 1), a mission which has been assigned to STS-2 because of that test flight's orientation. The Shuttle will fly with the radiators on the open bay doors pointed to Earth to achieve a benign thermal environment. This is the ideal Orbiter attitude for the OSTA-1 Earth viewing experiments described in Figure 2.

One experiment, the Shuttle Imaging Radar-A (SIR-A) has been adapted for use as a geological mapping tool from the synthetic aperture radar used on Seasat. This experiment will evaluate the potential of spaceborne radars for mineral exploration, petroleum exploration and mapping of lineaments.

Launch of OSTA is planned for early 1980, with an inclination of 40.5 degrees and an altitude of 160 nautical miles. The mission is managed by the Johnson Space Center with Rockwell International as the mission integration contractor. The instruments will be delivered to KSC during June 1979 where all levels of integration will be conducted.

Another resource observation experiment, the Shuttle Multispectral Infrared Radiometer (SMIRR) will be used to discriminate among rock types by assessing variability in reflectance signatures. Measurements will be made with a 20 cm telescope modified from Mariner-Venus-Mercury "73" hardware. It contains a linear array of ten detectors and associated filters.
Environmental observations will be conducted by a variety of experiments, including 1) the Measurement of Air Pollution from Space (MAPS), 2) the Ocean Color Experiment (OCE), and 3) the Night/Day Optical Survey of Lightning (NOSL) Experiment. The MAPS experiment is our first attempt to measure from space the interhemispheric variations in tropospheric carbon monoxide. We expect to improve our understanding of global circulation with MAPS because carbon monoxide has a chemical lifetime sufficient to act as a tracer for pollution transport phenomena.

The MAPS instrument is part of an evolution of technologies that use gas filter radiometers to measure atmospheric constituents. The OSTA-1 flight of the MAPS and Spacelab 3 flight of the Halogen Occultation Experiment (HALOE) engineering model allow the development to proceed in a stepwise manner. Figure 3 shows how Spacelab can bridge the gap between the expensive free flyer or operational flight systems, and the limited research that can be conducted via aircraft platforms.

The NOSL experiment will be conducted from the Orbiter cabin. Annotated films will be obtained which should provide insight regarding the role of lightning as an indicator of the development or intensity of severe storms.

The Feature Identification and Landmark Experiment (FILE) is part of the NASA advanced technology program. FILE will develop instrumentation which will allow future spacecraft to determine what features are in the view of the on-board sensors and then to command data taking accordingly. This important advance will allow high data rate channels to be conserv ed for use only when the sensor data is appropriate to the mission objectives.

THE SPACELAB 3 MISSION

The Spacelab 3 Mission demonstrates the strategy of decentralization we are using for the Applications Shuttle/Spacelab experiment program: experiments are developed under the cognizance of the discipline divisions to meet their program objectives. There is relatively minor influence by the mission management.

This management approach ensures that missions will be defined and configured in response to experiment requirements, rather than vice versa. This is essentially the way that the rocket, balloon, and aircraft programs are managed, but it is a formidable challenge to extend such discipline-oriented management to the highly complex and time critical schedules inherent with Spacelab. We believe that we have a workable strategy, however. It delays the firm assignment of experiments to missions until about two years before launch, thus striking a balance between experiment flexibility and Space flight discipline. One side benefit of this approach is that experiments originating outside of the Office of Space and Terrestrial Applications (or external to NASA) are easily accommodated.

The Spacelab 3 mission is dedicated to conducting experiments in a low-gravity environment, including minimal Orbiter rotation or maneuvering. These conditions are required to allow the fluid physics oriented experiments on the mission to be conducted in the absence of convection or perturbed initial conditions.

Spacelab 3 will be launched in the Spring of 1982. It is managed by the Marshall Space Flight Center with Teledyne/Brown Engineering as the mission integration contractor. The configuration is that of long module, plus pallet (Fig. 4). The orbit will be 57 degrees inclination at an altitude of 160 nautical miles. The high inclination will afford opportunities for conducting occultation experiments. The experiments have solar tracking capability and therefore do not require Orbiter maneuvering which would perturb the low-g environment.

The experiment hardware on the Spacelab 3 mission is mostly of the multi-user "facility" type with a number of experiments conducted on each of the "facilities." The key investigations are summarized in Fig. 5. There are three principal materials processing facilities. The Fluids Experiment System is the largest and will study crystal growth in the absence of convection. For example, triglycine sulfate crystals will be observed with optical observation techniques to determine concentration and thermal gradients. Similar techniques will be used in another experiment on this facility to observe convection and correlate it with the occurrence of defects and/or impurity variations in the crystals.

The Vapor Crystal Growth apparatus will produce Mercuric Iodide crystals for comparison with similar crystals grown on the ground. The seed crystals will be prepared on Earth and then grown in space by vapor transport, using the temperature oscillation method. The space crystals are expected to immediately surpass Earth crystals for use as gamma ray detectors because of far fewer structural growth defects.
The Monodisperse Latex Reactor experiment is more oriented toward near term space commercialization than the other experiments. Monodisperse latex polymer spheres will be manufactured in saleable quantities, primarily for instrument calibration and medical diagnostic tests. Dr. John Carruthers of NASA will describe this experiment and its implications in the space commercialization session.

The Environmental Observations program also has a low-gravity experiment on this mission, the Atmospheric Cloud Physics Laboratory (ACPL). This facility is dedicated to improving our understanding of the physical processes which take place during cloud formation. Droplet growth with polydisperse and monodisperse cloud condensation nuclei will be observed in the expansion chamber. The ACPL will extend ground based research techniques into space and will allow basic processes in cloud physics to be observed for the first time without the influence of gravity on large cloud droplets or ice crystals. The Spacelab 3 mission has two pallet mounted experiments which measure atmospheric constituents. They are the previously mentioned HALOE and the ATMS (Atmospheric Trace Molecule Measured by Spectroscopy) experiment. The latter will demonstrate the capability to monitor environmental quality by surveying the atmosphere for trace constituents and identifying their sources, flow patterns, and decay mechanisms. The instrument will accomplish this by measuring absorption of solar radiation in the two to 16 micron wavelength band with extremely high resolution.

The HALOE experiment is synergistic with ATMS in that the concentrations of some of the same constituents are measured. The objective of HALOE is to conduct preliminary scientific investigations of stratospheric ozone/chlorine photochemistry using gas filter correlation radiometry and broadband spectroscopy. Another important objective is to validate the instrument parameters, the measurement requirements, and the software procedures with this flight of engineering model hardware prior to commitment of the final flight article to a long duration free flyer mission on the Earth Radiation Budget Satellite.

There are also two Advanced Technology Experiments on the Spacelab 3 mission. One, the Drop Dynamics Module, will perform basic experiments concerning the dynamics of rotating and oscillating droplets with a view toward understanding dynamic processes not currently accessible by theory. The instrument will position either water or silicone oil droplets and then excite them with acoustic fields. This experiment directly addresses droplet theory which has been studied by scientists since Newton have pondered.

The other, the Geophysical Fluid Flow Cell performs spherical convection flow experiments with radially and latitudinally directed temperature gradients and rotation. In essence, this experiment simulates idealized fluid dynamics of planetary atmospheres. This experiment is of high importance to a large field of researchers including atmospheric physicists and astrophysicists.

Spacelab 3 represents in my view, a model of future Spacelab missions. None of the experiment requirements have been constrained to any degree, and the instruments are highly compatible. We are now beginning the detailed analysis of on-orbit crew requirements and we plan to provide discipline specialists in space to conduct such experiments.

MINOR MISSIONS

There are a number of instruments which we plan to accommodate on small structures because they are either technically or programmatically incompatible with dedicated missions like Spacelab 3. These instruments have been designed to be highly autonomous and do not require Spacelab systems. The payload of such a mission will likely be "mixed cargo;" that is, these instruments will fly with free-flyer spacecraft. The details of the near term missions are not final.

One such instrument which will be accommodated in this manner is especially interesting because it demonstrates what may be the lowest cost mode of Shuttle experimentation. It is termed the Materials Experiment Assembly (MEA) and will extend the Materials Processing rocket experiment program to the Shuttle. The MEA will be self contained; the only interface other than the physical structure is a few wires to a patch panel in the Orbiter aft flight deck. The MEA can be flown as a "payload of opportunity" and may even replace ballast. We feel that payloads like this offer early inducements to space utilization by having very low user costs.

PLANS FOR SPACELAB

What is the future of the Spacelab experiment program? The current plans envision an Applications Spacelab Program comprising a dedicated Spacelab mission and a few minor missions every eight months or so. If a more favorable budgetary climate develops, a larger program could follow. Also, the pace of activity could rise significantly if indus-
trial interest in experiments or production increases.

SUMMARY

The applications of Spacelab are varied and growing. The Spacelab mode of space experimentation provides a means to conduct many important investigations and fills a vital role as a "test bed," allowing our complementary programs to develop with minimal risk and cost.
OSTA-1 PAYLOAD

Figure 1.
OSTA-1 MISSION

EXPERIMENT

1. SHUTTLE IMAGING RADAR — A (SIR-A)
2. SHUTTLE MULTISPECTRAL INFRARED RADIOMETER EXPERIMENT (SMIRR)
3. OCEAN COLOR EXPERIMENT (OCE)
4. MEASUREMENT OF AIR POLLUTION FROM SPACE (MAPS)
5. NIGHTTIME/DAYTIME OPTICAL SURVEY LIGHTNING (NOSL)
6. FEATURE IDENTIFICATION AND LANDMARK EXPERIMENT

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STATE UNIVERSITY OF NEW YORK

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## GAS FILTER RADIOMETER EVOLUTION

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Figure 3.
Figure 4.
SPACELAB 3 MISSION

- FLUID EXPERIMENT SYSTEM (FES)
  SOLUTION GROWTH OF CRYSTALS IN ZERO-GRAVITY
  CRYSTAL GROWTH IN A SPACEFLIGHT ENVIRONMENT

- VAPOR CRYSTAL GROWTH (VCG)

- MONODISPERSE LATEX REACTOR (MLR)

- ATMOSPHERIC CLOUD PHYSICS LABORATORY (ACPL)
  CHECK-OUT ATMOSPHERIC SCIENCE EXPERIMENT SET
  CLOUD-FORMING EXPERIMENTS AND NUCLEATION STUDIES
  EXPANSION CHAMBER CLOUD MICROPHYSICS EXPERIMENT

- DROP DYNAMICS MODULE (DDM)
  DYNAMICS OF ROTATING & OSCILLATING FREE DROPS

- GEOPHYSICAL FLUID FLOW CELL (GFFC)

- ATMOSPHERIC TRACE MOLECULES OBSERVED BY SPECTROSCOPY (ATMOS)

- HALOGEN OCCULTATION EXPERIMENT (HALOE)

Figure 5.