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BOOK 3

SUPPORTING RESEARCH AND TECHNOLOGY (SR&T) REPORT

ATMOSPHERE, MAGNETOSPHERE AND PLASMAS IN SPACE (AMPS) SPACELAB PAYLOAD DEFINITION STUDY

Final Report
November 1976

Prepared for
National Aeronautics
and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland 20771

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DEFENSE AND SPACE SYSTEMS GROUP

ATMOSPHERE, MAGNETOSPHERE AND PLASMAS IN SPACE (AMPS) SPACELAB PAYLOAD DEFINITION STUDY FINAL REPORT

VOLUME VII

BOOK 3 - SUPPORTING RESEARCH AND TECHNOLOGY (SR&T) REPORT

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INTRODUCTION

This document provides an identification of the Supporting Research and Technology (SR&T) necessary to support the planned development of the Atmosphere, Magnetosphere and Plasmas in Space (AMPS) Space Shuttle Payload. The majority of the effort during this contract phase was expended in the design of the first two missions which are planned for 1981 and 1982. As a result, the major items identified for development relate to these flights, and it is likely that a further identification of SR&T items will take place as later flights mature.

The items identified as required to support the AMPS mission and requiring SR&T support and further work are:

a) A general purpose Experiment Pointing Mount

b) A technique for measuring the attitude of the pallet-mounted or deployed experiments

c) The development of a common optics cryogenically cooled interferometer spectrometer

d) The development of a differential absorption lidar system for the measurement of ozone densities in the earth's atmosphere

e) The development of dc-to-dc power processors which are capable of converting energy stored in a capacitor system at 500 V to energy supplied to equipment operating at 40 kV and at 20 kW (eventually up to 100 kW)

f) The development of a magnetic or possibly electrostatic deflection system capable of bending the beam of an electron accelerator.

A data sheet is included for each item, briefly describing the background and need for each item and the general objectives of the required development, and identifying the schedule requirements in support of the AMPS program.

This document is submitted in fulfillment of the Data Requirement SE-243B, Supporting Research and Technology Report.

EXPERIMENT POINTING MOUNT

Justification

A large number of the instruments included in the AMPS payload require either: 1) a large field of view or motion relative to other body-fixed instruments, or 2) fine pointing to accuracies better than Orbiter can provide (i.e., approximately 2 degrees) or rate stabilization over selected periods better than Orbiter can provide (i.e., approximately 0.01 deg/sec). Many NASA studies have shown that the most cost effective way to meet these requirements is with an independently gimballed pointing mount.

Objectives

An experiment pointing mount (EPM) must be developed with the majority of the instrument pointing and stability requirements as design criteria and should provide a flexible accommodation with regard to instrument size, weight, power, and thermal dissipation. Another major requirement is the ease of integration of the experiment pointing mount with the Orbiter since a minimum ground turnaround time is very important to the STS basing concept.

Schedule

These experiment pointing mount requirements are not unique to AMPS and have been recognized by NASA for general payload support. As a result, preliminary work has been done on several designs and a decision on which EPM design to support is planned by NASA. Development funding must take place in FY '78 in order to support an October 1981 AMPS launch date.

PALLET-MOUNTED OR DEPLOYED EXPERIMENT ATTITUDE MEASUREMENT

Justification

A general class of problems has surfaced wherein the angular attitude of a device must be known with respect to another device or a prescribed reference frame to tolerances less than can be achieved with normal structures. For example:

1) On AMPS it is required that the vector magnetometer, used in conjunction with the electron accelerator, be deployed to reduce the influence of the Orbiter magnetic field and yield a sufficiently accurate measurement of the earth's magnetic field. Such a measurement is utilized to point the accelerator relative to the magnetic field line and must be performed with an accuracy of 1 degree end to end. As is the case with many Orbiter payloads, the structural accuracy from the accelerator on one pallet across to another pallet and including a deployment mast cannot be relied upon to meet these requirements.

2) In the case where pallet-mounted instruments must be pointed relative to a reference (i.e., inertial, local vertical, etc.) to within a prescribed accuracy less than 2 degrees, it is doubtful that the Orbiter inertial reference can be singly utilized. The reason for this is that a relatively large structural relaxation is expected in the basic Orbiter fuselage when in orbit. Thus ground alignments cannot be maintained and pallet-mounted instruments must either measure their own attitude pointing reference in orbit or find a way to relate back to the Orbiter navigation base. One technique would be to measure on-orbit structural relaxation and consider it as a bias in the Orbiter instrument pointing commands. This technique is identical to the first example. Of course, other techniques could be utilized and these should be included in the trade studies which yield a solution to this supporting research and technology request.

Objectives

The objective of this SR&T program would be to explore the ways that attitude measurement for pallet-mounted instruments and deployed instruments could be accomplished to accuracies better than provided by the host Orbiter vehicle. These requirements and solutions should be categorized and a trade study performed. The results of the trade study should yield the technique(s) (and their cost and schedule) recommended for STS implementation.

Schedule

Study work should be accomplished from 1 January 1977 to 1 July 1977. Following competition, the hardware development should begin in January 1978 with deliveries in time to support OFT 2 and subsequent.

CRYOGENIC INTERFEROMETER SPECTROMETER

Justification

The measurement of infrared emissions from the earth's atmosphere in the spectral range from 1 to 50 microns will require the development of a cryogenically cooled optical system in order to obtain the necessary optical sensitivity.

The high orbital speed of the Shuttle will make it necessary to take rapid spectral scans in order to achieve good ground and altitude resolution of emission regions. At the present time, the best method to obtain high speed spectral scanning is by using interferometer techniques and obtaining the spectrum by Fourier transforms of the detector output. There is a strong need to work on increasing the speed of both the interferometer scan and the data analysis so that both the spectral and distance resolution of the interferometer can be improved.

Finally, because the low background requirement at long IR wavelengths necessitates cooling the optics to liquid nitrogen temperatures, it would be most desirable to incorporate instruments within a single collecting optics system. Furthermore, some of the best infrared detectors operate at liquid helium or liquid hydrogen temperatures. Thus, techniques are needed for incorporating the liquid nitrogen and liquid helium within the IR instrumentation assembly and for handling the cryogens during testing and launch operations.

Objectives

The general objective of this SR&T effort would be to develop a rapid scanning cryogenically cooled interferometer spectrometer for the infrared spectral range from 1 to 50 microns. Particular attention would be paid to the development of cooled collecting optics, rapid interferometer mirror speeds, and perfecting detector systems.

Schedule

Design and development work would have to be completed by 1980 so that AMPS system definitions can be made for incorporation on the first AMPS mission.

LIDAR

Justification

The in situ determination of ozone content at altitudes in the range from 20 to 80 kilometers above the earth can be done with a lidar system operating from the AMPS payload by means of differential absorption measurements using two separate lasers firing within milliseconds of each other. At the present time, there does not exist such a system that is ready for space flight. While the powers and frequencies of the laser systems that are needed are not beyond the state of the art, it will be necessary to develop a suitable configuration and to solve the design problems associated with a differential absorption lidar (DIAL) system which can be flown on AMPS. Some of these problems are alignment, power dissipation, detector sensitivity, and configuration.

Objectives

The general objectives of this SR&T effort would be to develop a differential absorption lidar system for the measurement of ozone densities in the earth's atmosphere. Such a design would solve the thermal, alignment, and configuration problems associated with space flight of a laser system.

Schedule

The design and development effort would have to be completed by 1980 so that the unit could be ready for the first AMPS flight.

HIGH POWER DC-TO-DC ELECTRICAL PROCESSORS

Justification

The electron accelerator on the first AMPS flight will require 20 kW of power to be delivered at voltages up to 40 kV. At the present state of the art in power processors 10 kW is the limit. While it is possible that two 10-kW units could be put in parallel to provide the desired power, it would be desirable to begin working on systems that will be able to deliver power at much higher levels. One of the limitations of the electron accelerator is the amount of power that it can deposit into the atmosphere. If higher powered processors can be developed, this limitation will be eliminated.

In any long-term view of the AMPS program, i.e., beyond two flights, there will be an ever increasing need for delivery of high voltage power at levels much greater than 10 kW. The development of 100-kW units would greatly expand the capability and usefulness of the Labcraft system.

Objectives

The general objectives of this SR&T effort will be to develop a dc-to-dc power processor which will be able to convert energy stored in a capacitor system at about 500 V to energy supplied to equipment operating at up to 40 kV. The conversion process should be capable of delivering at least 20 kW for early flights but should aim ultimately for a design limit on the order of 100 kW.

Schedule

For the initial 20-kW power level, development should be completed in late 1980 for incorporation on the first AMPS flight. The program should continue through 1982-3 to achieve the 100 kW or higher level.

ELECTRON ACCELERATOR BENDING OPTICS

Justification

Several of the experiments planned for the first AMPS flight could make use of the capability for bending the electron beam from the electron accelerator to various angles with respect to the earth's magnetic field. By using such a system, beams of known and controlled pitch angle could be injected along magnetic field lines, the pitch angle could be rapidly varied with the possibility of generating plasma waves, the pitch angle could be held constant during periods when the Shuttle was oscillating with respect to the magnetic field, and the exit characteristics of the electron beam would be more fully defined. All of these advantages could be obtained by a suitably designed magnetic deflection system placed at the exit aperture of the electron accelerator.

Objectives

The general objectives of this SR&T effort would be to design a magnetic or possibly electrostatic deflection system capable of bending the exit beam of the electron accelerator with rates up to degrees per millisecond and angles up to 70 degrees for beam energies from less than 1 kV to more than 40 kV with beam sizes on the order of one-half meter diameter or larger, for use on the AMPS electron accelerator system.

Schedule

The design and development effort would have to be completed by early 1980 so that the system could be incorporated on the electron accelerator early in its development and fabrication phases. The total accelerator system would fly on the first AMPS flight.