Acronym: MAMS

Title: Microgravity Acceleration Measurement System

Principal Investigator(s):
William Foster, Glenn Research Center, Cleveland, OH

Contact(s):
PI - William Foster, (216) 433-2368

Mailing Address(es):
William Foster
Glenn Research Center at Lewis Field
National Aeronautics and Space Administration
21000 Brookpark Road
Mail Code: MS50-4
Bldg. 50 Room 205CC
Cleveland, OH 44135

Developer(s):
Glenn Research Center, Cleveland, OH
ZIN Technologies, Cleveland, OH

Sponsoring Agency: National Aeronautics and Space Administration (NASA)

Increment(s) Assigned: 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20

Brief Research Summary (PAO): Microgravity Acceleration Measurement System (MAMS) is an ongoing study of the small forces (vibrations and accelerations) on the ISS that result from the operation of hardware, crew activities, as well as dockings and maneuvering. Results will be used to generalize the types of vibrations affecting vibration-sensitive experiments. Investigators seek to better understand the vibration environment on the space station to enable future research.

Research Summary:

- The Microgravity Acceleration Measurement System (MAMS) measures vibratory and quasi-steady acceleration within the United States Laboratory Module on the International Space Station (ISS).
- Vibrations exist on the ISS from a variety of sources, such as equipment operation, life-support systems, crew activities, aerodynamic drag, gravity gradient, rotational effects and the vehicle structural resonance frequencies.
- The quasi-steady acceleration is caused by forces from aerodynamic drag, gravity gradient effects, centripetal (rotational) motion, spacecraft mass expulsion, and vehicle attitude control actions.
- Two sensors, the Orbital Acceleration Research Experiment (OARE) Sensor Subsystem (OSS) and the High Resolution Accelerometer Package (HiRAP), monitor these disturbances. The OARE OSS is used to measure low range frequency (up to 1 Hz). The HiRAP is used to characterize the ISS vibratory environment from 0.01 Hz to 100 Hz.

Detailed Research Description: Changes in acceleration and moving mechanical parts can cause small vibrations to move through the Station's structure. These disturbances occur within the frequency range of 0.01 to 300 Hz. MAMS is one of two experiments onboard that will measure and record the vibrations.

The Space Acceleration Measurement System II (SAMS-II) will measure vibrations from vehicle acceleration, systems operations, and crew movements. MAMS will complement this data by recording accelerations caused by aerodynamic drag and Station movements caused by small attitude adjustments, gravity gradient, and the venting of water. These quasi-steady state accelerations occur in the frequency range below 1 Hz. MAMS consists of a low-frequency triaxial accelerometer, the Miniature Electro-Static Accelerometer (MESA), a high-frequency accelerometer, the High-Resolution Accelerometer Package (HiRAP), and associated computer, power, and signal processing subsystems contained within a Double Middeck Locker enclosure.

The MESA consists of a hollow, cylindrical flanged proofmass, two X-axis forcing electrodes, an outer cylindrical proofmass carrier with Y- and Z-axis electrodes, and control electronics enclosed in a protective case. Static electricity forces the sensor proofmass to remain centered between the electrodes. The "sensed" acceleration is proportional to the voltage needed to keep the sensor centered.

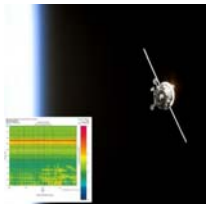
The MESA is mounted on a Bias Calibration Table Assembly (BCTA), a dual-gimbal mechanism allowing on-orbit calibration. Calibration is used to remove electronic bias from the "sensed" acceleration.

Currently MAMS is only operated during special events such as an ISS reboost and spacecraft dockings.

Project Type: Payload

Images and Captions:


NASA Image: ISS003E6010 - Culbertson poses with MAMS hardware in the U.S. Laboratory during Expedition Three.


NASA Image: ISS007E06980 - Back-dropped by the blackness of space and Earth's horizon, an unmanned Progress supply vehicle approaches the ISS during Expedition 7. Inset image shows microgravity acceleration data provided by the MAMS hardware during a Progress docking with ISS.


NASA Image: ISS013E65575 - Shown is the Microgravity Acceleration Measurement System (MAMS) used to measure acceleration during specific ISS operations. MAMS is located in EXPRESS Rack 1in the U.S. Laboratory.

Operations Location: ISS Inflight

Brief Research Operations:

- The crew will activate and deactivate MAMS as necessary.
- When necessary the crew will move hardware to alternate application locations when the microgravity environment for other payloads need to be measured.
- The crew will perform a filter cleaning/change out as required.

Operational Requirements: Crew time was required for transfer to EXPRESS Rack 1, lockers 3 and 4, activation and deactivation, and movement of hardware to alternate locations. Otherwise, MAMS operates automatically. Electrical power is controlled through a circuit breaker in the front panel.

Operational Protocols: Because MAMS measures subtle accelerations that affect only certain types of experiments, MAMS will not be operational all the time. Instead, it will be operated from the Glenn Research Center Telescience Support Center at appropriate times. After initial installation on station, MAMS will require a minimum of 4 days of continuous operation to characterize the sensors' performance and to calculate any sensor bias. MAMS was set up and activated on May 8, 2001, and continued operation for 8 days to collect data during normal Station operations. Since then, it has been reactivated several times to record dockings and other disturbances. It ran continuously for 4 weeks during late June and early July. Multiple calibrations taken over long periods of operation can be used to further improve the accuracy of MAMS data.

Review Cycle Status: PI Reviewed

Category: Technology Development

Sub-Category: Characterizing the Microgravity Environment on ISS

Space Applications: Most microgravity experiments require a quiescent environment in which the effects of gravity and other accelerations are reduced below a threshold level (determined by experiment parameters and design). Knowledge of the acceleration environment in which an experiment was operated is provided by MAMS data.

Earth Applications: MAMS supports many of the on-orbit microgravity experiments, many of which have Earth applications. MAMS measurements and data analysis done by the PI Microgravity Services (PIMS) project may be applied to terrestrial acceleration measurement and analysis, such as oil exploration, machinery vibration monitoring, seismic monitoring, etc.

Manifest Status: Continuing

Supporting Organization: Exploration Systems Mission Directorate (ESMD)

Previous Missions: MAMS has been operating on ISS since Expedition 2.

Results: One of the major goals of the International Space Station (ISS) is to provide a quiescent low-gravity environment to perform fundamental scientific research. However, small disturbances aboard the ISS impact the overall environment in which experiments are being performed. Such small disturbances need to be measured in order to assess their potential impact on the experiments. The Microgravity Acceleration Measurement System (MAMS) is used onboard the ISS to do just that.

MAMS data have been analyzed to examine the quasi-steady regime on station with a frequency below

0.01 Hz. These are related to aerodynamic drag, gravity gradient and rotational effects, venting of air or water, and appendage movement, such as that of the solar arrays and antennas. Characteristics were found in the data that were unexplainable for a short period of time. Analysts determined that the movement of the Ku-band antenna was the source of the unusual characteristics in the quasi-steady data collected by MAMS. (A Ku-band antenna is used to transmit payload science data and video from ISS to Earth.) The correlation was made after comparing the data with real-time observations from ISS. (Del Basso, 2002).

A special study using MAMS data was performed by ISS science officer Don Pettit during Expedition 6 as a part of Saturday Science. Pettit examined the motion of air bubbles in water to see how it correlated with quasi-steady accelerations, vibrations that are at or below a frequency of 0.01 Hz for a period greater than 100 seconds. (DeLombard, 2005).

Results Status: Pending More Information

Results Review Status: PI Reviewed

Results Publications:

Del Basso S, Laible M, O'Keefe E, Steelman A, Scheer S, Thampi S. Capitalization of Early ISS Data for Assembly Complete Microgravity Performance. Proceedings of the 40th AIAA Aerospace Sciences Meeting and Exhibit, Reno, NV. Jan 14 - 17, 2002 ;AIAA 2002-606.

DeLombard R, Kelly EM, Hrovat K, Nelson ES, Pettit DR. Motion of Air Bubbles in Water Subjected to Microgravity Accelerations. Proceedings of the 43rd AIAA Aerospace Sciences Meeting and Exhibit, Reno, NV. Jan 10 - 13, 2005 ;AIAA 2005-722.

Jules K, Hrovat K, Kelly E. The Microgravity Environment Levels of the International Space Station During the Buildup Period: Increments 2 to 8. 55th International Astronautical Congress. Vancouver, British Columbia, Oct. 4-8, 2004 ;IAC-04-J.6.01.

Jules K, McPherson K, Hrovat K, Kelly E, Reckart T. A Status Report on the Characterization of the Microgravity Environment of the International Space Station. 54th International Astronautical Congress. Bremen, Germany. 29 September - 3 October, 2003 ;IAC-03-J.6.01.

DeLombard R, Hrovat K, Kelly E, McPherson K, Jules K. An Overview of the Microgravity Environment of the International Space Station Under Construction. 40 th AIAA Aerospace Sciences Meeting and Exhibit. Reno, NV, Jan. 14-17, 2002 ;AIAA-2002-0608.

McPherson KM, Schafer CP, DeLombard R, Hrovat K, Foster WM, Kelly E. Microgravity Acceleration Environment of the International Space Station. Conference and Exhibit on International Space Station Utilization - 2001. Cape Canaveral, FL, Oct. 15-18, 2001 ;AIAA-2001-5113.

Related Publications:

Jules K, Hrovat K, Kelly E, McPherson K, Reckart T, Grodsinksy C. International Space Station Increment-3 Microgravity Environment Summary Report. NASA Technical Memorandum. 2002 ;2002-211693.

Jules K, Hrovat K, Kelly E, McPherson K, Reckart T. International Space Station Increment-2 Microgravity Environment Summary Report. NASA Technical Memorandum. 2002 ;2002-211335.

Jules K, Hrovat K, Kelly E. International Space Station Increment-2 Quick Look Report. NASA Technical Memorandum. 2002 ;2002-211200.

Jules K, Hrovat K, Kelly E, Reckart T. International Space Station Increment 6/8 Microgravity Environment Summary Report November 2002 to April 2004. NASA Technical Memorandum. 2006 ;2006-213896.

Web Sites:
PIMS
NASA Fact Sheet
NASA Glenn Research Center - MAMS

Related Payload(s): SAMS-II, MACE-II, ARIS-ICE

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