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MATERIALS FLIGHT EXPERIMENT CARRIER CAPABILITY AND FUTURE FLIGHT EXPERIMENTS ON HITCHHIKER-M CARRIER PROGRAM

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D. Davis
Center on the Commercial Development of Space (CCDS)
Center on Materials for Space Structures (CMSS)
Case Western Reserve University
Cleveland, Ohio 44106

ABSTRACT

The CMSS has designed, fabricated, and qualified a unique Materials FLight EXperiment (MFLEX) carrier. The MFLEX is a reusable materials experiment carrier designed to support a wide array of sensors that measure synergistic effects on candidate space materials in Low Earth Orbit (LEO). The MFLEX can be integrated on a variety of launch vehicles/carriers and multiple units can be networked to optimize the surface area of carriers such as the Hitchhiker-M currently being built by the Goddard Space Flight Center (GSFC).

INTRODUCTION

Advanced structural materials are being developed for the next generation of satellites and space stations. These materials have to withstand the harsh environment of space for long duration missions, with little or no maintenance. The major causes for degradation of materials are UV radiation, atomic oxygen, electron and proton radiation and thermal cycling (1). Atomic oxygen and vacuum thermal cycling (2) are the critical factors for LEO structures while radiation is critical in higher orbits. The evaluation of structural materials for LEO is done by a combination of ground based simulated exposure and space flight experiments.

The primary objective of the MFLEX is to introduce organic/inorganic materials and coatings to a flux of atomic oxygen in LEO, providing a variety of testing methods. The MFLEX has been designed to provide "real-time" data of the space effects on selected materials. The candidate materials will have undergone extensive ground-based testing prior to being integrated to the reusable space flight hardware designed for multi-mission Space Transportation System (STS) use.

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HARDWARE DESCRIPTION

It is convenient to divide the MFLEX into three modules: 1) the Motorized Lid Unit (MLU), the first (top) module, 2) the Sensor Control Unit (SCU), the second module and 3) the Electronics Control Unit (ECU), the third module.

The three separate MFLEX housings are machined from 6061-T651 Aluminum and clear anodized MIL-A-8625 Rev. E, Type II, Class I. They are uniform in length and width for assembly. The assembled MFLEX (Figure 1) measures 12" X 15" X 9" and weighs approximately 52 lbs.

Power requirements are 28V and operates at .5 Amps, with a peak power of 4.5 Amps during lid operations. Communications are via an RS-485 serial interface bus.

Motorized Lid Unit

The MLU houses sensored (active) materials experiments and a retractable motorized lid assembly which protects the experiments from contamination of direct exposure to unfavorable environments. The lid assembly (tractor feed type mechanism) is operated during the mission by ground command. Once the lid is retracted, data will be recorded from the active area and transmitted via the host carrier to Earth, for real time observation.

Six active tray assemblies can be mounted onto the Tray Frame Assembly, contained in the MLU. The active tray assemblies consist of the material specimens, appropriate sensors, Daughter Printed Curcuit Board (PCB), and the Mother PCB. See Figure 2.

The Daughter PCB provides the electronic interface for the sensors. Resistance can be varied on this PCB to allow flexibility for each experiments requirement, which also allows flexibility for different types of sensors to be used other than currently defined. A Daughter PCB is assembled onto each active tray for ease of assembly and removal. The Daughter PCB connects to the the Mother PCB which provides electrical distribution from the Tray Specific PCB and routes the electronic signal to the Daughter PCB.

The MLU also accommodates passive (unsensored) specimens on the sides of the top surface; these are not protected by the motorized lid assembly.

Sensor Control Unit

The SCU houses two printed circuit boards, 1) the Tray Specific Board (TSB) which provides analog signal conditioning, analog to digital conversion and signal multiplexing; and 2) the Common Functions Board (CFB), which provides the driver for the stepper motor and both power supply filtering/conditioning for the TSB.

Electronics Control Unit

The ECU houses two printed curcuit boards; 1) the Electronics Control Board which provides the processing, communications link, and watchdog functions; and 2) the Acoustic Emissions Boards which supports acoustic emission experiments.

HARDWARE CAPABILITY

Experiment Area

The passive area currently accommodates two 0.50", thirty-six 0.75", and twelve 1.0" diameter specimens. Two passive experiments can be accommodated, sized up to 0.25" X 2.4" X 10.5" each.

The active experiment area currently accommodates forty-eight 0.5", and seventy-two 0.75"; or it can house experiments up to 1" X 9" X 10". These experiments and their trays can be customized to accommodate almost any configuration, not exceeding physical constraints.

Sensor Capability

The MFLEX can support a variety of sensors that provide accurate measurement of materials erosion that occurs in-flight. Measurement data that requires recording during the mission will consist of resistance, light transmittance, temperature, strain, and frequency emissions. In order to support these requirements, CMSS has designed in capacity to incorporate several sensor types; included are two types of actinometers, three types of thermal sensors, two ranges of strain gages, photo-diodes, and acoustic microphones. See Table 1 for sensor specifications and ranges.

SUMMARY

The MFLEX is a unique integrated materials testing facility that is now available for users to directly obtain data "real-time" for evaluating materials in space. The MFLEX can be used to conduct material experiments in LEO or deeper space, retrievable or non-retrievable, short or long duration missions. The MFLEX can also be used to monitor the health of spacecraft structures.

The unique capability of modifying the host of sensors used for each experiment provides flexible testing methods for materials evaluation in space. The MFLEX facilitates a network capability that can be integrated onto a carrier. It has been proposed as an expanded materials test facility as an attached payload for a long duration experiment on Space Station Freedom.

FUTURE WORK

Materials Laboratory Experiment-01 (MatLab-01)

The MFLEX is scheduled to launch its maiden flight on STS-60, November 1993. The MFLEX is integrated as a piggyback payload on the Wake Shield Facility, a free-flyer experiment carrier designed by the CCDS at the University of Houston. The MFLEX is mounted perpendicular to the velocity vector (RAM). Conclusions will be provided at the 3rd Annual Materials in Space Symposium, May 1994.

Candidate Materials Space Experiment (CMSE)

July 1995, multiple MFLEX's will be exposed to the space environment using a Hitchhiker-M (HHM) carrier currently being designed by the GSFC. This carrier will be held into RAM by the Orbiters Remote Manipulator System (RMS). This experiment can potentially support up to 1000 material experiments.

Long Duration Experiment

CMSS is currently investigating the possible manifest of a long duration experiment.

REFERENCES

1. B.A. Banks, "Atomic Oxygen Interaction with Materials on LDEF." Proc. LDEF Materials Data Analysis Workshop, NASA Conference Pubs. 10046, July 1990.

2. R.C. Tennyson, G.E. Mabson, W.D. Morison and J. Kleiman, "The LDEF/UTAIS Composite Materials Experiment." Proc. LDEF First Post-Retrieval Symposium, NASA Conference Pubs. 3134, June 1991.

Table 1
Current MFLEX
Sensor Specifications

Qty	Sensor/spec	Range
96	Actinometer	
	high resolution channel range	0 to 500Ω
	resolution	0.5Ω
	large channel expanded range	0 to 10kΩ
	resolution	10Ω
24	Photodiodes	
	input range	0 to 300mA
	resolution	300μA
	diode voltage	0.v max
2	Solar cells	
	input range	0 to 1.5mA
	resolution	1.5μA
	diode voltage	1mV max
5	Acoustic microphone	
	voltage out	1.4Vpp
	noise	3μV
	dynamic range	84dB
9	±500μ Strain gauge	
	resolution	1μ strain
16	±5000μ Strain gauge	
	resolution	10μ strain
16	Thermistors	
	temperature range	-50°C to +150°C
	resolution	0.5°C from 0°C to 100°C
72	Platinum resistance thermometer	
	temperature range	-50°C to +150°C
	resolution	0.25°C
48	AD590 (ic)	
	input range	-60°C to +150°C
	resolution	0.21°C

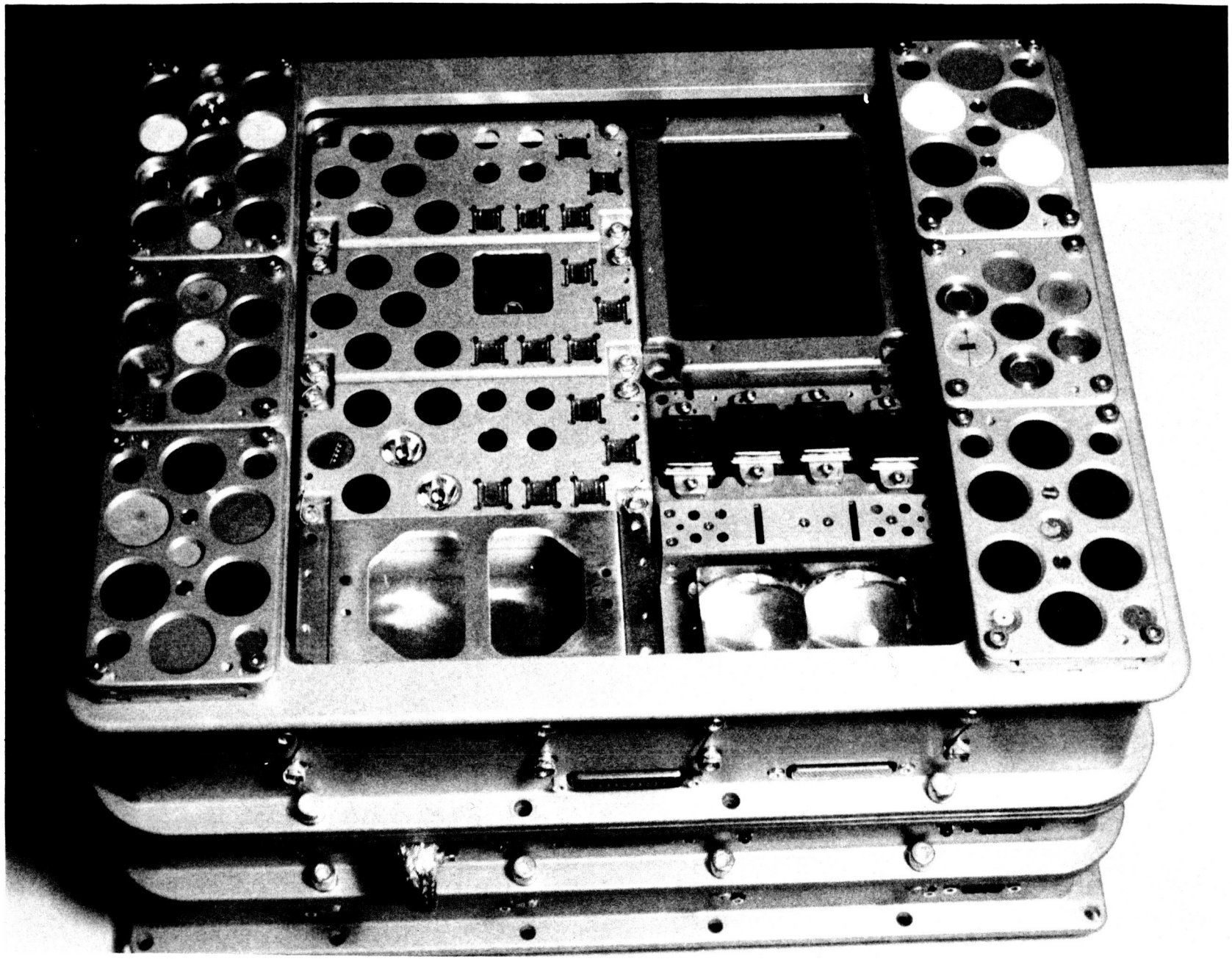

FIGURE 1
MATERIALS FLIGHT EXPERIMENT CARRIER CONFIGURATION FOR MATLAB-01

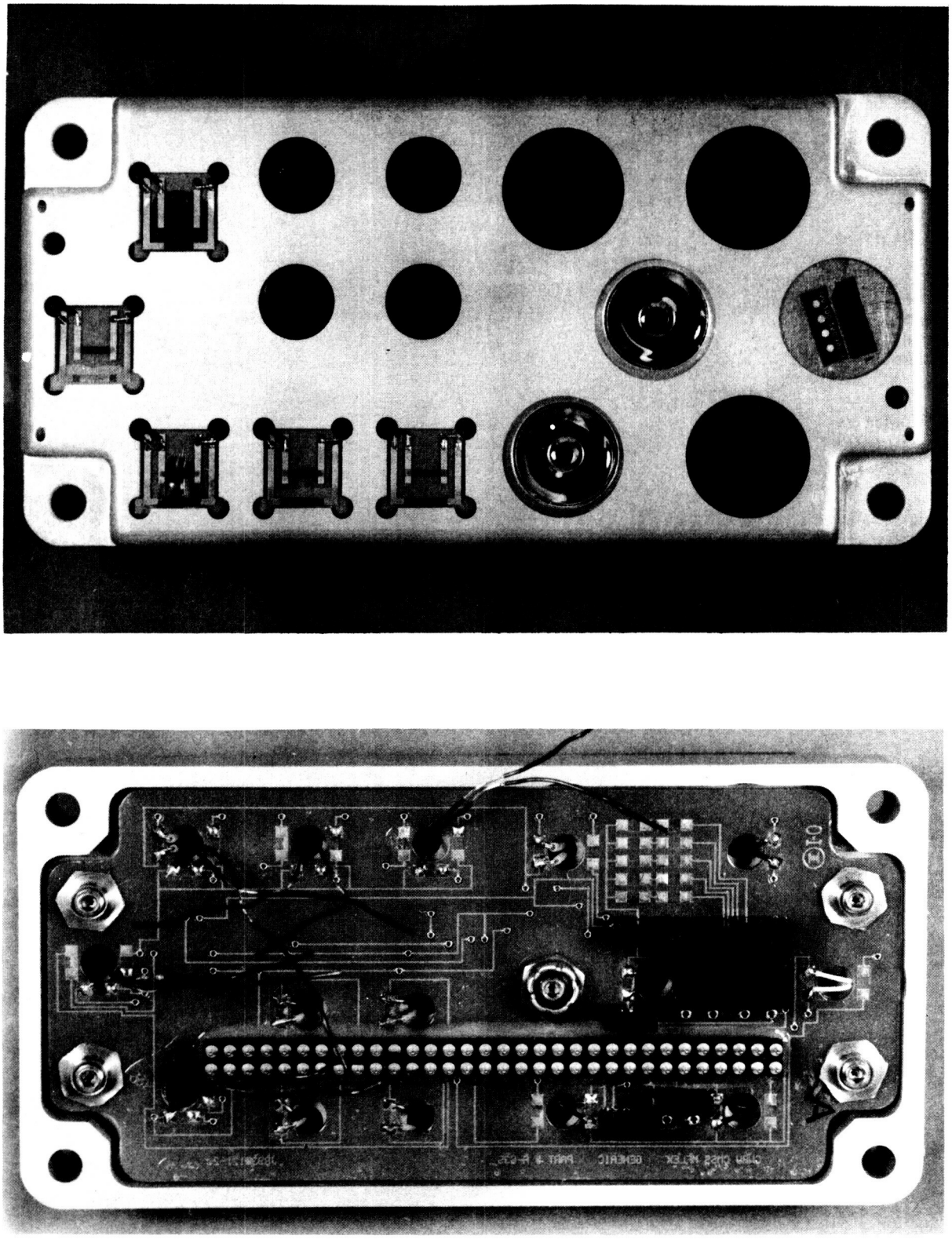

FIGURE 2

TOP - GENERIC ACTIVE TRAY ASSEMBLY WITH MATERIAL EXPERIMENTS

BOTTOM - DAUGHTER PRINTED CIRCUIT BOARD ASSEMBLY ON ACTIVE TRAY