Summary Report of Mission Acceleration Measurements for STS–65
Launched July 8, 1994

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MEASUREMENTS FOR STS-65

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ABSTRACT

The second flight of the International Microgravity Laboratory payload on-board the STS-65 mission was supported by three accelerometer instruments: the Orbital Acceleration Research Experiment (OARE) located close to the Orbiter center of mass, the Quasi-Steady Acceleration Measurement experiment in the Spacelab module, and the Space Acceleration Measurement System (SAMS) in the Spacelab module. A fourth accelerometer flew on the mission; the Microgravity Measuring Device recorded data in the middeck in support of exercise isolation tests. OARE and SAMS are both managed by the NASA Lewis Research Center. Data collected by these systems during IML-2 are displayed in this report. The OARE data represent the microgravity environment below 1 Hz. The SAMS data represent the environment in the 0.01 Hz to 100 Hz range. Variations in the environment caused by unique activities are presented in the report. Specific events addressed are crew activity, crew exercise, experiment component mixing activities, experiment centrifuge operations, refrigerator/freezer operations, and circulation pump operations. The analyses included in this report complement analyses presented in other mission summary reports.
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<td>Bubble, Drop and Particle Unit</td>
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<tr>
<td>DLR</td>
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<td>DSO</td>
<td>Detailed Supplementary Objective</td>
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<td>DTO</td>
<td>Development Test Objective</td>
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<td>EEPROM</td>
<td>Electrically erasable programmable read only memory</td>
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<td>GMT</td>
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<td>IML-2</td>
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<td>IVIS</td>
<td>Inertial Vibration Isolation System</td>
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<td>JSC</td>
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<td>KSC</td>
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<td>LeRC</td>
<td>NASA Lewis Research Center</td>
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</tr>
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</tr>
<tr>
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<td>PCIS</td>
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<td>Principal Investigator Microgravity Services</td>
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<tr>
<td>POCC</td>
<td>Payload Operations Control Center</td>
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<tr>
<td>PSD</td>
<td>Power spectral density</td>
</tr>
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<td>QSAM</td>
<td>Quasi-steady Acceleration Measurement</td>
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<td>Space Acceleration Measurement System</td>
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1. Introduction and Purpose

Fluid physics, materials sciences, combustion, fundamental sciences, and life sciences experiments are conducted on the NASA Space Shuttle Orbiters to take advantage of the reduced gravity environment resulting from the continuous free fall state of low earth orbit. Accelerometer systems are flown on the Orbiters to record the microgravity environment which is composed of quasi-steady accelerations and vibrations of the Orbiter, equipment, and local structures.

The second International Microgravity Laboratory (IML-2) flew on the Orbiter Columbia on mission STS-65 in July 1994. The IML-2 payload on STS-65 was dedicated to microgravity experiments. Two accelerometer systems managed by the NASA Lewis Research Center (LeRC) flew to support these experiments. The Orbital Acceleration Research Experiment (OARE) and the Space Acceleration Measurement System (SAMS) are sponsored by the Microgravity Science and Applications Division (MSAD) of the NASA Office of Life and Microgravity Science and Applications. The Quasi-steady Acceleration Measurement (QSAM) experiment, sponsored by the German Aerospace Research Establishment (DLR), also collected acceleration data as part of IML-2. The Microgravity Measuring Device (MMD) sponsored by NASA Johnson Space Center (JSC) was used in the middeck to record vibration levels associated with crew exercise.

The Principal Investigator Microgravity Services (PIMS) project at the NASA Lewis Research Center supports principal investigators of microgravity experiments as they evaluate the effects of varying acceleration levels on their experiments. This report is provided by PIMS to furnish interested experiment investigators with a guide to evaluating the acceleration environment during STS-65 and as a means of identifying areas which require further study. To achieve this purpose, we present various pieces of information. Section 2 of this report provides an overview of the STS-65 mission, the payloads, and the experiments manifested on the payloads. Section 3 describes the accelerometer systems flown on STS-65 and the means by which they recorded data and provided data to the user. Section 4 discusses some specific analysis of the MSAD accelerometer data in relation to various activities which occurred during the mission. Appendix A describes how OARE and SAMS data can be accessed through the internet. Appendices B and C provide plots of SAMS data as an overview of the microgravity environment during the entire mission. Appendix D contains a user comment sheet. Users are encouraged to complete this form and return it to the authors.

2. Mission Overview

At 12:43:00 pm EDT on 8 July 1994 the Space Shuttle Columbia launched on the STS-65
mission from NASA Kennedy Space Center (KSC). Landing was at KSC on 23 July at 6:38 am EDT. In terms of other time conventions used in this report, launch was at Greenwich Mean Time (GMT) 189/16:43 or Mission Elapsed Time (MET) 000/00:00 and landing was at GMT 204/10:38 or MET 14/17:55. Both GMT and MET are recorded in day/hour:minute:second format. The primary objective of the STS-65 mission was to perform science experiments on the IML-2 payload. IML-2 is an international payload with scientists from the European Space Agency, Canada, France, Germany, and Japan collaborating with NASA to provide the worldwide science community with a variety of complementary facilities and experiments. Research on IML-2 was dedicated to microgravity and life sciences. IML-2 experiments and facilities are listed in Table 1, some facilities have multiple experiments and principal investigators. Other payloads on STS-65 are listed in Table 2. Fourteen development test objectives (DTO) and seventeen detailed supplementary objectives (DSO) were accomplished on STS-65; they are listed in Tables 3 and 4.

3. Accelerometer Systems

Four accelerometer systems measured the microgravity and vibration environment of the Orbiter Columbia during the STS-65 mission: the Orbital Acceleration Research Experiment, the Space Acceleration Measurement System, the Quasi-steady Acceleration Measurement experiment, and the Microgravity Measuring Device

3.1 Orbital Acceleration Research Experiment

The OARE was designed to measure quasi-steady accelerations from below 10 nano-g up to 25 milli-g. OARE consists of an electrostatically suspended proof mass sensor, an in-flight calibration subsystem, and a microprocessor which is used for in-flight experiment control, processing, and storage of flight data [1-4]. The sensor output acceleration signal is filtered with a Bessel filter with a cut-off frequency of 1 Hz. The output signal is digitized at 10 samples per second and is processed and digitally filtered onboard the OARE instrument with an adaptive trimmed-mean filter prior to storage in electrically erasable programmable read only memory (EEPROM). Simultaneously, the unprocessed data are recorded on the Orbiter payload tape recorder. OARE payload tape recorder data were downlinked from the Orbiter about every three hours and were then available in the POCC for analysis.

The OARE system is mounted to the floor of Columbia's cargo bay on a keel bridge. The location and orientation of the sensors with respect to the Orbiter structural coordinate system are given in Table 5 and Fig. 1. For STS-65, the sign convention is such that when there is a forward acceleration of the Orbiter (such as the OMS firing), then this is reported as a positive $X_b$. 
(negative $X_0$) acceleration. Where the subscript 0 represents the Orbiter structural coordinate system and the subscript b represents the Orbiter body coordinate system. OARE data are available from MET 000/00:10 to 014/17:06. Appendix A describes how these data can be accessed via the internet.

3.2 Space Acceleration Measurement System

The Space Acceleration Measurement System was developed to measure the low-gravity environment of Orbiters in support of MSAD-sponsored science payloads. STS-65 was the tenth flight of a SAMS unit. A SAMS unit typically consists of three remote triaxial sensor heads, connecting cables, and a controlling data acquisition unit with a digital data recording system using optical disks with 200 megabytes of storage capacity per side. On STS-65, a SAMS unit and three remote triaxial sensor heads were located in the Spacelab module in support of IML-2 experiments. The three sensor heads recorded data at 50, 25, and 500 samples per second after lowpass filters were applied to the data with cutoffs at 10, 5, and 100 Hz, respectively. The sign convention is such that when there is a forward acceleration of the Orbiter (such as the OMS firing), then this is reported as a positive $X_b$ (negative $X_0$) acceleration. The locations and orientations of the SAMS heads, with respect to the Orbiter structural coordinate system, are given in Table 6 and Fig. 2. More detailed descriptions of the SAMS accelerometers are available in the literature [5-10].

On STS-65, 5.17 gigabytes of SAMS data are available between MET 000/09:21 and 013/08:59. SAMS data for STS-65 are available on CD-ROM from the PIMS project at LeRC. Appendix A describes how these data can be accessed via the internet.

3.3 Quasi-Steady Acceleration Measurement Experiment

The Quasi-Steady Acceleration Measurement (QSAM) experiment was developed by DLR to verify a technique to measure low frequency accelerations. The system is designed to detect accelerations below 0.01 Hz by means of signal modulation applied by rotating the sensor’s sensitive axis. QSAM is also equipped with a set of triaxial accelerometers to measure vibrations up to 50 Hz [11]. Most of the high frequency data were transmitted to the ground for analysis in the POCC. QSAM was located in the Spacelab module as indicated in Fig. 2.

3.4 Microgravity Measuring Device

On STS-65, the Microgravity Measuring Device was used to collect acceleration data in conjunction with crew exercise activity. The data, representing frequencies up to 10 Hz, are being used by the JSC Medical Science Division to evaluate the effectiveness of exercise
vibration isolation systems and to evaluate the ease of use of the MMD System. MMD data were observed in real-time by the crew via the Payload General Support Computer. Information obtained from this display was used in decisions to adjust the exercise ergometer isolation system.

4. Columbia Microgravity Environment—STS-65

The acceleration environment measured by an accelerometer system on the Orbiter is contributed to by numerous sources. All ongoing operations of crew life support systems and activities and operations of the Orbiter, crew, carrier and experiments tend to have vibratory and/or oscillatory components that contribute to the background acceleration environment. In this report we are concerned with the identification of activities that cause acceleration levels above this background. The remainder of this section discusses the environment related to crew exercise, experiment component mixing activities, NIZEMI centrifuge operations, refrigerator/freezer operations and circulation pump activity. The Appendices provide an overview of the microgravity and vibration environment during the STS-65 mission. Appendix B shows time history plots of SAMS Head A (10 Hz filter) data. Appendix C provides a frequency domain representation of the SAMS Head A data.

4.1 Crew Activity—Reference Plots

The seven member crew of STS-65 worked on a dual shift schedule. Because of this schedule, the variation in the microgravity environment between the crew sleep and awake periods that is seen in data from single shift missions is not seen in STS-65 OARE or SAMS data [10]. Fig. 3 shows OARE data for the extent of the STS-65 mission. Note that the quasi-steady environment represented by these data is relatively constant throughout the mission.

Fig. 4 shows an example of the vibration environment of the Spacelab as recorded by SAMS during a period when the entire crew was in the flight deck. The data plots in column a) of Fig. 4 are time histories of the three axes of SAMS Head A data starting at MET 009/04:30:00. The data plots in column b) of Fig. 4 show power spectral density (PSD) representations of the column a) data. For each axis the PSD is calculated according to Parseval's theorem to give an indication of the frequency distribution of power in the acceleration signal. These plots represent the microgravity and vibration environment in the Spacelab during STS-65, related to the various equipment and life support systems that were operational at the time. Fig. 5 shows SAMS Head C data in the same time period. Figs. 4 and 5 can be used as a basis of comparison for other activities discussed in this section. All SAMS data are displayed in terms of the Orbiter structural coordinate system.
4.2 Crew Exercise

Crew exercise on STS-65 was performed in the middeck and flight deck on an ergometer. The equipment was used in configurations isolated from the Orbiter structure using the Inertial Vibration Isolation System (IVIS) and the Passive Cycle Isolation System (PCIS). One period of exercise using the IVIS hardmounted to the flight deck was performed late in the mission for comparison purposes. Table 7 is a list of crew exercise times during STS-65. The vibration environment related to exercise is consistent with that observed on previous missions [7-10]. Exercise is characterized by excitation of frequency components related to the pedalling or rowing frequency of the crew member. Fig. 6 shows the time history and PSD of SAMS Head A data taken when the Pilot was exercising on the ergometer with the IVIS hardmounted to the flight deck. Note the increase of microgravity environment compared to Fig. 4. Comparison of other crew member's exercise periods indicates that exercise motion frequency and intensity levels vary among crew members. The disturbance caused by crew exercise may be seen in the Appendix C plots at the times listed in Table 7. MMD data collected in support of Medical Science Division are being analyzed by their personnel. No report is available at this time.

4.3 Experiment Component Mixing Activities

On MET 008, experiment operations required a crew member to mix experiment components. In live video of these activities, PIMS members observed the crew member both vigorously shaking a sample "up and down" and swinging the sample around, making full circles with his arm. Investigation of the SAMS data collected during this time indicates clear oscillations in the $X_0$ and $Z_0$ axes. The data suggest about seven to eight circles were made in about ten seconds in the XZ-plane. Fig. 7 shows SAMS Head B data collected during this activity. The swinging frequency suggested by the SAMS data shown in Fig. 7 correlates well with recorded downlink video of this event.

4.4 NIZEMI Operations

The Slow Rotating Centrifuge Microscope (NIZEMI) experiments in the Spacelab module exposed matter to levels of gravity ranging from $10^{-3}$ g to 1.5 g. The experiment support module contained an electric motor drive for the centrifuge used to produce the differing g-levels. The SAMS Head C data shown in Fig. 8 were collected when the NIZEMI centrifuge was operating. Note the strong frequency component at 80.3 Hz and that the scales of the time history and PSD plots of Fig. 8 are different than the other Head C data plots. This frequency component is not present at times when the NIZEMI centrifuge was not operating. It is believed that the component is related to the drive motor of the centrifuge.
4.5 Refrigerator/Freezer Operations

As on previous Spacelab missions, refrigerator/freezer units were flown on STS-65 to support life sciences experiments. In the color spectrogram of Fig. 9, note the strong 22.5 Hz signal and upper harmonics of this frequency. This type of signal is typical of refrigerator/freezer compressor cycling seen on STS-47. It is believed that this signal is related to a refrigerator in the Spacelab or middeck. This is under investigation.

4.6 Circulation Pump Operations

Three pumps are used on orbit to circulate hydraulic fluid to maintain the temperature of the hydraulic subsystem [10,12]. During STS-65, the BDPU principal investigators were concerned about the potential impact of circulation pump operations on their experiments. STS-65 OARE data were analyzed by PIMS team members, in near real-time, but no effect was seen. This was as expected because of the low frequency content of the OARE data and assumed high frequency nature of pump operations. During STS-65, the PIMS team at the LeRC User Operations Facility provided STS-62 SAMS data collected during circulation pump operation activation to the POCC Orbit Analysis Engineer. Using this information and near real-time data obtained from QSAM, the Mission Scientist team decided that circulation pump operation would not have a deleterious effect on IML-2 experiments.

Fig. 10 shows SAMS Head C data collected during a circulation pump activation. Analysis of STS-65 data indicates that a 6 Hz frequency previously identified as related to circulation pump operations [10] is not characteristic of this activity. The circulation pumps operate at 10,000 rpm which corresponds to a frequency of 167 Hz. This distinct frequency is not seen in associated SAMS data, while other frequencies in the 9300-11700 rpm range are. The PIMS group is investigating the possibility of a variable speed operation of the pumps.

5. Summary

This report serves as a road map to the SAMS and OARE data acquired during the STS-65 mission. Further analysis of specific events and comparisons with other missions will be performed and published in future documents.

The primary payload on the STS-65 mission was the second flight of the International Microgravity Laboratory in the Spacelab module. One SAMS unit was manifested in the Spacelab module with three triaxial sensor heads mounted on experiments in Spacelab racks. The OARE instrument was mounted in the Orbiter cargo bay to support the IML-2 experiments.

A summary of the vector magnitude rms and average accelerations for the entire mission was produced for the SAMS 10 Hz triaxial sensor head (Head A). Spectrograms were also
produced to give a frequency domain summary for the entire mission. These plots are presented in the Appendices B and C. Significant events were chosen to give a more detailed look at the acceleration disturbances at the SAMS and OARE sensor head locations. These events were crew exercise, experiment component mixing activities, NIZEMI centrifuge operations, refrigerator/freezer operations, and circulation pump activity.

6. References


### Table 1 IML-2 Experiments and Facilities

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<thead>
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<td>Biorack (BR)</td>
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<td>Biostack (BSK)</td>
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<tr>
<td>Extended Duration Orbiter Medical Program (EDOMP)</td>
<td>Center Aisle</td>
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<td>Spinal Changes in Microgravity (SCM)</td>
<td>Center Aisle</td>
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<td>Lower Body Negative Pressure Device (LBNPD)</td>
<td>middeck</td>
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<td>Microbial Air Sampler (MAS)</td>
<td>middeck</td>
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<td>Performance Assessment Workstation (PAWS)</td>
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### Table 2 Other STS-65 Payloads

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<td>Orbital Acceleration Research Experiment</td>
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<td>Military Application of Ship Tracks</td>
<td>MAST</td>
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### Table 3 STS-65 Development Test Objectives

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<td>DTO 307D</td>
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<td>External Tank Thermal Protection System Performance</td>
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<td>DTO 319D</td>
<td>Orbiter/Payload Acceleration and Acoustics Environment Data</td>
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<tr>
<td>DTO 667</td>
<td>Portable In-Flight Landing Operations Trainer</td>
</tr>
<tr>
<td>DTO 674</td>
<td>Thermo-Electric Liquid Cooling System Evaluation</td>
</tr>
<tr>
<td>DTO 805</td>
<td>Crosswind Landing Performance</td>
</tr>
<tr>
<td>DTO 913</td>
<td>Microgravity Measuring Device</td>
</tr>
</tbody>
</table>
Table 4. STS-65 Detailed Supplementary Objectives

<table>
<thead>
<tr>
<th>DSO's</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSO 314</td>
<td>Acceleration Data Collection</td>
</tr>
<tr>
<td>DSO 326</td>
<td>Window Impact Observations</td>
</tr>
<tr>
<td>DSO 484</td>
<td>Assessment of Circadian Shifting in Astronauts by Bright Light</td>
</tr>
<tr>
<td>DSO 485</td>
<td>Inter Mars TEPC</td>
</tr>
<tr>
<td>DSO 487</td>
<td>Immunological Assessment of Crewmembers</td>
</tr>
<tr>
<td>DSO 491</td>
<td>Characterization of Microbial Transfer Among Crewmembers During Space Flight</td>
</tr>
<tr>
<td>DSO 603B</td>
<td>Orthostatic Function During Entry, Landing and Egress</td>
</tr>
<tr>
<td>DSO 604</td>
<td>Visual-Vestibular Integration as a Function of Adaptation</td>
</tr>
<tr>
<td>DSO 605</td>
<td>Postural Equilibrium Control During Landing/Egress</td>
</tr>
<tr>
<td>DSO 608</td>
<td>Effects of Space Flight on Aerobic and Anaerobic Metabolism During Exercise</td>
</tr>
<tr>
<td>DSO 610</td>
<td>In-Flight Assessment of Renal Stone Risk</td>
</tr>
<tr>
<td>DSO 614</td>
<td>The Effect of Prolonged Space Flight on Head and Gaze Stability During Locomotion</td>
</tr>
<tr>
<td>DSO 621</td>
<td>In-Flight Use of Florinef to Improve Orthostatic Intolerance Postflight</td>
</tr>
<tr>
<td>DSO 626</td>
<td>Cardiovascular and Cerebrovascular Responses to Standing Before and After Space Flight</td>
</tr>
<tr>
<td>DSO 901</td>
<td>Documentary Television</td>
</tr>
<tr>
<td>DSO 902</td>
<td>Documentary Motion Picture Photography</td>
</tr>
<tr>
<td>DSO 903</td>
<td>Documentary Still Photography</td>
</tr>
</tbody>
</table>

Table 5. STS-65 OARE Head Location and Orientation

<table>
<thead>
<tr>
<th>OARE Sensor</th>
<th>Sample Rate: 10 samples/second</th>
<th>Location: Orbiter Cargo Bay Keel Bridge</th>
<th>Frequency: 0 to 1 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Orbiter Structural Axis</td>
<td>Sensor Axis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X₀</td>
<td>X₀₀ = 1153.3 in</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Y₀</td>
<td>Y₀ = -1.3 in</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Z₀</td>
<td>Z₀ = 317.8 in</td>
</tr>
</tbody>
</table>
Table 6. STS-65 SAMS Head Location and Orientation

### Unit D Head A (TSH-A)
- **Serial no.:** 821-32
- **Location:** Spacelab - Rack 8
- **Sample Rate:** 50 samples/second
- **Frequency:** 0 to 10 Hz

<table>
<thead>
<tr>
<th>ORIENTATION</th>
<th>LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Orbiter Structural Axis</strong></td>
<td><strong>Sensor Axis</strong></td>
</tr>
<tr>
<td>$X_0$</td>
<td>$-Y_A$</td>
</tr>
<tr>
<td>$Y_0$</td>
<td>$-X_A$</td>
</tr>
<tr>
<td>$Z_0$</td>
<td>$-Z_A$</td>
</tr>
</tbody>
</table>

### Unit D Head B (TSH-B)
- **Serial no.:** 821-14
- **Location:** Spacelab - Rack 9
- **Sample Rate:** 25 samples/second
- **Frequency:** 0 to 5 Hz

<table>
<thead>
<tr>
<th>ORIENTATION</th>
<th>LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Orbiter Structural Axis</strong></td>
<td><strong>Sensor Axis</strong></td>
</tr>
<tr>
<td>$X_0$</td>
<td>$Y_B$</td>
</tr>
<tr>
<td>$Y_0$</td>
<td>$X_B$</td>
</tr>
<tr>
<td>$Z_0$</td>
<td>$-Z_B$</td>
</tr>
</tbody>
</table>

### Unit D Head C (TSH-C)
- **Serial no.:** 821-8
- **Location:** Spacelab - Rack 10
- **Sample Rate:** 500 samples/second
- **Frequency:** 0 to 100 Hz

<table>
<thead>
<tr>
<th>ORIENTATION</th>
<th>LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Orbiter Structural Axis</strong></td>
<td><strong>Sensor Axis</strong></td>
</tr>
<tr>
<td>$X_0$</td>
<td>$-Y_C$</td>
</tr>
<tr>
<td>$Y_0$</td>
<td>$-X_C$</td>
</tr>
<tr>
<td>$Z_0$</td>
<td>$-Z_C$</td>
</tr>
</tbody>
</table>
Table 7. Crew exercise log [13]

<table>
<thead>
<tr>
<th>Start MET</th>
<th>Stop MET</th>
<th>Crewmember</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>000:20:24:47</td>
<td>000:20:56:27</td>
<td>MS3</td>
<td>Middeck</td>
</tr>
<tr>
<td>000:21:45:40</td>
<td>000:22:20:03</td>
<td>MS2</td>
<td>Middeck</td>
</tr>
<tr>
<td>001:04:50:31</td>
<td>001:05:15:08</td>
<td>PLT</td>
<td>Middeck</td>
</tr>
<tr>
<td>001:07:08:15</td>
<td>001:07:16:15</td>
<td>CDR</td>
<td>Middeck</td>
</tr>
<tr>
<td>002:05:15:29</td>
<td>002:05:42:15</td>
<td>CDR</td>
<td>Flight Deck</td>
</tr>
<tr>
<td>007:07:43:50</td>
<td>007:08:15:50</td>
<td>MS3</td>
<td>Flight Deck</td>
</tr>
<tr>
<td>008:06:39:15</td>
<td>008:07:47:34</td>
<td>MS2</td>
<td>Flight Deck</td>
</tr>
<tr>
<td>013:01:30:50</td>
<td>013:01:44:51</td>
<td>PLT</td>
<td>Flight Deck,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Hard Mounted</td>
</tr>
</tbody>
</table>
Figure 1  OARE instrument location on Columbia, STS-65
Figure 3  OARE data with trimmed-mean filter applied, STS-65, Orbiter body coordinate system.
Figure 4  SAMS Head A data starting at MET 009/04:30:00, STS-65, Entire crew in Flight Deck. Column a) acceleration vs. time, column b) power spectral density vs. frequency.
Figure 5  SAMS Head C data starting at MET 009/04:30:00, STS-65, Entire crew in Flight Deck. Column a) acceleration vs. time, column b) power spectral density vs. frequency.
Figure 6  SAMS Head A data starting at MET 013/01:35:00, STS-65, Pilot exercising on hard-mounted ergometer in Flight Deck. Column a) acceleration vs. time, column b) power spectral density vs. frequency.
Figure 7 SAMS Head B data starting at MET 008/22:09:24, STS-65, crew member swinging experiment sample in circles. Column a) acceleration vs. time, column b) power spectral density vs. frequency.
Figure 8  SAMS Head C data starting at MET 001/00:11:27, STS-65, NIZE Mi centrifuge active. Column a) acceleration vs. time, column b) power spectral density vs. frequency.
Figure 9  Two hour color spectrogram of SAMS Head C data starting at MET 002/06:00:00, STS-65. Horizontal axis is time, vertical axis is frequency, color variations represent magnitude of amplitude spectra. Note on/off cycle of 22.5 Hz and its upper harmonics, assumed to be a refrigerator compressor.
Figure 10  SAMS Head C data starting at MET 001/07:34:42, STS-65, circulation pump activation. Column a) acceleration vs. time, column b) power spectral density vs. frequency.
APPENDIX A  ACCESSING SAMS DATA VIA INTERNET

SAMS data are distributed on CD-ROM media and are available on a computer file server. In both cases, files of SAMS data are organized in a tree-like structure as illustrated in the figure. Data acquired from a mission are categorized based upon sensor head, mission day, and type of data. Data files are stored at the lowest level in the tree and the file name reflects the contents of the file. For example, the file named axm00102.15r contains data for sensor head A, the X axis, the time base was Mission Elapsed Time, day 001, hour 02, 1 of 5 files for that hour, and it contains reduced data. The file readme.doc provides a comprehensive description and guide to the data.

![SAMS Data File Structure](image)

Also available from the file server are some data access tools for different computer platforms.

SAMS data files may be accessed from a file server at NASA LeRC. The NASA LeRC file server beech.lerc.nasa.gov (tcp/ip address 139.88.19.43) can be accessed via anonymous file transfer protocol (ftp), as follows:

[1] Establish ftp connection to the beech file server.
[2] Login: anonymous
[3] Password: guest
[4] Change the directory to: pub
[5] List the files and directories in the pub directory.

A-1
[6] Change the directory to the mission of interest, for example: usml-1
[7] List files and directories for the specific mission chosen in previous step.
[8] Use the data file structure shown in the figure to find the files of interest.
[9] Transfer the data files of interest.

If you encounter difficulty in accessing the data using the file server, please send an electronic mail message to the internet address below. Please describe the nature of the difficulty and a description of the hardware and software you are using to access the file server.

pims@lerc.nasa.gov
APPENDIX B SAMS TIME HISTORIES

Accelerometer data collected on Orbiter missions are generally analyzed by the principal investigator or experiment team responsible for the system. The PI Microgravity Services (PIMS) project at the NASA Lewis Research Center was formed in part to support microgravity PI's in the evaluation of acceleration effects on their experiments and to characterize the vibrational environment of the microgravity carriers and vehicles. The primary continual source of accelerometer data from mission to mission is SAMS. Some of the SAMS data from STS-65 are presented in Appendices B and C to provide PI's with an overview of the environment during the mission.

The raw data recorded by SAMS is processed to compensate for temperature and gain related errors of bias, scale factor, and axis misalignment. The processing utilizes a fourth order temperature model to compensate the data and convert the raw digitized data into engineering units (Thomas, et al., 1992). The data are transformed to the shuttle structural coordinate system and formatted into files for distribution via CD-ROM and file server. See Appendix A for information on file server access to SAMS data.

The compensated data are further processed to produce the plots shown here. Two time history representations of the data are provided: ten second average and ten second root mean square (rms) plots. These calculations are presented in two hour plots with the corresponding average and rms plots on one page. The ten second average plots should be used to identify times when the steady level of the acceleration signal deviates from the background level. The ten second rms plots should be used to identify times when oscillatory and/or transient deviations from the background acceleration levels occurred.

Average and Root Mean Square Calculations

The average plots were produced using STS-65 SAMS, Head A data. Head A data were collected at 50 samples per second and a 10 Hz low pass filter was applied to the data by the SAMS unit prior to digitization. The plots were produced by calculating the average of ten second intervals of data for each axis and forming a vector magnitude with the resulting data streams.

The rms plots were produced by taking the root-mean-square of ten second intervals of data for each axis and forming a vector magnitude with the resulting data stream.

References

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SUMMARY

REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

Mission Elapsed Time (DAY/HR:MM)

000/08:00 to 000/10:00

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)

000/08:00 to 000/10:00
IML-2, Rack 8, Vector Magnitude AVG

Mission Elapsed Time (DAY/HR:MM)

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)
SUMMARY REPORT
OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

000/12:00  000/13:00  000/14:00
Mission Elapsed Time (DAY/HR:MM)

IML-2, Rack 8, Vector Magnitude RMS

000/12:00  000/13:00  000/14:00
Mission Elapsed Time (DAY/HR:MM)
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

IML-2, Rack 8, Vector Magnitude RMS
REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

Mission Elapsed Time (DAY/HR:MM)

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

001/05:00
001/06:00
Mission Elapsed Time (DAY/HR:MM)

IML-2, Rack 8, Vector Magnitude RMS

2.00x10^-4
1.37x10^-4
7.50x10^-5
0.00010
0.00005
0.00000
Acceleration(6)

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SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

Mission Elapsed Time (DAY/HR:MM)

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

IML-2, Rack 8, Vector Magnitude RMS
Summary Report of Mission Acceleration Measurements for STS-65

IML-2, Rack 8, Vector Magnitude AVG

- Acceleration (g)
- Mission Elapsed Time (DAY/HR:MM)

IML-2, Rack 8, Vector Magnitude RMS

- Acceleration (g)
- Mission Elapsed Time (DAY/HR:MM)
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

Mission Elapsed Time (DAY/HR:MM)

001/16:00

001/17:00

001/18:00

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)

001/16:00

001/17:00

001/18:00
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

IML-2, Rack 8, Vector Magnitude RMS
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65 I
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)

Accretion (b)
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

IML-2, Rack 8, Vector Magnitude RMS
SUMMARY

REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

IML-2, Rack 8, Vector Magnitude RMS
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

002/08:00 002/09:00 002/10:00
Mission Elapsed Time (DAY/HR:MM)

IML-2, Rack 8, Vector Magnitude RMS

002/08:00 002/09:00 002/10:00
Mission Elapsed Time (DAY/HR:MM)
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

IML-2, Rack 8, Vector Magnitude RMS
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)

Acceleration (g)
SUMMARY REPORT
OF
MISSION ACCELERATION MEASUREMENTS FOR
STS-65

IML-2, Rack 8, Vector Magnitude AVG

Mission Elapsed Time (DAY/HR:MM)

003/00:00 003/01:00 003/02:00

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)

003/00:00 003/01:00 003/02:00
IML-2, Rack B, Vector Magnitude AVG

IML-2, Rack B, Vector Magnitude RMS
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65
SUMMARY

REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

**IML-2, Rack 8, Vector Magnitude AVG**

003/06:00 - 003/07:00

**IML-2, Rack 8, Vector Magnitude RMS**

003/06:00 - 003/07:00
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

003/09:00
Mission Elapsed Time (DAY/HR:MM)

IML-2, Rack 8, Vector Magnitude RMS

003/08:00
Mission Elapsed Time (DAY/HR:MM)
I SUMMARY
REPORT
OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

003/11:00
003/10:00
003/12:00

Mission Elapsed Time (DAY/HR:MM)

2.00x10^-4
1.37x10^-4
7.50x10^-5

Acceleration (g)

B-40
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

Mission Elapsed Time (DAY/HR:MM)

003/12:00

003/13:00

003/14:00

2.00×10⁻⁴

1.37×10⁻⁴

7.5×10⁻⁵

(6)
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

Mission Elapsed Time (DAY/HR:MM)

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

![Graph showing acceleration data for IML-2, Rack 8, Vector Magnitude AVG and RMS.](image-url)
IML-2, Rack 8, Vector Magnitude AVG

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)

004/02:00 to 004/04:00

Acceleration (g)
IML-2, Rack 8, Vector Magnitude AVG

Mission Elapsed Time (DAY/HR:MM)

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65
Summary Report of Mission Acceleration Measurements for STS-65

**IML-2, Rack 8, Vector Magnitude AVG**

**IML-2, Rack 8, Vector Magnitude RMS**
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

Mission Elapsed Time (D/A/H/M/M)

004/12:00
004/13:00
004/14:00

Acceleration (g)

1.37 x 10^-4
2.00 x 10^-4
7.50 x 10^-5

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (D/A/H/M/M)

004/12:00
004/13:00
004/14:00

Acceleration (g)

0.0000
0.0005
0.0010
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

IML-2, Rack 8, Vector Magnitude RMS
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

Mission Elapsed Time (DAY/HR:MM)

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)
IML-2, Rack 8, Vector Magnitude AVG

Mission Elapsed Time (DAY/HR:MM)

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude, AVG

Mission Elapsed Time (DAY/HR:MM)

004/21:00

004/22:00

2.00x10^-4

1.37x10^-4

7.50x10^-5

0.0005

0.0010

0.0000

(5) Acceleration

(5) Acceleration

B-57
IML-2, Rack 8, Vector Magnitude AVG

Mission Elapsed Time (DAY/HR:MM)

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)
IML-2, Rack 8, Vector Magnitude AVG

IML-2, Rack 8, Vector Magnitude RMS
IML-2, Rack 8, Vector Magnitude AVG

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65 II

IML-2, Rack 8, Vector Magnitude AVG

IML-2, Rack 8, Vector Magnitude RMS
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

Mission Elapsed Time (DAY/HR:MM)

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)
Summary Report of Mission Acceleration Measurements for STS-65

IML-2, Rack 8, Vector Magnitude AVG

IML-2, Rack 8, Vector Magnitude RMS
SUMMARY

REPORT

OF

MISSION

ACCELERATION

MEASUREMENTS FOR

STS-65

IML-2, Rack 8, Vector Magnitude AVG

Mission Elapsed Time (DAY/HR:MM)

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

Mission Elapsed Time (DAY/HR:MM)

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)
SUMMARY
REPORT OF MISSION
ACCELERATION
MEASUREMENTS
FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

IML-2, Rack 8, Vector Magnitude RMS
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

**IML-2, Rack 8, Vector Magnitude AVG**

- Acceleration (g): 2.00x10^-4
- 1.37x10^-4
- 7.50x10^-5

**IML-2, Rack 8, Vector Magnitude RMS**

- Acceleration (g): 0.0010
- 0.0005
- 0.0000

Mission Elapsed Time (DAY/HR:MM)

006/12:00 to 006/14:00
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

Mission Elapsed Time (DAY/HR:MM)

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)
SUMMARY

REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

Mission Elapsed Time (DAY/HR:MM)

006/22:00 006/23:00 007/00:00

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)

006/22:00 006/23:00 007/00:00
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

Mission Elapsed Time (DAY/HR:MM)

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

ML-2, Rack 8, Vector Magnitude AVG

Mission Elapsed Time (DAY/HR:MM)

ML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)

2.00 x 10^-4

1.37 x 10^-4

7.50 x 10^-5

0.0010

0.0005

0.0000

Acc. (g)

Acc. (g)
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

Mission Elapsed Time (DAY/HR:MM)

007/06:00 007/07:00 007/08:00

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)

007/06:00 007/07:00 007/08:00
REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

**IML-2, Rack 8, Vector Magnitude AVG**

- Acceleration (g) range: 7.50 x 10^-5 to 2.00 x 10^-4
- Mission Elapsed Time (DAY/HR:MM): 07/08:00 to 07/10:00

**IML-2, Rack 8, Vector Magnitude RMS**

- Acceleration (g) range: 0.0000 to 0.0100
- Mission Elapsed Time (DAY/HR:MM): 07/08:00 to 07/10:00
Summary Report of Mission Acceleration Measurements for STS-65

IML-2, Rack 8, Vector Magnitude AVG

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)
SUMMARY

REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IBL-2, Rack 8, Vector Magnitude AVG

Mission Elapsed Time (DAY/HR:MM)

007/12:00 007/13:00 007/14:00

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)

007/12:00 007/13:00 007/14:00
SUMMARY

REPORT OF MISSION

ACCELERATION MEASUREMENTS FOR STS-65
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65
IML-2, Rack 8, Vector Magnitude AVG

Acceleration(g)

IML-2, Rack 8, Vector Magnitude RMS

Acceleration(g)
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

007/21:00
Mission Elapsed Time (DAY/HR:MM)

007/22:00
Mission Elapsed Time (DAY/HR:MM)

IML-2, Rack 8, Vector Magnitude AVG

0.0010
0.0005
0.0000
0.0000

Acceleration

2.00x10^-4
1.37x10^-4
7.50x10^-5

IML-2, Rack 8, Vector Magnitude RMS

(6)u0!0Japaz_V

(6)u0!10Jala_V

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SUMMARY

REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

Acceleration(g)

0.0010

IML-2, Rack 8, Vector Magnitude RMS

Acceleration(g)

0.0000
SUMMARY
REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65
SUMMARY
REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)

Acceleration (g)

0.0010
0.0005
0.0000

0.0010
0.0005
0.0000

008/06:00
008/07:00
008/08:00

008/06:00
008/07:00
008/08:00
SUMMARY REPORT
OF MISSION ACCELERATION MEASUREMENTS FOR STS-65
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

008/10:00 008/11:00 008/12:00
Mission Elapsed Time (DAY/HR:MM)

IML-2, Rack 8, Vector Magnitude RMS

008/10:00 008/11:00 008/12:00
Mission Elapsed Time (DAY/HR:MM)
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

Mission Elapsed Time (DAY/HR:MM)

Acceleration (g)

0.0000
0.0005
0.0010
2.00 x 10^-4
1.37 x 10^-4
7.50 x 10^-5

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)

Acceleration (g)

0.0000
0.0005
0.0010
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

IML-2, Rack 8, Vector Magnitude RMS
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

![Graph 1](IML-2, Rack 8, Vector Magnitude AVG)

![Graph 2](IML-2, Rack 8, Vector Magnitude RMS)

Mission Elapsed Time (DAY/HR:MM)
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

Mission Elapsed Time (DAY/HR:MM)

009/05:00
009/04:00
009/06:00

Acceleration

2.00x10^-4
1.37x10^-4
7.50x10^-5

0.00010
0.00005
0.00000

(5)
Summary Report of Mission Acceleration Measurements for STS-65

IML-2, Rack 8, Vector Magnitude AVG

Mission Elapsed Time (DAY/HR:MM)

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)
IML-2, Rack 8, Vector Magnitude AVG

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

IML-2, Rack 8, Vector Magnitude RMS
SUMMARY

REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

Mission Elapsed Time (DAY/HR:MM)

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

009/17:00
Mission Elapsed Time (DAY/HR:MM)
009/18.00

009/16:00
Mission Elapsed Time (DAY/HR:MM)
009/18.00

IML-2, Rack 8, Vector Magnitude AVG
2.00x10^-4
1.3x10^-4
0.0010

1.50x10^-5
0.0005
0.0000

Acceleration
(5)
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

Mission Elapsed Time (DAY/HR/MM)

009/19.00

009/20.00

009/18.00

2.00x10^{-4}

1.37x10^{-4}

7.50x10^{-5}

(5) }}

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SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

010/00:00 010/01:00 010/02:00
Mission Elapsed Time (DAY/HR:MM)

IML-2, Rack 8, Vector Magnitude RMS

010/00:00 010/01:00 010/02:00
Mission Elapsed Time (DAY/HR:MM)
Summary Report of Mission Acceleration Measurements for STS-65

IML-2, Rack 8, Vector Magnitude AVG

Mission Elapsed Time (DAY/HR:MM)

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

IML-2, Rack 8, Vector Magnitude RMS
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

**IML-2, Rack 8, Vector Magnitude AVG**

- Acceleration (g) range: $2.00 \times 10^{-4}$ to $1.37 \times 10^{-4}$
- Mission Elapsed Time (DAY/HR:MM): 010/10:00 to 010/12:00

**IML-2, Rack 8, Vector Magnitude RMS**

- Acceleration (g) range: 0.0010 to 0.00005
- Mission Elapsed Time (DAY/HR:MM): 010/10:00 to 010/12:00
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS.65

IML-2, Rack 8, Vector Magnitude AVG

Mission Elapsed Time (DAY/HR:MM)

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude, AVG

Mission Elapsed Time (DAY/HR:MM)

01/10/14:00

01/10/14:00

01/10/15:00

01/10/16:00

2.00x10^-4

1.37x10^-4

7.50x10^-5

0.0010

0.0005

0.0000

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SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

IML-2, Rack 8, Vector Magnitude RMS
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

![Graph 1: IMI-2, Rack 8, Vector Magnitude AVG](image1)

![Graph 2: IMI-2, Rack 8, Vector Magnitude RMS](image2)
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

IML-2, Rack 8, Vector Magnitude RMS
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

IML-2, Rack 8, Vector Magnitude RMS
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

**II-4 - 2, Rack 8, Vector Magnitude AVG**

**IML-2, Rack 8, Vector Magnitude RMS**
SUMMARY

REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

IML-2, Rack 8, Vector Magnitude RMS
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

Mission Elapsed Time (DAY/HR:MM)

011/22:00 011/23:00 012/00:00

0.0000 0.0005 0.0010

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)

011/22:00 011/23:00 012/00:00
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

Mission Elapsed Time (DAY/HR:MM)

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)

Acceleration(g)

0.0000 0.0005 0.0010 0.0015 0.0020 0.0025 0.0030 0.0035 0.0040 0.0045 0.0050 0.0055 0.0060 0.0065 0.0070 0.0075 0.0080 0.0085 0.0090 0.0095 0.0100

0.0000 0.0005 0.0010 0.0015 0.0020 0.0025 0.0030 0.0035 0.0040 0.0045 0.0050 0.0055 0.0060 0.0065 0.0070 0.0075 0.0080 0.0085 0.0090 0.0095 0.0100

Mission Elapsed Time (DAY/HR:MM)
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

IML-2, Rack 8, Vector Magnitude RMS
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

**IML-2, Rack 8, Vector Magnitude AVG**

Mission Elapsed Time (DAY/HR:MM)

**IML-2, Rack 8, Vector Magnitude RMS**

Mission Elapsed Time (DAY/HR:MM)
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

Mission Elapsed Time (DAY/HR:MM)

Accretion

ML-2, Rack 8, Vector Magnitude AVG

ML-2, Rack 8, Vector Magnitude RMS

01/12/17:00

01/12/16:00

01/12/18:00

0.0010

0.0005

0.0000

2.00×10^-4

1.37×10^-4

7.50×10^-5

(6)
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)

01/12/18:00 01/12/19:00 01/12/20:00

Acceleration(g)

0.0010

0.0005

0.0000

0.00000

0.00025

0.00050

0.00075

0.00100

0.00125

0.00150

0.00175

0.00200
I. SUMMARY

REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

![Graph of IML-2, Rack 8, Vector Magnitude AVG](image)

- Acceleration(g)
- Mission Elapsed Time (DAY/HR:MM)
- 01/20:00 to 01/22:00

![Graph of IML-2, Rack 8, Vector Magnitude RMS](image)

- Acceleration(g)
- Mission Elapsed Time (DAY/HR:MM)
- 01/20:00 to 01/22:00

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SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

Mission Elapsed Time (DAY/HR:MM)

013/00:00 013/01:00 013/02:00

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)

015/00:00 013/01:00 015/02:00
IML-2, Rack 8, Vector Magnitude AVG

IML-2, Rack 8, Vector Magnitude RMS

Mission Elapsed Time (DAY/HR:MM)
REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

IML-2, Rack 8, Vector Magnitude AVG

IML-2, Rack 8, Vector Magnitude RMS
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65
APPENDIX C SAMS COLOR SPECTROGRAMS

Accelerometer data collected on Orbiter missions are generally analyzed by the principal investigator or experiment team responsible for the system. The PI Microgravity Services (PIMS) project at the NASA Lewis Research Center was formed in part to support microgravity PI's in the evaluation of acceleration effects on their experiments and to characterize the vibrational environment of the Space Shuttle Orbiters. The primary continual source of accelerometer data from mission to mission is SAMS. Some of the SAMS data from STS-62 are presented in Appendices B and C to provide PI's with an overview of the environment during mission.

The raw data recorded by SAMS are processed to compensate for temperature and gain related errors of bias, scale factor, and axis misalignment. The processing utilizes a fourth order temperature model to compensate the data and convert the raw digitized data into engineering units (Thomas, et al., 1992). The data are transformed to the shuttle structural coordinate system and formatted into files for distribution via CD-ROM and file server. See Appendix A for information on file server access to SAMS data.

The SAMS data have been further processed to produce the plots shown here. Color spectrograms are provided as an overview of the frequency characteristics of the SAMS data during the mission. Each spectrogram is a two-hour composite of amplitude spectra for consecutive ten second intervals. These plots should be used to identify times when the frequency character of the acceleration environment changes.

The color spectrograms were produced using STS-65 SAMS Head A data. The data were taken in two hour periods and an amplitude spectrum was calculated for consecutive ten second intervals. The frequency bandwidth for the spectra is 0.1 Hz.

The spectral data were scaled by taking the log of each data point and assigning a color to the integer result. Eight colors were used for eight intervals between $1 \times 10^{-7}$ g and $1 \times 10^{-3}$ g. In using this method, a range of acceleration values are assigned to the same color.

References

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Figure C-1 IML-2 Rack 8, Vector Magnitude

Figure C-2 IML-2 Rack 8, Vector Magnitude
Figure C-3 IML-2 Rack 8, Vector Magnitude

Figure C-4 IML-2 Rack 8, Vector Magnitude
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

Figure C-5 IML-2 Rack 8, Vector Magnitude

Figure C-6 IML-2 Rack 8, Vector Magnitude
Figure C-7  IML-2 Rack 8, Vector Magnitude

Figure C-8  IML-2 Rack 8, Vector Magnitude
Figure C-9 IML-2 Rack 8, Vector Magnitude

Figure C-10 IML-2 Rack 8, Vector Magnitude
Figure C-11  IML-2 Rack 8, Vector Magnitude

Figure C-12  IML-2 Rack 8, Vector Magnitude
Figure C-13  IML-2 Rack 8, Vector Magnitude

Figure C-14  IML-2 Rack 8, Vector Magnitude
Figure C-15  IML-2 Rack 8, Vector Magnitude

Figure C-16  IML-2 Rack 8, Vector Magnitude
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

Figure C-17  IML-2 Rack 8, Vector Magnitude

001/16:00 001/17:00 001/18:00
Mission Elapsed Time (Day/HH:MM)

0.1 1.0 8.0 6.0 4.0 2.0 0.1
Frequency (Hz)

10.0 8.0 6.0 4.0 2.0 0.1
Acceleration (g)

001/18:00 001/19:00 001/20:00
Mission Elapsed Time (Day/HH:MM)

Figure C-18  IML-2 Rack 8, Vector Magnitude

C-19
Figure C-19 IML-2 Rack 8, Vector Magnitude

Figure C-20 IML-2 Rack 8, Vector Magnitude
Figure C-21 IML-2 Rack 8, Vector Magnitude

Figure C-22 IML-2 Rack 8, Vector Magnitude
Figure C-27  IML-2 Rack 8, Vector Magnitude

Figure C-28  IML-2 Rack 8, Vector Magnitude
Figure C-29  IML-2 Rack 8, Vector Magnitude

Figure C-30  IML-2 Rack 8, Vector Magnitude
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

Figure C-31 IML-2 Rack 8, Vector Magnitude

Figure C-32 IML-2 Rack 8, Vector Magnitude
Figure C-33  IML-2 Rack 8, Vector Magnitude

Figure C-34  IML-2 Rack 8, Vector Magnitude
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

Figure C-35  IML-2 Rack 8, Vector Magnitude

Figure C-36  IML-2 Rack 8, Vector Magnitude
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

Figure C-39 IML-2 Rack 8, Vector Magnitude

Figure C-40 IML-2 Rack 8, Vector Magnitude
Figure C-41  IML-2 Rack 8, Vector Magnitude

Figure C-42  IML-2 Rack 8, Vector Magnitude
Figure C-43  IML-2 Rack 8, Vector Magnitude

Figure C-44  IML-2 Rack 8, Vector Magnitude
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

Figure C-45 IML-2 Rack 8, Vector Magnitude

Figure C-46 IML-2 Rack 8, Vector Magnitude
Figure C-47  IML-2 Rack 8, Vector Magnitude

Figure C-48  IML-2 Rack 8, Vector Magnitude
Figure C-49  IML-2 Rack 8, Vector Magnitude

Figure C-50  IML-2 Rack 8, Vector Magnitude
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

Figure C-51  IML-2 Rack 8, Vector Magnitude

Figure C-52  IML-2 Rack 8, Vector Magnitude
Figure C-53  IML-2 Rack 8, Vector Magnitude

Figure C-54  IML-2 Rack 8, Vector Magnitude
Figure C-55  IML-2 Rack 8, Vector Magnitude

Figure C-56  IML-2 Rack 8, Vector Magnitude
Figure C-57  IML-2 Rack 8, Vector Magnitude

Figure C-58  IML-2 Rack 8, Vector Magnitude
Figure C-59  IML-2 Rack 8, Vector Magnitude

Mission Elapsed Time (Day/HH:MM)

Figure C-60  IML-2 Rack 8, Vector Magnitude

Mission Elapsed Time (Day/HH:MM)
Figure C-61  IML-2 Rack 8, Vector Magnitude

Figure C-62  IML-2 Rack 8, Vector Magnitude
Figure C-63  IML-2 Rack 8, Vector Magnitude

Mission Elapsed Time (Day/HH:MM)

Figure C-64  IML-2 Rack 8, Vector Magnitude

Mission Elapsed Time (Day/HH:MM)
Figure C-67 IML-2 Rack 8, Vector Magnitude

Figure C-68 IML-2 Rack 8, Vector Magnitude
Figure C-69  IML-2 Rack 8, Vector Magnitude

Figure C-70  IML-2 Rack 8, Vector Magnitude
Figure C-71  IML-2 Rack 8. Vector Magnitude

Figure C-72  IML-2 Rack 8. Vector Magnitude
Figure C-75 IML-2 Rack 8, Vector Magnitude

Figure C-76 IML-2 Rack 8, Vector Magnitude
Figure C-77  IML-2 Rack 8, Vector Magnitude

Figure C-78  IML-2 Rack 8, Vector Magnitude
Figure C-79  IML-2 Rack 8, Vector Magnitude

Figure C-80  IML-2 Rack 8, Vector Magnitude
Figure C-83 IML-2 Rack 8, Vector Magnitude

Mission Elapsed Time (Day/HH:MM)

Figure C-84 IML-2 Rack 8, Vector Magnitude

Mission Elapsed Time (Day/HH:MM)
Figure C-87  IML-2 Rack 8, Vector Magnitude

Figure C-88  IML-2 Rack 8, Vector Magnitude
Figure C-89  IML-2 Rack 8. Vector Magnitude

Figure C-90  IML-2 Rack 8. Vector Magnitude
Figure C-91  IML-2 Rack 8, Vector Magnitude

Figure C-92  IML-2 Rack 8, Vector Magnitude
Figure C-93  IML-2 Rack 8, Vector Magnitude

Figure C-94  IML-2 Rack 8, Vector Magnitude
**Figure C-95** IML-2 Rack 8, Vector Magnitude

**Figure C-96** IML-2 Rack 8, Vector Magnitude
Figure C-97  IML-2 Rack 8, Vector Magnitude

Mission Elapsed Time (Day/HH:MM)

Figure C-98  IML-2 Rack 8, Vector Magnitude

Mission Elapsed Time (Day/HH:MM)
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

Figure C-99 IML-2 Rack 8, Vector Magnitude

Figure C-100 IML-2 Rack 8, Vector Magnitude
Figure C-101 IML-2 Rack 8, Vector Magnitude

Figure C-102 IML-2 Rack 8, Vector Magnitude
**Figure C-105** IML-2 Rack 8, Vector Magnitude

**Figure C-106** IML-2 Rack 8, Vector Magnitude
Figure C-109  IML-2 Rack 8, Vector Magnitude

Figure C-110  IML-2 Rack 8, Vector Magnitude
Figure C-111  IML-2 Rack 8, Vector Magnitude

Figure C-112  IML-2 Rack 8, Vector Magnitude
Figure C-113 IML-2 Rack 8, Vector Magnitude

Figure C-114 IML-2 Rack 8, Vector Magnitude
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

Figure C-117  IML-2 Rack 8, Vector Magnitude

Figure C-118  IML-2 Rack 8, Vector Magnitude
Figure C-123 IML-2 Rack 8, Vector Magnitude

Figure C-124 IML-2 Rack 8, Vector Magnitude
Figure C-125 IML-2 Rack 8, Vector Magnitude

Figure C-126 IML-2 Rack 8, Vector Magnitude
Figure C-127  IML-2 Rack 8, Vector Magnitude

Figure C-128  IML-2 Rack 8, Vector Magnitude
Figure C-129 IML-2 Rack 8, Vector Magnitude

Figure C-130 IML-2 Rack 8, Vector Magnitude
SUMMARY REPORT OF MISSION ACCELERATION MEASUREMENTS FOR STS-65

Figure C-137 IML-2 Rack 8, Vector Magnitude

Figure C-138 IML-2 Rack 8, Vector Magnitude
Figure C-139  IML-2 Rack 8, Vector Magnitude

Figure C-140  IML-2 Rack 8, Vector Magnitude
Figure C-141 IML-2 Rack 8, Vector Magnitude

Figure C-142 IML-2 Rack 8, Vector Magnitude
Figure C-145 IML-2 Rack 8, Vector Magnitude

Figure C-146 IML-2 Rack 8, Vector Magnitude
Figure C-147  IML-2 Rack 8, Vector Magnitude

Figure C-148  IML-2 Rack 8, Vector Magnitude
Figure C-151 IML-2 Rack 8, Vector Magnitude

Figure C-152 IML-2 Rack 8, Vector Magnitude
Figure C-153 IML-2 Rack 8, Vector Magnitude

Figure C-154 IML-2 Rack 8, Vector Magnitude
Figure C-155 IML-2 Rack 8, Vector Magnitude

Figure C-156 IML-2 Rack 8, Vector Magnitude
APPENDIX D  USER COMMENTS SHEET

We would like you to give us some feedback so that we may improve the Mission Summary Reports. Please answer the following questions and give us your comments.

1. Do the Mission Summary Reports fulfill your requirements for acceleration and mission information? _____Yes _____No If not why not?
Comments:

2. Is there additional information which you feel should be included in the Mission Summary Reports? _____Yes _____No If so what is it?
Comments:

3. Is there information in these reports which you feel is not necessary or useful?
   _____Yes _____No If so, what is it?
Comments:

4. Do you have internet access via: ( ____)ftp ( ____)mosaic ( ____)gopher ( ____)other?
Have you already accessed SAMS data or information electronically?
   _____Yes _____No
Comments:

Completed by: Name:_________________________ Telephone_________________________
Address:_________________________ Facsimile_________________________

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or

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e-mail to: pims@lerc.nasa.gov
Summary Report of Mission Acceleration Measurements for STS-65
Launched July 8, 1994

Melissa J.B. Rogers and Richard DeLombard

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Washington, D.C. 20546-0001


Unclassified - Unlimited
Subject Categories 29 and 19

The second flight of the International Microgravity Laboratory payload on-board the STS-65 mission was supported by three accelerometer instruments: the Orbital Acceleration Research Experiment (OARE) located close to the Orbiter center of mass, the Quasi-Steady Acceleration Measurement experiment in the Spacelab module, and the Space Acceleration Measurement System (SAMS) in the Spacelab module. A fourth accelerometer flew on the mission; the Microgravity Measuring Device recorded data in the middeck in support of exercise isolation tests. OARE and SAMS are both managed by the NASA Lewis Research Center. Data collected by these systems during IML-2 are displayed in this report. The OARE data represent the microgravity environment below 1 Hz. The SAMS data represent the environment in the 0.01 Hz to 100 Hz range. Variations in the environment caused by unique activities are presented in the report. Specific events addressed are crew activity, crew exercise, experiment component mixing activities, experiment centrifuge operations, refrigerator/freezer operations and circulation pump operations. The analyses included in this report complement analyses presented in other mission summary reports.