Space Flight Utilizaiton of the Materials ISS Experiment Facility

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I. Introduction

The Materials International Space Station Experiment (MISSE) Facility is a commercial facility that will occupies the International Space Station (ISS) ExPRESS Logistics Carrier – 2 (ELC-2) inboard payload mounting site. The MISSE Facility was designed and built by Alpha Space Test and Research Alliance, LLC (Alpha Space), to enable scientific testing of new or existing materials in the Low Earth Orbit (LEO) environment.

Access to the LEO environment for materials testing has been difficult. The original testing of materials in the LEO environment consisted of the Long Duration Exposure Facility (LDEF), which required two dedicated Space Shuttle missions for deployment and retrieval. Cost for the LDEF program was in excess of $1.0 Billion, including deployment and retrieval flights. The MISSE testing systems were developed as part of a Risk Mitigation Experiment on the Russian Space Station Mir as the Mir Environmental Effects Payload (MEEP). The MISSE program initially developed by the NASA Langley Research Center, was integrated to the ISS by the USAF Space Test Program as part of the Space Experiment Review Board Process within the Department of Defense (DoD). Eight MISSE Missions later, the commercialization of the MISSE Facility was initiated.

The Alpha Space philosophical approach to the flight of experiments on the MISSE is simple. Alpha Space is the hardware development and integration knowledgeable entity required to enable a scientist to do research. The scientist is the knowledgeable person on the research that needs to be conducted. With Alpha Space performing the Integration, Safety and Flight activities, the scientist only needs to focus on the research, thus producing a much better experiment.

II. The Alpha Space Philosophy for Experiments

A. *Spaceflight Hardware Development*

Watching an experiment developer who does not fully understand the methods, engineering, requirements, or environments of space flight vehicles wallow in a mire of paper until his experiment is canceled is difficult to endure. Integrating an experiment without the understanding that "gravity is not your friend" and "you can't open the window to let the smell out" is a difficult concept for people to understand. NASA JSC developed the JSC-STD-8080 JSC Design and Procedural Standards for hardware development to aid in the hardware development process, but without a complete understanding of the flight vehicles, safety process and testing requirements, a scientist will end up devoting most their time to hardware development and not be able to devote any time to experiment development.

Alpha Space Payload Integration Engineers have learned while integrating DoD flight experiments that scientists are logical and intelligent individuals that often are not versed in the nuances that accompany flight on the ISS. With help from these engineers, DoD flight experiments maintained a high success rate for data acquisition.

B. *Flying on the MISSE Facility*

The Alpha Space philosophy means that the experiment developer will provide the minimal, but necessary, information to have their experiment integrated into the MISSE. Once this minimal amount of information is provided, the scientist can then provide the best experiment samples for testing in LEO.

It can be as simple as providing a passive sample, or as complex as providing a sample that produces electrical data for in-flight analysis. Either way, Alpha Space will provide the scientist with the necessary avenue to obtain the necessary data.

III. The MISSE Facility

The MISSE Facility and support hardware are specifically designed to minimize impacts to the scientist budget and experiment design. The impact to experiment design is the most important element of the facility's design, since, if the measurement on the sample interferes with the science, then proper science is not collected.

The MISSE Facility is composed of three major elements, the MISSE Flight Facility, the MISSE Sample Carrier (MSC) and the MISSE Transfer Tray (MTT).

A. *The MISSE Flight Facility*

The MISSE Flight Facility is composed of three major elements, the MISSE Structure, the MISSE Power and Data Box (MP&DB), and the MISSE Switch Box (MSB). The MISSE Flight Facility is shown on orbit in Figure 1.

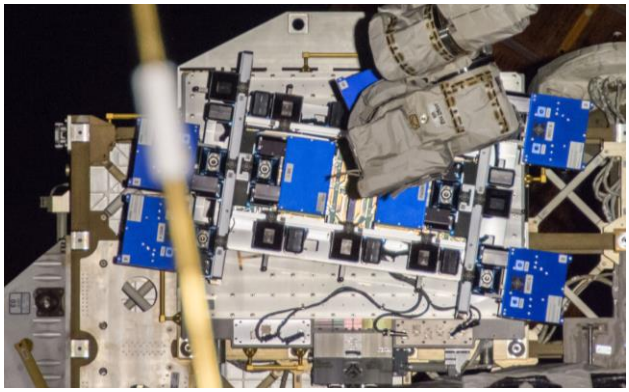

Figure 1. The MISSE Flight Facility.

1) The MISSE Structure

Because the MISSE was designed to be operational until the end-of-life of the ISS, the MISSE Structure was developed and fabricated with ZERO active components. Each possible component location or activity must be performed, accessed, and replaced robotically in case of a component failure. The structure itself is made of anodized aluminum with a grounding path from the MSC or MP&DB or MSB to the ISS reference ground to meet experiment flight vehicle requirements.

2) The MISSE Power and Data Box

The MP&DB handles all power distribution for the facility, powering the MSB, and twelve (12) MSC locations on the facility by converting the 120 Vdc Operational voltage from the ISS into 28 Vdc feeds for each of the active components on the MISSE Flight Facility.

3) The MISSE Switch Box

The MSB takes the six (6) discrete commands from the ELC ExPCA and converts them into 64 semi-independent switches for use throughout the MISSE Flight Facility.

B. The MISSE Sample Carriers (MSC)

The MSC is the generic term for the MISSE interface for materials samples that will be flown on the MISSE Flight Facility. The MSC is a standard material science sample carrier with the instruments to support materials science research. The MSC can be installed at any MISSE Flight Facility location, thus letting the best viewing position for the sample science requirements be selected for each mission.

1) The MISSE Sample Carrier

The MSC is specifically designed to provide the experiment sample with space exposure, High Definition pictures, protection and ancillary data, e.g. temperature, atomic oxygen exposure, UV exposure, and molecular contamination.

Figure 2. The MISSE Sample Carrier

C. The MISSE Transfer Tray

The MTT is the primary mode of transport of the MISSE Flight Facility components, the MSCs, MSB and the MP&DB, to be transferred through the JEM airlock to the externally mounted facility and return MSCs from the facility to the ISS internal volume. The MTT can transfer as many as eight individual components from the pressurized launch vehicle to the ISS and then to the MISSE Flight Facility on ELC-2 outside the ISS. After robotically installing new MSCs, the MTT returns from the MISSE Flight Facility with the previously exposed MSC's. This transfer to and from the MISSE Flight Facility occurs every six months and is further explained in the Flight Operations Section.

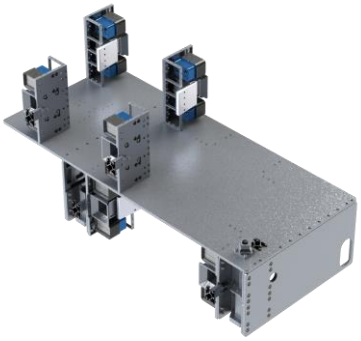

Figure 4. The MISSE Transfer Tray

IV. Flight Operations

Flight operations begin with the initial contact with Alpha Space to acquire a determined amount of surface area, power & data requirements (if any) and viewing direction. Once this is obtained, the flight integration process begins, followed by the Flight Operations, and then the Post Flight retrieval process.

A. Flight Integration

The Flight Integration Timeline is established so that Alpha Space can provide the sample providers a time efficient method to perform testing in the LEO environment. The initiation of the timeline begins with the establishment of the MISSE Interface Definition Document (IDD) approximately 12 months before flight. This document determines how Alpha Space will mount your samples to the experiment decks, any power interfaces, and any data interfaces that the sample provider requires for experiment success. The IDD is a living and evolving document that covers the entire integration process for the samples. For experiments that have data requirements, Alpha Space provides a data Interface Control Document (ICD) that demonstrates the proper packet information that is required for communications on the RS-422 connection for the experiment. Once the sample provider meets the requirements of the IDD and the ICD, Alpha Space will document the flight layout of the experiment and hold a Critical Design Review (CDR). This CDR is presented so that all of the sample providers have a chance to see how Alpha Space will be mounting the samples for flight. The CDR is the last chance that a sample provider will be able to change information related to the planned samples to be flown. After the CDR, Alpha Space presents the integrated MSC layout to the Integrated Safety Review Panel (ISRP), formerly known as the Payload Safety Review Panel (PSRP), for approval of any hazards identified with the experiment sample complement.

Once the ISRP has approved Alpha Space's safety approach, the fabrication of the experiment decks is performed. Six months before launch, the experiment samples are delivered to Alpha Space for integration into the experiment decks. For this operation, Alpha Space coordinates the delivery schedule with the sample providers, so the sample providers can be present during integration of the samples into the experiment decks. At this point, the testing of the integrated deck begins. After the integrated deck is tested as required, the deck is integrated into the MSC for flight. The configured MSCs are tested to ensure that the MSCs meet the requirements from the ISRP and the Payload Integration Office. The completed test data are presented to the ISRP at the Phase III Safety Review. Once the testing of the MSCs for a flight are complete, the MSCs are purged and stored in such a way that the science samples are protected from the environment. Alpha Space, at this point, provides a Certification of Flight Readiness for all the MSCs clearing the way for Flight. The MSCs are transferred to the NASA Cargo Mission Contract contractor for stowage in the launch vehicle. The entire time, from initial contact to first data from orbit, is less than 12 months. Passive samples can be integrated into flight carriers much more quickly.

B. Flight Operations

Flight Operations begin with the launch of the vehicle that will be transporting the hardware to the ISS. After launch, the spacecraft carrying the MSCs docks with the ISS and the cargo transfer begins. The MSCs are transferred to the Japanese Experiment Module (JEM) for installation on the MTT for the transfer of the hardware to the external mounting location. Once attached to the MTT, the MTT is placed in the JEM ORU Transfer Interface (JOTI) on the JEM Airlock Slide Table for passing through the airlock. The MTT is then moved by the ISS robotic arm from the JEM Airlock to the MISSE Facility to begin the robotic transfers of the hardware. Once all MSCs are robotically mounted to the facility, science data collection can begin. The science data collection is conducted in three different processes. The first process is the photography of the samples that occurs every month on experiment samples mounted in an MSC. The second process is carried out on a weekly basis for all active experiments. The third process is carried out on any "One and Done" experiments.

1) The Photography Process

This process is defined pre-flight and is performed during one orbit during the "night" pass. The MSC camera "zeros" to a white background, then the camera trolley moves to the first position, turns on the lights and take the high definition images. It then moves to the next position and repeats the process until all samples have been photographed. This process begins within 3 days of installation to take the baseline pictures of the samples to show ISS arrival conditions. Once the photographs are completed, the data is transferred to Alpha Space for dissemination to the experiment sample owners.

2) The Weekly Process

For experiment samples that are active, weekly activities must be planned and coordinated with the ISS Payload Operations and Integration Cadre (POIC). The POIC consists of the various disciplines necessary to operate payloads on the ISS. Any activity that an experiment provider needs to be performed, must be coordinated with the POIC. The Weekly Process actually starts two weeks in advance, with planned schedule activities identified. The POIC will then take the input from all the active experiments requiring activities, coordinates the activities with available data bandwidth, commanding capabilities, etc. and produces an overall weekly schedule. This schedule is updated daily for the activities scheduled for that day. Alpha Space performs all coordination activities with the POIC based upon the sample providers input and the MISSE Facility requirements.

3) The "One and Done" Process

For experiments that require only one activation on orbit, Alpha Space coordinates with the experiment owner/provider to determine the activation date for the experiment. The operations team coordinates with all sample providers, and then include this in the Weekly Process to schedule the event with the POIC. Once complete, the experiment is placed in a "safe" state for return on the next installation cycle.

C. Sample Return

The experiment sample return begins with the transfer of the MTT, with the next compliment of MSCs, from the JEM Airlock to the MISSE Facility. The new MSCs are installed and the existing MSCs are removed and placed on the MTT for return. The MTT is then transferred to the JOTI on the JEM Airlock Slide Table and transferred inside the JEM. To prevent damage to the JEM Airlock, all hardware must be above the dew point to prevent condensation on Airlock Hardware. Once interior to the ISS, the individual MSCs are bagged with an Oxygen Absorption packet. This Bag is then placed in a second bag with desiccant to remove any residual humidity from the bags. The second bag is then sealed and placed in an ISS standard stowage bag for return to earth. Once the return spacecraft is on the ground, Alpha Space acquires the MSCs from the spacecraft and returns them to the Alpha Space facility for removal of the samples from the MSC decks. The removal of the samples from the MSC decks is coordinated with the sample providers, so shipping of samples can occur as quickly as possible upon de-integration.

V. SCIENCE PROTECTION

The most significant improvements, over the previously flown MISSE systems, in the MISSE Facility provided commercially by Alpha Space include high definition photography provided on a scheduled basis: access to the facility does not require coordination and performance of an Extra Vehicular Activity (EVA); robotic servicing automated closure of the MSCs that prevents contamination from visiting vehicles; and lastly, continuous access to materials testing.

VI. Additional Additions to the MISSE

Material testing on orbit has included solar cell testing in the previous MISSE series payloads. To facilitate the development and testing of solar cells, Alpha Space is developing a Solar Cell Testbed and a Solar Cell Calibration System. The specialized hardware required for these two additions will allow for Air Mass Zero calibration and testing of solar cells on a common platform. Allowing for a direct comparison of data from multiple samples.