Investigation Title: Enhanced Dynamic Load Sensors (EDLS) on Mir

Principal Investigator(s): Sherwin Beck, NASA/Langley Research Center

Additional Investigator(s):

INVESTIGATION OBJECTIVES

The Enhanced Dynamic Load Sensor (EDLS) experiment is designed to measure the crew-induced forces and torques imparted on the Mir habitat module's interior surfaces. The EDLS hardware measure the magnitude and frequency of the crew-induced disturbances of the Mir microgravity environment.

PHASE 1 MISSIONS

Mir 21 - Mir 24, NASA 2 - NASA 5

OPERATIONAL ACTIVITIES

- EDLS hardware (ESM and sensors) transported to Mir and installed in the Priroda module in 1996
- Approximately 20 EDLS sessions performed during NASA 2/Mir 21 missions (5/96-8/96)
- Original EDLS ESM replaced with similar ESM for MiDSE experiment (1997)
- Approximately 15 high quality EDLS sessions performed during NASA 4/Mir 22/Mir 23 missions (2/97-5/97)

The torque/force sensors were mounted in the Mir Priroda module and used as restraints by the crew in the performance of their normal work routine duties involving glovebox activities.

RESULTS

Analysis of data collected indicated that the crew loads induced on module internal structures are no greater than 70 Newtons at a frequency of range from 0 to 10 Hertz (Hz). During the initial arrival periods, crew induced loads are higher but as space adaptation period progressed, these loads were reduced. A crewmember learns to reduce his/her effort needed to perform intended motions, thus reducing the loads imparted to the spacecraft structure.

CONCLUSIONS

Not provided by PI.

PUBLICATIONS

1. Lofton R, Conley C. International Space Station Phase 1 Risk Mitigation and Technology Demonstration Experiments. 48Th International Astronautical Congress; 1997 Oct 6-10; Turin, Italy; International Astronautical Federation.

Investigation Title: Inventory Management System (IMS)

Principal Investigator(s): Robert J. Hanley, NASA/ Johnson Space Center; Thomas D. Akers, NASA/ Johnson Space Center; Ronald M. Sega, NASA/ Johnson Space Center

Additional Investigator(s):

INVESTIGATION OBJECTIVES

1. To develop and evaluate the operational techniques associated with the use of IMS software and BCR in conjunction with flown checklists to document and maintain inventory control of equipment transferred between the Shuttle and Mir Space Station.
2. To evaluate the use of bar code labels on stowage locations and equipment.
3. To evaluate the use of preflight electronic stowage documentation.

PHASE 1 MISSIONS

STS-79, NASA 4

OPERATIONAL ACTIVITIES

Not available at this time.

RESULTS

Not available at this time.

CONCLUSIONS

Not available at this time.

PUBLICATIONS

Not available at this time.

Investigation Title: Mir Audible Noise Measurement (MANM)

Principal Investigator(s): C. Parsons, NASA/Johnson Space Center

Additional Investigator(s):

INVESTIGATION OBJECTIVES

1. To determine where acoustic mitigation may be required to ensure crew protection if Russian hardware exceeds noise level limits.

PHASE 1 MISSIONS

STS-74

OPERATIONAL ACTIVITIES

The hardware (sound level meter, one-third octave filter, microphone, noise dosimeter, audio recorder, and headphones) was taken to the Mir and positioned in a central location within a designated module. Crewmembers noted the location using the audio recorder and took sound level measurements. Questionnaires were also completed during flight to document the crewmembers' subjective acceptability of the measured noise levels.

RESULTS

The results of this experiment show that the US standard noise criteria (NC) 50 curve level was exceeded at the majority of the measurement locations. Overall, the crew's subjective impressions of the Mir acoustic environment was favorable, though a longer term evaluation of the environment may provide more valuable data.

CONCLUSIONS

Not provided by PI.

PUBLICATIONS

1. Lofton R, Conley C. International Space Station Phase 1 Risk Mitigation and Technology Demonstration Experiments. 48Th International Astronautical Congress; 1997 Oct 6-10; Turin, Italy; International Astronautical Federation.
2. Bieirie J. Mir Acoustic Environment. 26Th International Conference on Environmental Systems; 1996 Jul 8-11; Monterey, California; Society of Automotive Engineers.

Investigation Title: Mir Electric Field Characterization (MEFC)

Principal Investigator(s): M. A. Chavez, NASA/Johnson Space Center; G. D. Arndt, P. H. Ngo

INVESTIGATION OBJECTIVES

The primary objective of the Mir Electric Fields Characterization (MEFC) Experiment is to sample the RF environment in low Earth, high inclination orbits.

The secondary objective of the MEFC experiment is to measure the electric field intensity in various Mir modules to get typical values of field intensity within a spacecraft.

PHASE 1 MISSIONS

STS-79, STS-81, STS-84

OPERATIONAL ACTIVITIES

External signals measured through Orbiter overhead window. Mir internal RF environment measured within Priroda and Core modules.

RESULTS

Data was collected during STS-79 and STS-81 which provides a sample of the RF environment in low Earth, high inclination orbits and within the Priroda module.

CONCLUSIONS

Active frequency bands were identified and the field strength in those bands was seen to be moderate. Due to a hardware failure during STS-84, limited data was collected aboard Mir; however, data collected aboard the Priroda module during STS-79 and STS-81 showed a benign internal RF environment, suggesting good shielding effectiveness to the external environment.

PUBLICATIONS

Not provided by PI.

Investigation Title: Mir Environmental Effects Payload (MEEP)

Principal Investigator(s): Buck Gay, NASA/Johnson Space Center

Additional Investigator(s):

INVESTIGATION OBJECTIVES

1. To assess the magnitude of molecular contamination in ISS critical exterior surfaces in the space environment.
2. To quantify the performance and degradation rate of candidate and selected ISS exterior surface materials.

PHASE 1 MISSIONS

STS-76, STS-79, STS-81, STS-84, STS-86, NASA 6

OPERATIONAL ACTIVITIES

Not provided by PI.

RESULTS

See Passive Optical Sample Assembly #1 and #2, Orbital Debris Collector, and Polished Plate Micrometeoroid Detector.

CONCLUSIONS

Not provided by PI.

PUBLICATIONS

None.

Investigation Title: Mir Structural Dynamics Experiment (MiSDE)

Principal Investigator(s): Hyoung-Man Kim, Ph.D., Boeing

Additional Investigators: Sergei Simakov, Ph.D., Vyatcheslav Mezhin, and Mohamed Kaouk, Ph.D.

INVESTIGATION OBJECTIVES

1. Demonstrate the feasibility of correlating math models of large space structures by on-orbit modal testing.

PHASE 1 MISSIONS

NASA 3/STS-81, NASA 4/STS-84, NASA 5/STS-86, NASA 6.

OPERATIONAL ACTIVITIES

The experiment was performed from November 1996 to December 1997 and the MiSDE data was obtained from a total of 45 test sessions: 25 with the Mir alone and 20 with the Shuttle-Mir mated.

RESULTS

Modal parameters (frequency, damping, and mode shape) were extracted from a total of 35 transient events and model refinements were performed on a total of six configurations using the extracted modes.

CONCLUSIONS

The results from this study demonstrated that on-orbit modal testing and model refinement for large space structures are feasible within operational constraints.

PUBLICATIONS

1. Kim, H.M. and Kaouk, M., "Mir Structural Dynamics Experiment: First Phase Test and Model Refinement," *Proc. 40th AIAA SDM Conference,* St. Louis, MO, Paper No. AIAA-99-1453, April 1999.
2. Kim, H.M. and Kaouk, M., *Final Report: Mir Structural Dynamics Experiment,* The Boeing Company, Dec. 1998.
3. Kim, H.M. and Kaouk, M., "Mir Structural Dynamics Experiment: First Phase Test and Data Analysis," *Proc. 39th AIAA SDM Conference,* Long Beach, CA, Paper No. AIAA-98-1721, April 1998.
4. Kim, H.M. and Bokhour, E.B., "Mir Structural Dynamics Experiment: A Flight Experiment Development," *Proc. 38th AIAA SDM Conference,* Kissimmee, FL, Paper No. AIAA-97-1169, pp. 577-585, April 1997.

Investigation Title: Mir Wireless Network Experiment (MWNE)

Principal Investigator(s): Yuri Gawdiak, NASA/Ames Research Center

Additional Investigator(s):

INVESTIGATION OBJECTIVES

1. To evaluate the function of this system as part of remote communications planning for the ISS
2. To test commercial radio frequency wireless data links and mobile computer equipment to determine effective ranges and data throughput rates
3. To investigate the effects of radiation on advanced computer systems
4. To investigate human/computer interaction factors in a microgravity environment

PHASE 1 MISSIONS

STS-76

OPERATIONAL ACTIVITIES

The system was launched on STS-74. The experiment was performed aboard STS-76 and Mir Spektr in March, 1996.

RESULTS

- Sustainable Network throughput: 200-400 kbits/second, capable of supporting MANM requirements
- Operating range: within two adjacent station modules
- Passed flight qualification, electromagnetic compatibility and safety review.
- No computer failures during operation after 4 months of stowage aboard Mir (Spektr location 210)
- Reduced power radios will work, but coverage and range is affected
- Radios had mechanical capacitor adjustment drift due to launch vibration resulting in 10% decreased throughput.

CONCLUSIONS

Not provided by PI.

PUBLICATIONS

1. Lofton R, Conley C. International Space Station Phase 1 Risk Mitigation and Technology Demonstration Experiments. 48Th International Astronautical Congress; 1997 Oct 6-10; Turin, Italy; International Astronautical Federation.

Investigation Title: Optical Properties Monitor

Principal Investigator(s): Donald R. Wilkes, AZ Technology

Additional Investigators: Edgar R. Miller, James M. Zwiener, and Jean M. Bennett

INVESTIGATION OBJECTIVES

1. To study the effects of the natural and induced environment around the Mir on Spacecraft Materials.

PHASE 1 MISSIONS

STS-81 - Launch; STS-89 - Retrieval

OPERATIONAL ACTIVITIES

April 1997 - EVA Deployment

April 1997 - January 1998 - Operation

January 1998 - EVA Retrieval

RESULTS

The OPM performed very well for the Mir mission and has provided unique data on the behavior of materials around a Space Station.

CONCLUSIONS

Data gathered by the OPM has provided important data for ISS and should be reflown on ISS to assess the environment and materials performance during early ISS activities.

PUBLICATIONS

1. ISS/Mir Space Environmental Effects Experiments; ISS Contamination/Materials Technical Interchange Mtg: January 13, 1998.
2. Optical Properties Monitor; 2nd ISS Phase 1 Research Program Interim Results Symposium; April 2, 1998.
3. Optical Properties Monitor; Space Environment and Effects Flight Experiments Workshop; MSFC, June 23, 1998.
4. In-Situ Materials Experiments on the Mir Station; SPIE 43rd Annual Meeting; July 19, 1998.
5. Optical Properties Monitor; ISS Optical Property Degradation Review Technical Interchange Meeting; September 29, 1998.
6. Optical Properties Monitor; 3rd ISS Phase 1 Research Program Interim Results Symposium; November 4, 1998.
7. The Mir Environment and Material Effects as Observed on the OPM Experiment; 37th AIAA Aerospace Sciences Mtg; Jan. 1999.

Investigation Title: Orbital Debris Collector (ODC)

Principal Investigator(s): Freidrich Horz, Ph.D., NASA/Johnson Space Center

Additional Investigator(s): Not provided by PI

INVESTIGATION OBJECTIVES

The objectives for the ODC experiment were: to measure the potential risks of a high inclination Earth orbit by collecting samples of space debris which collides with the Mir Space Station and to characterize the types of collisions which occur in orbit and the potential for damage to the Mir and the future International Space Station caused by such collisions.

PHASE 1 MISSIONS

STS-76, NASA 2 - NASA 5, STS-86

OPERATIONAL ACTIVITIES

The ODC experiment was delivered to the Mir Space Station and mounted on the Priroda module during an EVA by STS-76 Shuttle astronauts. PPMDC remained outside the Mir Space Station, requiring no crewtime during the NASA 2, NASA 3, NASA 3, NASA 4, and NASA 5 missions. During an EVA by the STS-86 Shuttle crew, the experiment was retrieved and returned to Earth for analysis.

RESULTS

Not provided by PI

CONCLUSIONS

Not provided by PI

PUBLICATIONS

Not provided by PI

Investigation Title: Passive Optical Sample Assembly (POSA #1 and #2))

Principal Investigator(s): Jim Zwiener (POSA #1), NASA/Marshall Space Flight Center; Gary Pippin (POSA #2), Boeing Defense & Space Group

Additional Investigator(s):

INVESTIGATION OBJECTIVES

1. To identify the locations, dimensions, and characteristics of the damage at micrometeoroid and debris impact sites (POSA #1).

2. To assess the magnitude of particulate and molecular contamination during exposure to the Mir environment on candidate and selected ISS external surface materials (POSA #2).

3. To obtain data to help quantify the performance and degradation rate of candidate materials (POSA #2).

PHASE 1 MISSIONS

STS-76, STS-79, STS-81, STS-84, STS-86

OPERATIONAL ACTIVITIES

- All four MEEP experiments delivered to Mir by STS-76
- Successfully deployed on March 26th and 27th, 1996 during STS-76
- MEEP successfully retrieved on October 1, 1997 during STS-86 mission and returned to the ground.
- The MEEP was exposed to the Mir external space environment for 18 months

RESULTS

Contamination Detected on MEEP Experiments

POSA #1 contamination: space facing side >6000 angstroms; Mir facing side ~350 angstroms

POSA #2 contamination: visible contamination on space facing side; no visible contamination on Mir facing side.

Characteristics of Contamination Detected

POSA #1, space and Mir facing sides: deposit uniform in texture; varies in thickness. Identified as a silicate.

POSA #2, space facing side: mostly splatter or droplet contamination; identified as human waste

Potential Sources of Contamination Detected on MEEP Experiments

POSA #1, space facing side: stored solar array on docking module; silicone offgassing, converted to a silicate during exposure to atomic oxygen

POSA #2, space facing side: waste water dumps or leaks; either Mir or Shuttle (evaluations of potential sources are continuing)

CONCLUSIONS

- Contamination is a potentially serious threat to lifetime performance of critical ISS exterior materials
- Thermal properties of baseline ISS materials all indicated a sensitivity to contamination thickness
- Contamination depositions and effects are a function of material type, exposed surface are time, line of sight, distance, surface temperature, and local natural environmental elements (AO, UV interactions)

PUBLICATIONS

None.

Investigation Title: Polish Plate Micrometeoroid Debris (PPMD) Collector

Principal Investigator(s): William Kinard, NASA/Langley Research Center

Additional Investigator(s): Not provided by PI

INVESTIGATION OBJECTIVES

The objectives of the PPMDC experiment were: to gain a better understanding of the types of debris found at high inclination Earth orbit, to allow for better determinations of methods of protection needed for spacecraft orbiting the Earth at high inclinations, and to identify methods needed to control harmful debris orbiting the Earth.

PHASE 1 MISSIONS

STS-76, NASA 2 - NASA 5, STS-86

OPERATIONAL ACTIVITIES

The PPMDC experiment was delivered to the Mir Space Station and mounted on the external docking module during an EVA by STS-76 Shuttle astronauts. PPMDC remained outside the Mir Space Station, requiring no crewtime during the NASA 2, NASA 3, NASA 3, NASA 4, and NASA 5 missions. During an EVA by the STS-86 Shuttle crew, the experiment was retrieved and returned to Earth for analysis.

RESULTS

Not provided by PI

CONCLUSIONS

Not provided by PI

PUBLICATIONS

Not provided by PI

Investigation Title: Shuttle-Mir Alignment Stability Experiment (SMASE)

Principal Investigator(s): Russell E. Yates, NASA/Johnson Space Center; S. Shitov, Ph.D., RSC/Energia

Additional Investigator(s):

INVESTIGATION OBJECTIVES

1. To explore the human factor considerations of the Mir in regard to how forces exerted by normal crew activity affect the Mir structure and its navigational system.

PHASE 1 MISSIONS

STS-71, STS-74, STS-76, STS-79 (docked phase only)

OPERATIONAL ACTIVITIES

Shuttle and Mir vehicle attitude data were collected during multiple three-hour data collection periods while the two vehicles were docked. Navigational-dependent events were, including attitude thruster firings, Inertial Measurement Unit (IMU) alignments, and star tracker data takes occurred. The data from the experiment was used to determine the stability of and causes of any unexpected instability between the Shuttle and Mir navigation systems.

RESULTS

Results have shown that the measured transformation between the Shuttle and the Mir Space Station was within 0.3 degrees of preflight predictions. Typically, the relative stability between the two vehicles was about 0.6 degrees root mean square. The stability was excellent, considering attitude time tag errors were as large as 2.5 seconds. This experiment has provided data for the validation of analytical tools that will be used to predict the transformation between U.S. and Russian segments of the ISS.

CONCLUSIONS

The stability data indicates that Russian vehicle attitude data will meet the U.S. segment accuracy requirement of 0.5 degrees/axis. Transferring attitude data between U.S. and Russian segments is feasible and will benefit the ISS.

PUBLICATIONS

1. Lofton R, Conley C. International Space Station Phase 1 Risk Mitigation and Technology Demonstration Experiments. 48Th International Astronautical Congress; 1997 Oct 6-10; Turin, Italy; International Astronautical Federation.

Investigation Title: Space Portable Spectroreflectometer (SPSR)

Principal Investigator(s): Ralph Carruth, NASA/Marshall Space Flight Center

Additional Investigators: Jim Zwiener, Rachel Kamanetzky, Don Wilkes, and Stanislav Naumov

INVESTIGATION OBJECTIVES

Direct measurement of solar absorptivity of Mir thermal radiators to determine degradation due to years of exposure to the space environment and contamination; Obtain data applicable to ISS long-term degradation; Demonstrate portable instrument could be utilized EVA

PHASE 1 MISSIONS

NASA 6 Operational and Returned on NASA 7

OPERATIONAL ACTIVITIES

Not provided by PI.

RESULTS

SPSR was utilized during one EVA and data was acquired from one of the KVANT II radiators; the rigidizing tether, for stability, did not fit handrail and the SPSR display faded out which affected data.

CONCLUSIONS

Mir radiator surface was relatively clean of contaminants; there was some degradation of solar absorptivity (as expected) but difficult to quantify due to problems with the rigidizing tether and the SPSR display; data appeared to indicate that value was within russian end of life predictions.

PUBLICATIONS

1. "In-Situ Materials Experiments on the Mir Station," SPIE Vol. 3427
2. "Space Portable Spectroreflectometer (SPSR) Investigation on Mir Space Station," AIAA 99-0101

Investigation Title: Test of Portable Computer System (TPCS) Hardware

Principal Investigator(s): Rodney L. Lofton, NASA/Johnson Space Center

Additional Investigators: Andrew L. Klausman

INVESTIGATION OBJECTIVES

The TPCS experiment was designed to determine the quantity of Single Event Upsets (SEUs) that occur on ISS Portable Computer System hardware due to the radiation environment at the ISS orbital inclination. The TPCS hardware consisted of a COTS IBM-760ED laptop computer with 48 Mbytes of RAM, a power supply unit, a floppy disk drive, two hard drives, and associated power, data, and video cables.

PHASE 1 MISSIONS

NASA 6, NASA 7

OPERATIONAL ACTIVITIES

NASA 6 (7) crewmember unstowed and set up the TPCS hardware at two week intervals throughout a mission. The crewmember activated the SEU software (Super Memory Checker) and ran the software continuously for approximately 8 hours per session, recording “upsets”

RESULTS

All hardware and software worked as expected.

Super Memory Checker (SMEM) software program ran 102 hours during NASA 6 and 76.5 hours during NASA 7.

Total number of SEUs measured: 9 during NASA 6, 5 during NASA 7.

CONCLUSIONS

The IBM 760ED laptop computer seems to be well suited for space-based tasked than predecessor laptops. The off-the-shelf laptor’s internal memory is not radiation harden, so random memory bit changes can be expected on the order of 9 per 100 hours of operation.

PUBLICATIONS

1. “Results of Risk Mitigation Experiment 1332 for Space Shuttle and Space Station Mir Missions”, Final Report 1998.

Investigation Title: Water Microbiological Monitor (WMM)

Principal Investigator(s): Duane L. Pierson, Ph.D., NASA/Johnson Space Center

Additional Investigators: None listed.

INVESTIGATION OBJECTIVES

1. To detect and quantify the bacterial count in Mir potable water from three sources: the hot potable water dispenser, the cold potable water dispenser and the SVO-ZV (ground-supplied water) dispenser on board Mir.

PHASE 1 MISSIONS

Mir 22/NASA 3, Mir 23/NASA 4, Mir 25/NASA 5

OPERATIONAL ACTIVITIES

Hot, cold and SVO-ZV water was collected on flight days 15, 55 and 135 to process microbial capture devices (MCD) and placed in an incubator at 25 to 37 degrees Celcius. The crewmember performed a colony count and video recorded (approximately 1 minute of film making sure that the writing on the device was focused in the field of view) the MCD two and five days after the initial collection. After examination, the MCDs were returned to the incubator. Visual examination of each MCD was performed and the bacterial colony count was compared to the comparison card. Findings were recorded on data recording sheets and on the MCD. MCDs were examined for 5 days. After 5 days the MCDs were stowed in a returning kit for return to Earth. After return to Earth the bacterial colonies were identified.

RESULTS

Information not currently available.

CONCLUSIONS

Information not currently available.

PUBLICATIONS

Information not currently available.