## ISS Program Science Database Instructions

The summary you are providing will be posted on the ISS Program Science Toolbox (http://iss-science.jsc.nasa.gov/) with a subset of fields used for public distribution on the NASA portal. If the payload has flown in the past, please check the summary on the website for accuracy. Please submit any changes to Tracy Thumm (tracy.thumm-1@nasa.gov) or Judy Tate (judy.tate-1@nasa.gov).

If the payload has not flown before, please provide a summary using the template below. Please use the descriptions of the fields as a guide when writing. Should you have any questions or comments, please contact Judy or Tracy.

Thank you,

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Deputy Program Scientist
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# Summary Template
# ISS Program Science Database

**Acronym: ANDE 2**

**Payload Title:** ***Atmospheric Neutral Density Experiment 2***

**Principal Investigator(s):** Andrew Nicholas, Naval Research Laboratory, Washington, DC

**Co-Investigator:**
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**Category:** Technology Development

**Sub-Category:** Spacecraft and Orbital Environments

**Mailing Address:** Johnson Space Center, Mailcode WR1, 2101 NASA Parkway, Houston, TX, 77058

**Payload Developer(s):** United States Department of Defense Space Test Program, Johnson Space Center, Houston, TX

**Sponsoring Agency:** NASA

**Increment(s) Assigned:** 18

**Mission:** STS-127 (2J/A)

**Brief Research Summary (PAO):** Two microsatellites launched from the Shuttle payload bay will measure the density and composition of the low Earth orbit (LEO) atmosphere while being tracked from the ground. The data will be used to better predict the movement and decay of objects in orbit.

**Research Summary:** Atmospheric Neutral Density Experiment's (ANDE) objectives are to measure atmospheric density and composition in Low Earth Orbit (LEO) and to better characterize the parameters used to calculate a satellite's drag coefficient. This experiment consists of two microsatellites, called ANDE Active (AA) spacecraft (Castor) and the ANDE Passive (AP) spacecraft (Pollux), that are launched from the Space Shuttle cargo bay. These spherical satellites are 19 inches in diameter and will be tracked by the Satellite Laser Ranging systems and the Space Surveillance Network.

**Detailed Research Description:** The ANDE mission's main objective is to measure the total atmospheric density between 100 and 400 km. The density data that is gathered will be used to improve orbit determination calculations of the orbits of resident space objects.

ANDE consists of two spherical micro satellites. These satellites are launched from the Space Shuttle cargo bay into a circular orbit just below the International Space Station altitude.

Both satellites will be tracked by the Satellite Laser Ranging (SLR) system and the U.S. Space Surveillance Network (SSN). These satellites have the same dimensions, but have different masses. Because of the difference in mass, the satellites will drift apart over time. Observing the satellites' position will provide a study on spatial and temporal variations in atmospheric drag associated with geomagnetic activity.

**Project Type:** Payload

**Images and Captions:**

**Operations Location:** Shuttle Sortie

**Brief Research Operations:** The ANDE spacecraft are located inside an Internal Cargo Unit (ICU) that will get ejected from the DoD’s Canister for All Payload Ejections (CAPE) in the Space Shuttle’s payload bay by crewmembers activating a switch. Once the ICU canister is a safe distance from the Space Shuttle the two microsatellites will be released at an altitude of approximately 350 km.

**Operational Requirements:** ANDE uses two spherical micro satellites which are launched from the Space Shuttle cargo bay. Both satellites are 19 inch diameter spheres, have a mass of 50 and 25 kg, and are constructed of aluminum. The surface of both spheres contains an embedded array of sensors including 30 retro reflectors, six laser diodes for tracking, and six photovoltaic cells for determining orientation and spin rate. Both spheres also have thermal monitor systems. The ANDE spacecraft are located inside the Internal Cargo Unit (ICU). The ICU is made of three aluminum sections. Each section is separated by a light band separation system. Once ejected from the cargo bay, the ICU will separate and deploy the ANDE spheres at a safe distance from the shuttle.

**Operational Protocols:** ANDE will be launched from the Space Shuttle cargo bay. The two micro satellites will be contained inside the ICU canister. Once the ICU canister is a safe distance from the Space Shuttle, two micro satellites will be released at an altitude of approximately 350 km.

**Review Cycle Status:** DoD Reviewed

**Space Applications:** Understanding the atmospheric effects on spacecraft in Low Earth Orbit will lead to improved calculations for orbit determinations and collision avoidance.

**Earth Applications:** Improving calculations that are used when observing orbits, may lead to advancements in the fields of mathematics and physics here on Earth.

**RPO:** Space Operations (SO)

**Previous ISS Missions:** STS-116 (12A.1)

**Results Summary:**

**Results Publications:**

**Related Publications:**

**Web Sites:**

**Related Payloads: STP-H2-ANDE**

**Last Update:**

# Field Descriptions
# ISS Program Science Database
http://iss-science.jsc.nasa.gov

**Acronym:** Official acronym assigned to the payload.

**Payload Title:** Official name assigned to the payload.

**Principal Investigator(s):** Scientist(s) responsible for the experiment, institution affiliation and location. PI should always be listed as this person receives scientific credit for the experiment in public communications (i.e., do not list a coordinating organization or point of contact or experiment manager here). Format: John Smith, Ph.D., University, City, State

**Co-Investigator:** Individuals who are involved in the experiment. Please list name, affiliation and location. Format: Mary Smith, Ph.D., University, City, State.

**Contact(s):** Name, email address and phone number of the PI and the name, email address and phone number of the primary individual to contact in the absence of the PI.

**Category and Sub-Category:** Please select from one category and one sub-category from the following:

- Human Research and Countermeasure Development for Exploration
    - Bone and Muscle Physiology in Space
    - Cardiovascular & Respiratory Systems in Space
    - Human Behavior and Performance
    - Immune System in Space
    - Integrated Physiology Studies
    - Microbiology in the Space Environment
    - Neurological and Vestibular Systems in Space
    - Radiation Studies
- Observing the Earth and Educational Activities
    - Educational Activities
    - Observing the Earth
- Physical and Biological Sciences in Microgravity
    - Animal Biology in the Space Environment
    - Cellular Biology and Biotechnology
    - Physical Sciences
    - Plant Biology in Microgravity
    - Protein Crystal Growth

- Results from ISS Operations
    - Crewmember-Initiated Science
    - Environmental Monitoring of ISS
    - Medical Monitoring of ISS Crewmembers
- Technology Development for Exploration
    - Characterizing the Microgravity Environment on ISS
    - Environmental Monitoring on ISS
    - Picosattellites & Control Technologies
    - Spacecraft and Orbital Environments
    - Spacecraft Materials
    - Spacecraft Systems

**Mailing Address:** Mailing address for the Principle Investigator and Co-Investigators. This information will used for internal use only.

**Payload Developer(s):** NASA center, Space Agency and/or the company or institution where the investigation and hardware are developed.

**Sponsoring Agency:** Space agency responsible for launch the investigation. The options are as follows:

- Canadian Space Agency (CSA)
- European Space Agency (ESA)
- Federal Space Agency (FSA)
- Japan Aerospace Exploration Agency (JAXA)
- National Aeronautics and Space Administration (NASA)

**Increment(s) Assigned:** A list of increments that this payload has been or is scheduled to be performed.

**Mission:** This applies only if the payload was manifested as a Sortie mission. Please indicate the mission number. For Example: STS-121/ULF1.1

**Brief Research Summary (PAO):** Short, concise description of the payload (no more than 3 sentences) summarizing what is being done and why. Written for a public audience with minimal jargon.

**Research Summary:** Slightly more detailed than the PAO summary in a bulletized format to answer the following questions:

- why research is needed
- what will be accomplished
- what will be the impact

Information is available on the internal and public website, and is used to generate 1-pagers. (Shorter is better, absolutely no more than about 10 sentences, written on an $8^{th}$ grade level).

**Detailed Research Description:** Provides a place for a more technical description of the objectives of an experiment aimed at an interdisciplinary scientific audience. May have several paragraphs as needed. May use technical terminology, but all terms should be defined or linked. This field will also include the description of hardware.

**Project Type:** Indicates type of project: Payload or Sub-payload

**Images and Captions:** Image of the investigation with a detailed caption. Image should be provided in .jpg format.

**Operations Location:** Indicates where the payload is performed: Pre/Postflight, Sortie or ISS Inflight.

**Brief Research Operations:** Brief summary of the operations used to perform activities for the payload, written in bulletized format for a general audience at and $8^{th}$ grade level. This field becomes part of the 1-pager.

**Operational Requirements:** Defines constraints and requirements to be met to complete the experiment (numbers of subjects or observations, spacing of observations, downlink of data, return of samples, etc.). No more than 10 sentences.

**Operational Protocols:** Overview of what is done on orbit to complete the experiment so that a reader can imagine the procedure. No more than 10 sentences.

**Space Applications:** Information on how this experiment supports/benefits the space program.

**Earth Applications:** Information on how this experiment supports/benefits people on Earth.

Manifest Status:

**RPO:** Official name of organization in charge of the payload. The options are as follows:
- Applied Technology Flight Program – KSC (ATFP-KSC)
- Human Research Program – ARC (HRP-ARC)
- Human Research Program – JSC (HRP-JSC)
- Life Support and Habitation – GRC (LSH-GRC)
- Life Support and Habitation – MSFC (LSH-MSFC)
- Space Operations (SO)
- Canadian Space Agency (CSA)
- European Space Agency (ESA)
- Japan Aerospace Exploration Agency (JAXA)
- Space Operations-Italian Space Agency (SO-ASI)

**Previous Missions:** Missions that the payload was manifested on, prior to ISS, or related payloads already completed on ISS. Should include enough of a summary for understanding of the previous results and how they led by progression to this research.

**Results Summary:** Summarizes the progress of the investigation to date. Information provided only after payload operations have begun or are completed onboard ISS/Sortie. The first paragraph should summarize the number of subjects, samples or sessions completed over the number of increments performed. Following paragraphs contain an overview of information contained in 30-day Postflight reports, 1-year Postflight reports, presentations or publications. The final paragraph summarizes what the investigation means in terms of future application.

**Results Publications:** Citation listing of publications resulting from the operation of the investigation on ISS.

**Related Publications:** Citation listing of publications related to the investigation. Publications that set the stage for the planned research, including background on the topic, and publications describing the experiment preflight. Information is available on the public website.

**Web Sites:** Listing of public websites with information regarding the investigation.

**Related Payloads:** Other payloads that are currently on or have flown on ISS that have similar objectives.

**Last Update:** This field will indicate when the last update was made to the investigation information.

# ANITA
## *Analyzing Interferometer for Ambient Air*

**Principal Investigator(s):** Gijsbert Tan, European Space Research and Technology Center, Noordwijk, The Netherlands

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**Payload Developer(s):**
European Space Agency, Noordwijk, The Netherlands
Kayser-Threde, Munich, Germany
Johnson Space Center, Flight Research Management Office, Houston, TX

**Sponsoring Agency:** National Aeronautics and Space Administration (NASA)

**Increment(s) Assigned:** 15, 16, 17, 18

**Brief Research Summary (PAO):** Analyzing Interferometer for Ambient Air (ANITA) will monitor 32 potential gaseous contaminants, including formaldehyde, ammonia and carbon monoxide, in the atmosphere on board the station. The experiment will test the accuracy and reliability of this technology as a potential next-generation atmosphere trace-gas monitoring system for the station.

**Research Summary:**

- For the safety and health of the crew, the spacecraft atmosphere needs to be continuously monitored for harmful trace gases.
- The ANITA flight experiment will test a technology novel to spaceflight for monitoring the atmosphere on ISS.
- In case of accidental release of harmful gaseous contaminants (large or small amounts), extreme off-gassing of materials, or malfunctions in the air revitalization system, fast response by the astronauts is mandatory.

**Detailed Research Description:** The ANITA flight experiment is a trace gas monitoring system based on Fourier Transform Infrared (FTIR) technology. The initial flight of ANITA will test the accuracy and reliability of the FTIR technology as a potential next generation atmosphere trace gas monitoring system for ISS.

ANITA is calibrated to simultaneously monitor 32 gaseous contaminants (including formaldehyde, ammonia and carbon monoxide) at low parts per million levels in the cabin atmosphere. Its quasi on-line, fast time resolution allows air quality to be analyzed, and in the future it could be used for immediate initiation of countermeasures if so required. However, considering the experimental character of the gas analyzer, the actual ANITA analysis results (contaminant identification and concentration) are invisible to the crew. Only the ground support team will have access to the data.

The ANITA calibration models developed prior to flight are based on a set of reference spectra of the 32 gaseous contaminants. Earlier air quality analyses have determined that these trace gases may be present in the ISS cabin atmosphere. However, if the actual gas scenario is clearly outside the predefined limits (e.g. new gas contaminants, different concentration ranges of known gases, etc.) the calibration models will need modification during operation. New calibration models and/or patches to the existing in-flight calibration models will, if required, be developed by the ANITA ground team and electronically delivered to ANITA. The ANITA ground model will be used for any real-time troubleshooting and calibration model tests. The ANITA unit requires no in-flight calibration gases during its operational lifetime, thus minimizing the on-orbit consumables only to electrical power.

**Project Type:** Payload

Pictured above are the different components that are used in the ANITA experiment.
(click to enlarge)

**Operations Location:** ISS Inflight

**Brief Research Operations:**

- ANITA will analyze air samples from local and remote areas onboard ISS. Data will be down-linked daily to the ground team.

**Operational Requirements:** In routine operation, ANITA samples the air immediately in front of the unit. In addition, it can analyze air samples gathered manually from remote locations. The remote air samples are taken applying specially provided air sampling bags and a hand pump. ANITA has two units, the Air Flushing Unit and the Interferometer. Through gas Transfer Tubes the Air Flushing Unit brings in an air sample in to the previously depressurized gas cell in the Interferometer. The gas cell is depressurized automatically using a pump. The Infrared spectrum of the air sample is measured in the Interferometer. The data is processed and stored in the ANITA A31p laptop onboard ISS. The data is downlinked daily to the ground team.

**Operational Protocols:** The ISS crew will start ANITA by setting up the laptop and initiating the 10-day experimental phase. ANITA will be set in Local Sampling. This sampling of air will occur in the immediate vicinity of ANITA. However, it is foreseen to have also two Non-Local samples analyzed. Non-Local Sampling involves ANITA analyzing air samples from other locations onboard ISS. Since ANITA is in a fixed location, the crew will fill an ANITA Sample Bag with air by means of a hand pump. The bag will be flushed three times with local air before the air sample is taken. The crewmember will stop the Local Sampling and connect the ANITA Sample Bag to the Air Flushing Unit. The valve on the bag is opened, allowing the sample to be drawn into the gas cell. The analysis of the Non-Local air sample is automatic. After this process is completed, the crewmember will re-initiate the Local Sampling. The data is sent through the daily downlinks to the ground team.

After the 10-day experimental phase ANITA remains operational initially for 6 months for further data logging. Non-Local Sampling may take place once per month or when needed.

**Review Cycle Status:** PI Reviewed

**Category:** Technology Development

**Sub-Category:** Characterizing the Microgravity Environment on ISS

**Space Applications:** This will lead to new atmospheric monitoring systems for future spaceflight.

**Earth Applications:** The ANITA application of FTIR technology provides an improved multi-component gas measurement system for various purposes, such as workplace monitoring (including airplanes and submarines), environmental monitoring, and control of industrial processes.

**Manifest Status:** Planned

**RPO:** Human Research Program - JSC (HRP-JSC)

**Previous Missions:** This is the first test of this technology for full application in a human spacecraft.

**Results Status:**

**Web Sites:**

**One-pager:** ANITA

**Related Payload(s):** DAFT

**Comments:**

**Last Update:** 8/13/2005

**Acronym:** BCAT-4

**Title:** Binary Colloidal Alloy Test-4

**Principal Investigator(s):** Prof. David A. Weitz, Peter J. Lu (Harvard)
and Prof. Paul M. Chaikin (NYU / Princeton)

**Contact(s):** PIs:
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Secondary (Samples 1 – 7) – Peter J. Lu / plu@fas.harvard.edu / 617-496-8915
Primary (Samples 8 – 10) – Prof. Paul M. Chaikin / chaikin@physics.nyu.edu / (212) 998-7694
Secondary (Samples 8 – 10) – Andrew D. Hollingsworth / andrewdh@nyu.edu / (212) 998-8460

**Payload Developer(s):** NASA Glenn Research Center and ZIN Technologies, Cleveland, OH

**Sponsoring Agency:** National Aeronautics and Space Administration (NASA)

**Increment(s) Assigned:** 16, 17, and 18)

**Brief Research Summary (PAO):**
BCAT-4 is a follow-on experiment to BCAT-3 (which has been performed during Increments 8, 9, 10, 12 and 13 and is scheduled to run on 15 and 16). BCAT-4 will study 10 colloidal samples. Seven of these samples will determine phase separation rates and add needed points to the phase diagram of a model critical fluid system initially studied in BCAT-3. Three of these samples will use model hard-spheres to explore seeded colloidal crystal nucleation and the effects of polydispersity, providing insight into how nature brings order out of disorder.

**Research Summary:**
The goals of this International Space Station (ISS) Small Payload experiment are twofold: (1) to further investigate critical, fundamental problems in colloid science (the previous BCAT-3 experiment provided some pleasant surprises and more data points are needed); and (2) to evolve the field of "colloidal engineering", which creates materials with novel properties using colloidal particles as precursors. To find answers to these important questions, BCAT-4 takes advantage of the microgravity environment on the ISS to prevent the model colloidal particles from encountering sedimentation, convection, and gravitational jamming.

BCAT-4 has two parts, BCAT-4-CP and BCAT-4-Poly:

- For the BCAT-4-CP critical point samples (1 - 7), astronauts photograph samples of polymer and colloidal particles (tiny nanoscale spheres suspended in liquid) that model liquid/gas phase changes. Results will help scientists develop fundamental physics concepts previously cloaked by the effects of gravity. The focus of the BCAT-4-CP part of the experiment (as for the BCAT-3 Critical Point (CP) experiment) is to watch what happens during phase separation near the critical point. BCAT-4 adds more samples to help fill in the phase diagram for a model 2-phase liquid-gas system, with the liquid being denser than the gas. When watching the two separate on Earth, the liquid just pools at the bottom. For the BCAT-CP experiments, phase separation slows down near the critical point, until right at that point (where there is no phase separation), the time to separate is considered infinite. Exactly what happens at an individual particle level really close to that point is being explored by the experiments. BCAT-3 and BCAT-3+ are indicating that the phase separation rates expected from theory are not applicable for a significant class of samples with binodal decomposition possibly playing a more significant role than previously anticipated.

- BCAT-4-Poly consists of polydisperse colloidal particles (samples 8, 9 and 10). These samples push the boundaries of known self-assembly and thermodynamics processes in complex fluids.

> The effects of polydispersity on crystallization in the ~0.59, *i.e.*, glassy, volume fraction range will be studied. The three contrasting samples will be (1) as monodisperse as possible (*e.g.*, < 5%), (2) a slightly polydisperse sample (*e.g.*, < 10%), and (3) a bi-disperse sample; mostly one average particle size, but with a few large 'nano-dirt' particles in one sample (~ 14 times the average particle radius) to provide crystal nucleation sites. Clean observations of phase transitions in these systems of particles provide much needed insight about the interplay of particle interactions, polydispersity and sedimentation in affecting phase behavior. Clean observations, for example, about how the liquidous lines are perturbed by particle non-ideality reveal trends that are broadly useful in suspension science – trends that should improve design criteria for control of soft materials ranging from protein crystallization to paints. Traditional questions about the relative packing fractions, which crystallization phase is manifested, and the passing from one phase to the other, may be studied in these systems without the perturbing effects of sedimentation and gravitational jamming.

Astronauts on board the International Space Station (ISS) set up the BCAT-4 experiment and use a camera to take pictures of the critical point samples as they evolve in time. This is done both manually and with a computer controlled system called EarthKAM. They also use a flashlight and a camera to capture pictures of the colored light diffracted by crystals that may form for some of the samples (8 – 10) in the absence of gravity, but not on earth.

**Detailed Research Description:** In an ordinary pot of boiling water, bubbles of water vapor coalesce on the bottom of the pot, growing until they detach and float to the surface where they escape into the atmosphere. At the boiling temperature water exists simultaneously in two distinct phases, liquid and gas, and as the bubbles burst, those two phases are spatially separated. But what should the mixture look like in the absence of gravity, when the vapor no longer floats to the top? Moreover, the behavior changes with increasing pressure: seal the pot, as in a pressure cooker, and the boiling temperature rises. Continuing the pressure increase, the mixture will reach its critical point, a unique pressure and temperature value where the properties of the liquid and gas merge. Just above this point is the supercritical regime where there are no longer distinct phases, but rather a homogeneous supercritical fluid. Seven of the BCAT-4 samples add important data points to the phase diagram explored by the critical point samples in BCAT-3, where the phases analogous to liquid and gas can be seen as two different colors.

Data from the BCAT-3-CP critical point samples indicate that when the masking effects of gravity are removed, pleasant surprises await us. An unexpected rate of phase separation for these critical point samples is being seen, which is exciting and requires addition samples to fill in the phase diagram. These experiments are essential to understand the origin of the behavior and to provide enough quantitative detail for theorists to model.

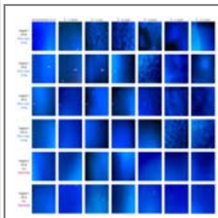
Supercritical fluids are technologically important because they uniquely combine the properties of liquids and gases, flowing easily (like gases), yet still having tremendous power to transport dissolved materials and thermal energy (like liquids). Supercritical water so efficiently transports heat that it is being explored in Iceland as a potentially superior geothermal power source; it is also used to remove toxic waste from contaminated soil. Additionally, NASA's Jet Propulsion Laboratory is working on using supercritical fluids as unique propellants for future rocket engines. A better understanding of critical behavior as a result of microgravity experiments like BCAT-3-CP might thus contribute to fundamental understanding that may contribute to the future development such diverse things as new drugs, cleaner power, and interplanetary transportation.

The colloid-polymer mixtures are in a glass cuvette, which the astronauts can illuminate with a flashlight from the rear, at a high angle. The colloidal spheres scatter the light from the flashlight, and appear blue, so the bright blue areas in the photographs are regions with high colloid density. The darker areas, filled with solvent and polymer, don't scatter much light, which is why these areas are darker. The term "phase separation" is clearly visualized in the photographs: the sample has separated into two phases, a bright blue "liquid" phase with a high colloid density, and a darker "gas" with far lower colloid-density. We measure the characteristic width of the bright-blue region, quantifying the size of the liquid regions, as a function of time.

The BCAT-4-CP critical point samples may have a tremendous impact upon fundamental physics. Understanding critical phenomena was an important theoretical advance in physics during the last half century, but ground-based experiments have been limited by gravity, which invariably causes the denser liquid phase to fall to the bottom of any container, precluding direct observation of phase separation, which in the absence of gravity should manifest a boundary between separating phases that looks like a jagged coastline,  BCAT-4-CP builds on the BCAT-3-CP experiment, which was the first experiment to begin to use the size advantages of colloids to systematically attempt to precisely locate the critical point and characterize the behavior around it. These larger particles are not only large enough to scatter light, but large enough to slow down the dynamics in a way that allows us to photograph the sample evolving over a period of weeks.

The BCAT-4-Poly polydisperse and seeded samples will consist of PMMA particles in an index matching decalin/tetralin mixture (the same colloid and solvent materials as the critical-point samples, but at a volume fraction of ~0.59). Although these samples are at or above the so-called glass transition point, colloidal crystals are expected to form. The particle size distribution and the addition of spherical seed particles should affect the free energy barrier for crystal nucleation, that is, the rate at which crystals nucleate. Photography will be used to study their evolution, with the hope of seeing white light backlit samples diffract the light so that the color changes with viewing angle. This will help reveal the shape of the nuclei, which provide information about the way the crystals grow in microgravity. The crystallites might grow fast in certain crystallographic directions which could give them a layer like structure. Also their shape will give some hints about the processes that limit the growth. Comparison with analogous ground-based experiments will reveal differences in the growth behavior in microgravity.

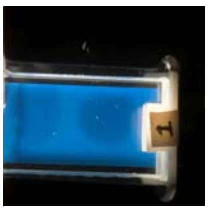
**Project Type:** Payload; Small Payload Class

| | |
|---|---|
| <br>NASA Image: ISS008E20221- BCAT-3 sample holder affixed to a wall inside ISS on Expedition 8.<br>(click to enlarge) | <br>NASA Image: ISS010E06640 - ISS Commander and Science Officer, Leroy Chiao performing BCAT-3 operations on board ISS during Expedition 10.<br>(click to enlarge) |
| <br>Critical point fluctuations observed in BCAT-3 onboard the ISS.<br>(click to enlarge) | <br>NASA Image: ISS012E07685 - Expedition 12 Commander and Science Officer William McArthur photographs BCAT-3 experiment samples.<br>(click to enlarge) |

BCAT-4 Slow Growth Sample Module

BCAT
on the MWA

BCAT
alternate
setup



NASA Image: ISS012E13082_nr - BCAT-3-CP sample 1 taken during ISS Expedition 12 using a new camera setting and flash placement. The new camera flash position allows the camera to see the light from the evolving critical fluid experiment interface. These tests will now enable the EarthKAM computer to take a series of computer controlled photographs, which will track the evolution of this critical fluid experiment after it has just been mixed in the absence of gravity. (click to enlarge)

Cathy Frey (BCAT Crew Trainer) and Peter Lu (BCAT Investigator) showing Dan Tani (Inc. 16) time-lapse “video” of sample evolution from photos taken by Bill McArthur during Inc. 12.

**Operations Location:** ISS Inflight, Maintenance Work Area (MWA) or mounted on a rail
**Brief Research Operations:**

- BCAT-4 consists of ten different individual sample cells. Critical point samples make up seven of the sample cells. The remaining 3 samples study colloidal crystals.
- For BCAT-4-CP Critical Point Samples: Crew members will homogenize the samples and photograph one sample at a time, to capture the rate of phase separation in the samples using EarthKAM automated photography over a period of 2 – 3 weeks per sample. Images will be downlinked to allow scientists to provide immediate feedback to the astronauts.
- For the BCAT-4-Poly Colloidal Crystal Samples: Crew members will homogenize the samples and will look for crystals at various lighting angles. The crystals will be manually photographed and downlinked for immediate feedback to the astronauts.
- After photography the samples are stowed and left undisturbed to allow for continued growth of the colloidal structure for up to 6 months.

**Operational Requirements:** The BCAT-4 experiment consists of ten small samples of colloidal particles. The microscopic colloid particles and a polymer (for sample 1 – 7) are all mixed together in a liquid. The ten BCAT-4 samples are contained within a small case the size of a school textbook. The experiment requires a crew member to set up on the Maintenance Work Area (MWA) or on a handrail/seat track configuration, EarthKAM hardware and software to take digital photographs of Samples 1 – 7 at close range using the onboard Kodak 760 camera. Samples 8 – 10 require manual photographs (at least initially) be taken by an astronaut. The pictures are down-linked to investigators on the ground for analysis.

**Operational Protocols:** Sessions have slightly different photography requirements but the general operational protocol for a session is as follows:

- Crew sets up the historical Video camera to document the BCAT-4 operations as performed on-board
- Crew sets up all hardware on MWA (Slow Growth Sample Module, DCS760 Camera, flash and EarthKAM software with SSC Laptop
- Crew homogenizes (mixes) the sample(s) and takes the first photographs manually
- EarthKAM software automates the rest of the photography session over a 3-day to 3-week period.
- Crew performs a Daily Status Check once a day to assure proper alignment and focus
- At the completion of the run, a crew member tears down and stows all hardware (30 minutes)

**Review Cycle Status: Reviewed by one PI**

**Strategic Objective:**

- Expanding our understanding of the laws of nature and enriching lives on Earth.
- Creating technology to enable the next explorers to go beyond where we have been.
- Educating and inspiring the next generation to take the journey.

**Strategic Objective Mapping:** (1) Form the basis of using supercritical fluids in reduced gravity. The unique properties of supercritical fluids are described below. (2) Study the order-disorder transition and the effects of polydispersity and seeded crystal nucleation that can be manifested in the absence of gravity.

Space Applications: This experiment addresses basic physics questions, but some of the areas may eventually have applications for space exploration. Supercritical fluids, which are one of the applications of the critical point experiment, are of potential application in propulsion systems for future spacecraft design.
Earth Applications: Increased knowledge of some of the areas of this basic physical research may have future benefits in the application of the same physical processes on Earth.

- BCAT-4-CP: Increased knowledge of some of the areas of this basic physical research may have future benefits in the application of the same physical processes on Earth. Supercritical fluids (fluids possessing properties of a gas and a liquid simultaneously) have numerous applications in a wide variety of fields. An example is supercritical carbon dioxide used to decaffeinate coffee beans. Supercritical fluids can also be used to wash toxic waste from soil, to extract higher concentrations of compounds from plants for use in new drugs. The development and use of newer supercritical fluids is dependent on further understanding of the critical point of those fluids, which BCAT-3-CP and BCAT-4-CP are providing. Additionally, product shelf-life may be dependent upon binodal decomposition; so, a better understanding of this could have an enormous commercial impact.

- BCAT-4-Poly: Generally, colloidal nucleation experiments seek an understanding of the most fundamental liquid/solid transition. Though direct applications of that understanding do not drive the research, growth of ordered colloidal phases has attracted interest in a number of areas, *e.g.* ceramics, composites, optical filters and photonic bandgap materials. Moreover, there is currently great interest in using fields and gradients to control order in self-assembled systems such as diblock copolymers and microemulsions for advanced materials.

**Manifest Status:** Candidate
**RPO:** Life Support and Habitation - GRC (LSH-GRC)
**Previous Missions:** The predecessors to BCAT-4; BCAT-3 operated on ISS, and BCAT, operated on *Mir* in 1997 and 1998. And hence the acronym Binary Colloidal Alloy Test-4, which is no longer the perfect descriptor for what is now flying.

**Results:** BCAT-3 critical point samples were operated from Increments 8 – 13. The phase separation rates in microgravity were unknown to researchers, and because of this, the samples have been remixed for another session using EarthKAM, an f/32 focal length setting, and autoexposure, to verify and provide more quantitative observations. Final results will not be available until the experiment is complete on ISS Expedition 15 or 16.

**Results Publications:** Several publications are in preparation for submission to peer-reviewed journals.

**Related Publications:**


Lu PJ, Weitz DA, Foale CM, Fincke EM, Chiao L, McArthur WS, Williams JN, Meyer WV, Owens J Hoffmann MI, Sicker RJ, Rogers RB, Frey CA, Krauss AS, Funk GP, Havenhill MA, Anzalone SM, and Yee HL, Science Applications International Corporation, Microgravity Phase Separation Near the Critical Point in Attractive Colloids, Proceedings of the 45th Aerospace Sciences Meeting and Exhibit. 2007; AIAA-2007-1152.

Lu PJ, Conrad JC, Wyss HM, Schofield AB, and Weitz DA. Fluids of Clusters in Attractive Colloids, PRL **96,** 028306 (2006).

Doherty MP, Koudelka JM, Motil SM, Saavedra SM. Light Scattering for complex Fluids Research on ISS: Investigator Dreams and Anticipated Hardware Development. Proceedings of the 37th Aerospace Sciences Meeting and Exhibit. 1999; AIAA 1999-0964.

Manley S, Cipelletti L, Trappe V, Bailey AE, Christianson RJ, Gasser U, Prasad V, Segre PN, Doherty MP, Sankaran S, Jankovsky AL, Shiley B, Bowen J, Eggers J, Kurta C, Lorik T, Weitz DA. Limits to Gelation in Colloidal Aggregation. Physical Review Letters. 2004; 93(10):108302.

Lant CT, Smart AE, Cannell DS, Meyer WV, Doherty MP. Physics of hard spheres experiment--a general purpose light scattering instrument. Applied Optics. 1997: **36**, No. 30, 7501-7507.

Doherty MP, Lant CT, Ling JS. The Physics of Hard Spheres Experiment on MSL-1: Required Measurements and Instrument Performance. Proceedings of the 36th Aerospace Sciences Meeting and Exhibit. 1998; AIAA 1998-0462.

Ansari RR, Hovenac EA, Sankaran S, Koudelka JM, Weitz DA, Cipelletti L, Segre PN. Physics of Colloids in Space Experiment. Space Technology and Applications International Forum. 1999.

Cheng ZD, Chaikin PM, Zhu JX, Russel WB, and Meyer WV, "Crystallization Kinetics of Hard Spheres in Microgravity in the Coexistence Regime: Interactions between Growing Crystallites", Phys. Rev. Lett. 88, 015501 (2002).

Cheng ZD , Zhu JX, Russel WB, Meyer WV, Chaikin PM, "Colloidal hard-sphere crystallization kinetics in microgravity and normal gravity", Appl. Optics **40**, 4146-4151 (2001).


**Media Coverage:**

- GLT Science "Uncommon Knowledge", http://wglt.org/programs/uncommon/index.phtml, Why are Colloids Important? (USA, 5 February 2007) [mp3]
- NASA ISS Payloads Newsletter (USA, September 2004) [ pdf ]
- Science@NASA (USA, 16 June 2004)
- NASA Explores (USA, 29 June 2004)

**Video:**

Inc_10_BCAT-3.wmv
Inc_10_BCAT-3_1.wmv
Inc_10_BCAT-3_2.wmv

**Web Sites:** www.bcat.grc.nasa.gov, http://exploration.grc.nasa.gov/life/bcat3_iss.html,
http://microgravity.grc.nasa.gov/life/bcat3samples.html,
http://www.deas.harvard.edu/projects/weitzlab/index.html,
http://www.physics.harvard.edu/~plu/
BCAT-3
Photographing Physics: Critical Research in Space

**One-pager:** BCAT-3-CP

**Related Payload(s):** BCAT-3 Investigations, EXPPCS

**Last Update:** 6/12/07

# Bisphosphonates

## *Bisphosphonates as a Countermeasure to Space Flight Induced Bone Loss*

**Principal Investigator(s):**
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Toshio Matsumoto, M.D., Ph.D., University of Tokushima, Kuramoto, Japan

**Contact(s):**
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Co-PI - Toshio Matsumoto

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Dr. Toshio Matsumoto
Department of Medicine and Bioregulatory Sciences
University of Tokushima Graduate School of Health Biosciences
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Tokushima 770-8503
Japan

**Payload Developer(s):** Johnson Space Center, Human Research Program, Houston, TX

**Sponsoring Agency:** National Aeronautics and Space Administration (NASA)

**Increment(s) Assigned:** 17

**Brief Research Summary (PAO):** Bisphosphonates as a Countermeasure to Space Flight Induced Bone Loss (Bisphosphonates) will determine whether bisphosphonates, in conjunction with the routine in-flight exercise program, will protect ISS crewmembers from the regional decreases in bone mineral density documented on previous ISS missions.

**Research Summary:**

- The potential for loss of bone mass is one of the most important medical concerns for long- duration manned space flight with regional losses of 1-2% per month in spite of the fact that crewmembers exercise while in space.
- Bisphosphonates are a group of medicines that block breakdown of bone and are used to treat osteoporosis and other disorders related to bone turnover.
- This study will test the effectiveness of two bisphosphonates; alendronate, taken as a pill once per week; and zoledronic acid, given by intravenous infusion with an effect lasting several months.

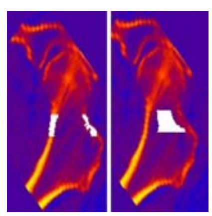
- If shown to be an effective countermeasure to space flight-induced bone loss, bisphosphonates could help prevent several bone-related problems for crewmembers on ISS and on future long-duration missions. These problems include loss of bone mineral mass and the possibility of developing renal stones during or after space flight.

**Detailed Research Description:** The purpose of this investigation is to determine whether bisphosphonates, in conjunction with the routine in-flight exercise program, will protect ISS crewmembers from the regional decreases in bone mineral density documented on previous ISS flights. Two dosing regimens will be tested: (1) an oral dose of 70 mg of alendronate taken weekly during flight and (2) an I.V. dose of zoledronic acid, 4 mg, administered just once approximately 45 days before flight. The rationale for including both alendronate and zoledronic acid is that two dosing options will: maximize crew participation, increase the countermeasure options available to flight surgeons, increase scientific opportunities, and minimize the effects of operational and logistical constraints. Operational and logistical constraints may favor one option versus the other. The purpose of this study is not to test one dosing option versus the other. Rather, the intent is to show that bisphosphonates plus exercise will have a measurable effect versus exercise alone in preventing space flight-induced bone loss.

The primary measurement objective of this study will be to obtain preflight and postflight Quantitative Computed Tomography (QCT) scans of the hip. The QCT scans will provide volumetric bone density information of both cortical and trabecular (spongy) bone regions of the hip. This study aims to show that bisphosphonates will significantly reduce bone mineral density loss documented previously on untreated ISS crewmembers.

Secondary measurement objectives will include: preflight and postflight Dual-energy X-Ray Absorptiometry (DXA) scans of the whole body, spine, hip, and heel; preflight and postflight scans of the tibia using peripheral Quantitative Computed Tomography (pQCT); preflight and postflight blood draws to measure serum markers of bone metabolism, and preflight, inflight, and postflight urine collections to measure urinary markers of bone metabolism. . Urine measurements will also be used to look at the risk for developing renal stones before, during and after flight.

**Project Type:** Payload



One mm thick sections through the mid frontal plane of the hip, showing regions of evaluation in white superimposed on a false color image of the Quantitative Computed Tomography (QCT) data. The left hand image shows the cortical region of the femoral neck and the right hand image shows the trabecular bone regions.
(click to enlarge)

**Operations Location:** ISS Inflight

**Brief Research Operations:**

- While in flight, Alendronate subjects will ingest a pill weekly.

- All subjects will conduct three urine collection sessions.

**Operational Requirements:** This experiment requires the participation of 10 long duration crewmembers. Subjects will complete DXA and pQCT Scans (L-360, L-45, R+5, R+180, and R+360, R+720, and R+1080), High Resolution QCT scans (L-45, R+5, R+360), 24-hr urine collections (L-30, L-10, R+0, R+14, R+30, R+180), and blood draws (L-100, L-30, L-10, R+0, R+14, R+30, and R+180). Alendronate subjects will complete an Alendronate Tolerance Test on L-180, and they will take Alendronate on L-17, L-10, and L-3. Zoledronic Acid subjects will be administered the bisphosphonate on L-45 and will conduct one or more additional blood draws for post-infusion health monitoring.

**Operational Protocols:** While in flight, Alendronate subjects will ingest a pill weekly. All subjects will conduct three urine collection sessions (FD 4 weeks, 12 weeks, and 24 weeks). Crewmembers will also take a daily Vitamin D supplement during the duration of the mission.

**Review Cycle Status:**PI Reviewed

**Category:** Human Research and Countermeasure Development for Exploration

**Sub-Category:** Bone and Muscle Physiology in Space

**Space Applications:** The purpose of this investigation is to determine whether bisphosphonates, in conjunction with the routine in-flight exercise program, will protect ISS crewmembers from the regional decreases in bone mineral density documented on previous ISS flights. If shown to be an effective countermeasure to space flight-induced bone loss, bisphosphonates could prevent or ameliorate several potential bone-related problems identified in NASA's Critical Path Roadmap. If bisphosphonates improve the efficiency of in-flight exercise to maintain bone mass, then more crew time could be made available to ameliorate other problem areas.

**Earth Applications:** The benefits of this research are primarily for space travelers. Knowledge gained from this investigation may generate useful information applicable to patients on Earth with accelerated bone loss due to disuse (e.g., spinal cord injury patients or those with prolonged immobilization). The timeframe required for relevant knowledge to be transferred to the medical community at large would be an estimated 4-6 years.

**Manifest Status:** Planned

**RPO:** Human Research Program - JSC (HRP-JSC)

**Previous Missions:** Bisphosphonates is a unique investigation that has not been conducted in microgravity.

**Results Status:**

**Related Publications:**

Bone HG, Hosking D, Devogelaer JP, Tucci JR, Emkey RD, Tonino RP, Rodriguez-Portales JA, Downs RW, Gupta J, Santora AC, Liberman UA. Alendronate Phase III Osteoporosis Treatment Study Group. Ten years' experience with alendronate for osteoporosis in postmenopausal women. New England Journal of Medicine. 2004 ;350(12):1189-1199.

LeBlanc A, Schneider V, Shackelford L, West S, Oganov V, Bakulin A, Voronin L. Bone Mineral and lean tissue loss after long duration spaceflight. Journal of Musculoskeletal and Neuronal Interactactions. 2000 ;1(2):157-160.

LeBlanc AD, Driscoll TB, Shackelford LC, Evans HJ, Rianon NJ, Smith SM, Feeback DL, Lai, D. Alendronate as an Effective Countermeasure to Disuse Induced Bone Loss. Journal of Musculoskeletal and Neuronal Interactions. 2002 ;2(4): 335-343.

Shapiro J, Beck TJ, Mustapha B, Ruff CB, Ballard P, BrintzenhofeSzoc K, Caminis J. Zoledronic Acid Counteracts Bone Loss in the Spinal Cord Injury Model of Microgravity. Journal of Bone Mineral Research. 2004 ;19:S445.

Watanabe Y, Ohshima H, Mizuno K, Sekiguchi C, Fukunaga M, Kohri K, Rittweger J, Felsenberg D, Matsumoto T, Nakamura T. Intravenous pamidronate prevents femoral bone loss and renal stone formation during 90-day bed rest. Journal of Bone Mineral Research. 2004 ;19(11):1771-1778.

**Web Sites:**
**One-pager:** Bisphosphonates

**Related Payload(s):** Subregional Bone

**Comments:** Updated the PAO summary to reflect the current style of the press kits. 02/21/2007 tlt.

5/29/07: Updated summary based on email from HRP. jmt

**Last Update:** 5/29/2007

# Summary Template
# ISS Program Science Database

**Acronym: DRAGONSat**

**Payload Title:** ***Dual RF Astrodynamic GPS Orbital Navigator Satellite***

**Principal Investigator(s):** David B. Kanipe, NASA/Johnson Space Center, Houston, Texas

**Co-Investigator:**
Steve Provence, Ph.D., NASA/Johnson Space Center, Houston, Texas
Tim Straube, NASA/Johnson Space Center, Houston, Texas
Helen Reed, Ph.D., Texas A&M University, College Station, Texas
Robert Bishop, Ph.D., University of Texas, Austin, Texas
Glenn Lightsey, Ph.D., University of Texas, Austin, Texas

**Contact(s):** PI – David B. Kanipe, david.b.kanipe@nasa.gov, (281) 483-4685
Primary – Steve Provence, Ph.D., robert.s.provence@nasa.gov, (281) 483-3443
Secondary – Tim Straube**,** timothy.m.straube@nasa.gov, (281) 483-7291

**Mailing Address:** 2101 NASA Parkway, Mail Code: EG, Houston, TX 77058-3696

**Payload Developer(s):**
Texas A&M University, College Station, Texas
University of Texas, Austin, Texas

**Sponsoring Agency:** National Aeronautics and Space Administration (NASA)

**Increment(s) Assigned:** 18

**Mission:** STS-127 (2J/A)

**Brief Research Summary (PAO):**
This payload consists of two pico-satellites (one built by the University of Texas and one built by Texas A&M University) and the payload launcher (SSPL). The research has two goals: 1) demonstrate Autonomous Rendezvous & Docking (AR&D) in low earth orbit and 2) gather flight data with JSC-designed DRAGON GPS receiver. AR&D is the capability of two independent spacecraft to rendezvous in orbit and dock without crew intervention. This project will ultimately demonstrate AR&D in low earth orbit and provide NASA with flight data that is directly linked to the ESAS Technology Focus Area under Avionics & Software.

**Research Summary:**
- NASA has never successfully demonstrated autonomous rendezvous and docking (AR&D) in space
- This is a low cost, low risk project designed to prove that AR&D can be performed successfully
- It will also provide invaluable flight data for the GPS receiver designed by JSC Engineering which is designed strictly for space applications

- Demonstrate precision relative navigation
- Demonstrate precision real-time navigation
- Provide orbit determination

- Since AR&D is a requirement for the Constellation Program, this research can be directly utilized by the program
- Data from this project will have a direct impact on the development of AR&D capability for the Constellation Program

**Detailed Research Description:**
The Engineering Directorate at the Johnson Space Center is responsible for the development of technologies required to conduct rendezvous and proximity operations in space as set forth in the President's Vision for Exploration. A major element of this vision is the ability for two spacecraft to autonomously rendezvous and dock (AR&D) in space. Since the United States space program has never demonstrated this capability, it is the purpose of this University Design Project for two universities - the University of Texas and Texas A&M University - to each build a satellite that will ultimately rendezvous and dock with each other in space without the benefit of human intervention.

This is anticipated to be an eight year program with a launch of the university satellites approximately every two years. Each mission builds upon the previous mission culminating in a fully autonomous rendezvous and docking mission. In addition, the universities are required to use a GPS receiver designed by JSC Engineering in order to gather flight data in the orbit environment to determine its functionality. The objective is to demonstrate precision real-time navigation capability as well as precision relative navigation between the two satellites.

The two satellites are launched together in the Space Shuttle Payload Launcher (SSPL) which is attached to the side wall of the orbiter payload bay. They are adjacent in the SSPL but when launched they will separate and begin the experiment. The data collected will be downlinked to ground stations for as long as the satellites are able to transmit.

**Project Type:** Payload

**Images and Captions:**

**Operations Location:** Sortie

**Brief Research Operations:** The two DRAGONSat spacecraft are located in the SSPL on the side wall of the orbiter payload bay. They will be ejected from the SSPL by a crewmember through a switch activation. Once a safe distance from the Space Shuttle, the two pico-satellites will separate.

**Operational Requirements:** DRAGONSat is comprised of two 5"X5"x5" satellites which are launched from the orbiter payload bay. A pico-satellite is defined as being 5"X5"x10", so each of these spacecraft is actually one half of a pico-satellite. Both satellites are composed of aluminum with a mass of approximately 7.5 kg. The surface of each pico-sat is covered with photo voltaic cells which will enable a longer active life in orbit. Each satellite also has a dipole antenna and two antennas for the GPS receiver. The satellites are ejected from the SSPL which is located on the payload bay sidewall.

**Operational Protocols:** The two satellites comprising DRAGONSat are launched together in the Space Shuttle Payload Launcher (SSPL) which is attached to the side wall of the orbiter payload bay. They are adjacent in the SSPL but when ejected, and once they are at a safe distance from the Space Shuttle, they will separate and begin the experiment. The data subsequently collected will be downlinked to ground stations for as long as the satellites are able to transmit.

**Review Cycle Status:** DoD reviewed

**Category:** Technology Development for Exploration

**Sub-Category:** Picosatellites & Control Technologies

**Space Applications:** This project will demonstrate AR&D in space and provide NASA with actual flight data that is directly linked to the ESAS Technology Focus Area under Avionics & Software. AR&D will be utilized in the Constellation Program for unmanned cargo vehicles and in-space assembly. Data from this low cost project will have a direct impact on the development of that capability.

**Earth Applications**: Student education is enhanced by engaging in a real world scenario including requirements, geographical distance, system engineering, project management, and dealing with diverse cultures. This project will also develop critical skills that will be invaluable to NASA (and contractors) in the future as the aerospaace workforce continues to mature and retire. This project also gives NASA insight into the best and brightest students.

**RPO:** Space Operations (SO)

**Previous ISS Missions:** None

**Results Summary:**

**Results Publications:**

**Related Publications:**

**Web Sites:**

**Related Payloads:** None

**Last Update:**

# Summary Template
# ISS Program Science Database

**Acronym: ENose**

**Payload Title: JPL Electronic Nose**

**Principal Investigator(s): M. A. Ryan, Ph. D., Jet Propulsion Laboratory, Pasadena, CA**

**Co-Investigator: Margie L. Homer, Ph.D., Jet Propulsion Laboratory, Pasadena, CA**

**Contact(s): PI – M. A. Ryan, <Margaret.A.Ryan@jpl.nasa.gov>, 818-354-8028**
**Primary (Instrument Manager) – Carol R. Lewis, <Carol.R.Lewis@jpl.nasa.gov>, 818-354-3767**
**Secondary (Co-Investigator) – Margie L. Homer, <Margie.L.Homer@jpl.nasa.gov>, 818-354-5114**

**Category: Technology Development for Exploration**

**Sub-Category: Environmental Monitoring on ISS**

**Mailing Address:**
**PI: M. A. Ryan, Jet Propulsion Laboratory, 4800 Oak Grove Drive, Mail Stop 184-105, Pasadena, CA 91109**
**Co-I: Margie Homer, Jet Propulsion Laboratory, 4800 Oak Grove Drive, Mail Stop 184-105, Pasadena, CA 91109**

**Payload Developer(s): Jet Propulsion Laboratory (JPL)**

**Sponsoring Agency: National Aeronautics and Space Administration (NASA)**

**Increment(s) Assigned: Start in Increment 18 (ULF2 launch), finish in Increment 19**

**Mission: N/A since payload is not manifested as a Sortie mission.**

**Brief Research Summary (PAO):**
**The JPL Electronic Nose (ENose) is a full-time, continuously operating event monitor designed to detect air contamination from spills and leaks in the crew habitat in spacecraft. It fills the long-standing gap between onboard alarms and complex analytical instruments. ENose provides rapid, early identification and quantification of atmospheric changes caused by chemical species to which it has been trained; ENose can also be used to monitor cleanup processes after a leak or a spill.**

**Research Summary:**

- **Many air quality problems are known to have occurred on numerous International Space Station (ISS), MIR and Space Shuttle flights. In most of these events, the problem chemical(s) were either never identified or were identified only after the crew had been exposed to it. These represent health and safety risks to the astronauts.**
- **No instrument currently exists on board ISS to detect and quantify chemical leaks or spills in real time; ENose is designed to help reduce risks associated with astronaut exposure to toxic or dangerous chemicals.**
- **The First Generation ENose flew on board STS-95 in 1998 and operated successfully during its six-day mission. The Second Generation ENose, a ground demonstration, successfully detected and identified 21 chemicals during extensive ground testing. The**

**Third Generation ENose, to be delivered in late 2007, will be deployed as a technology demonstration instrument on board ISS for an extended duration, six-month experiment.**

- **The JPL ENose atmospheric event monitor can provide rapid, early identification and quantification of target chemicals.**
- **Target chemical species for the ISS technology demonstration include leaks or spills of selected compounds such as organic solvents, Freon, mercury, ammonia, sulfur dioxide, and possibly marker chemicals which signal the beginnings of electrical fires.**
- **The JPL ENose can be also used to monitor cleanup processes after a spill or leak has occurred.**

**Detailed Research Description:**

**The JPL Electronic Nose (ENose) is an array-based sensing system which contains 32 conductometric sensors. The Second Generation ENose was trained to detect, identify and quantify 21 chemical species, the majority of which are organic solvents or commonly used organic compounds, which might be released through a leak or a spill in a spacecraft crew cabin. It was extensively ground-tested, and includes data analysis software which will identify and quantify the release of a target chemical within 30 minutes of detection.**

**In preparation for an upcoming, long-term (six month) technology demonstration aboard the ISS, the JPL ENose team has now developed and is building a Third Generation ENose to be delivered in late 2007. In this work, the capabilities of the original JPL ENose are being expanded. Concurrently, the processes, tools and analyses which influence all aspects of development of the device are also being expanded. Until recently, the analyte set has focused on organic compounds such as common solvents and a few selected inorganic compounds, ammonia, water and hydrazine. For the ISS technology demonstration, two inorganic species, mercury and sulfur dioxide, have now been added to the analyte set. To accommodate these inorganic species, the sensor array incorporates a hybrid sensor approach, including both new sensing materials and new sensing platforms made up of microhotplate sensor substrates. Materials approaches to these analytes have been determined using models of sensor-analyte response developed under this program. Predictive models have also been used to complement array training for additional software analyses, including chemical family identification and identification of unknown analytes. Analysis of data taken by the sensor array will be included on the ENose control computer, and event analysis will be available within 15-30 minutes of event onset.**

**The ENose event monitor, by identifying and quantifying trained-for chemical species, fills the gap between an alarm (which provides no ID or quantification) and high-end analytical instruments. ENose has demonstrated a wide dynamic range, ranging from fractional ppm to 10,000 ppm. Its array based sensing mechanism means that it can be trained to detect new chemical species, and training data can be uplinked to add new species to its on-board data library. ENose runs continuously (30 to 360 data points/hr) and autonomously; it requires only minimal crew interaction and requires no consumables. The ENose which will fly on ISS is low mass (4 kg), small volume (4 liters) and low power (15 W), in addition to being microgravity-insensitive, robust, and rugged. It is capable of analyzing volatile aerosols as well as vapors.**

**Future applications of the JPL ENose may also include environments other than the spacecraft crew cabin and similar enclosed environments. Such applications may include integration with larger devices such as analytical instruments, and with environmental monitoring and control systems.**

**Project Type: Payload**

**Images and Captions:**


**Figure 1: The Third Generation ENose and the two subsystems that comprise it: the Sensor Unit (grey component; science core), located within the Interface Unit; and the Interface Unit (white component; hardware and software connections to the ISS). The ENose is shown here in two different orientations for clarity.**

**Figure 2: ENose baseline deployment option on board ISS. ENose is shown attached via Velcro patches to an EXPRESS Rack face. Power and data cables connect the ENose to ISS EXPRESS (Expedite the Processing of Experiments to the Space Station) Rack power and Ethernet resources.**

**Operations Location: ISS Inflight; baselined for deployment on an EXPRESS Rack.**

**Brief Research Operations:**

- **Upon arrival on board ISS, ENose will be unpacked from stowage and set up by an astronaut.**
- **ENose will operate autonomously and continuously after it is deployed, connected and turned on by the crew. Once that is done, unless it needs to be moved, it will need little crew interaction.**
- **ENose will sample the cabin air continuously by pumping air through the device and data will be taken at least once every two minutes.**
- **A subset of the data will be shown on the display screen.**
- **JPL would like data to be downlinked so we can work with it during the experiment.**
- **As needed, the device can be powered off at the ISS interface unit and the entire ENose can be picked up and moved to a new location, then attached, connected and powered on again. JPL proposes that the device have a “base location", and that it be moved to one to three other locations for periods of one to three weeks during the experiment.**
- **The ENose experiment will run for at least six months.**

**Operational Requirements:**

- **Crew member sets up ENose**
    a. **Remove from stowage – ENose is launched assembled in soft stowage**
    b. **Affix to EXPRESS Rack and attach cables**
    c. **Turn on (switch) and confirm turn-on through observations**
- **ENose runs continuously for minimum of six months**
    a. **data transferred to ground in Health and Status packets and in periodic file transfer**
    b. **data archived in ENose until file transfer available (up to 30 days)**
- **Crew member performs confirmational events**
    a. **collect air sample in vicinity of ENose for later analysis on ground**
    b. **open packet such as cleaning wipe and hold in front of air intake for 60 seconds**
    c. **Periodic: 2 - 4 times per month**
- **ENose may be relocated**
    a. **Leave in one location 3 hours or more**
    b. **Not a portable device, not meant to be used as a "sniffer"**
    c. **Power-only option up to 30 days**

**Operational Protocols:**

- **Installation/Setup: Retrieve from stowage; install with bracket assembly and/or Velcro; connect power cable; connect data cable; turn power switch on.**
- **Health check: is LED illuminated? Is display working? Are air inlet and outlet not blocked?**
- **Experiment operation: Autonomous; possible occasional crew commanding; periodic status checks (once or twice per month); periodic crew attended events (if ENose detects a potential spill or leak).**
- **Maintenance: If ENose is relocated, reset the IP address.**
- **Experiment removal, for relocation or when experiment is completed: Turn power switch off, disconnect data cable, disconnect power cable, unmount.**
- **Stowage after conclusion of experiment: Place into original foam container; restow into crew transfer bag.**

**Review Cycle Status: Initial prioritization submittal for Increment 18**

**Space Applications:**

**Among the goals of NASA's Life Support and Habitation Program (LSH) is to provide new technologies that contribute to the next generation of human life support systems required for the exploration of space and to improve the habitability of future spacecraft. The Advanced Environmental Monitoring and Control (AEMC) Project of the LSH Program develops advanced technologies to monitor the physical, chemical, and microbial environments of the human compartments and life support systems of current and future spacecraft and of extravehicular activity (EVA) systems. A capability to provide more frequent monitoring than once a day is required to detect sudden releases of hazardous chemicals and marker chemicals released as a result of overheating electronics; the event monitor which fills this requirement would also be used to monitor the progress of cleanup process after a release of hazardous compounds.**

**The JPL ENose responds to this event monitoring requirement. Specifically, development of an electronic nose at JPL responds to the AEMC need to provide technology for reducing crew and equipment risk that is comparable to or better than currently available technology. The JPL ENose is designed to monitor for changes between full analyses. The 24-hour Spacecraft Maximum Allowable Concentration (SMAC) is the level of concern between complete air analyses, as 24 hours is the most frequent that full analysis is required.**

**The event monitor function filled by the JPL ENose is envisioned to be one part of a distributed system for automated monitoring and control of the breathing atmosphere in inhabited spacecraft. It is designed as an event or incident monitor, capable of providing rapid, early identification and quantification of changes in the atmosphere caused by leaks or spills of compounds to which the device has been trained. The flexibility of the device includes the ability**

to be trained to new compounds, the possibility of providing sensor sets for particular analyte suites, and a wide dynamic range (fractional ppm to 10,000 ppm), making it a valuable part of an air quality monitoring and control system that is comprised of several types of instruments. Such a system can be included in an environmental control system which actuates remediation of anomalous events.

Earth Applications: Many important and diverse earth-based applications exist for electronic nose technology. One major driver is the current need for advanced detection devices for security (both civilian and military) and health safety applications, such as the detection of explosives and infection monitoring. Furthermore, the need for biochemical detectors that are able to sense the presence of pathogens in humans and that can contribute to the early detection of diseases is high. Recently, medical applications of electronic noses have been explored. The use of a novel electronic nose to diagnose the presence of pulmonary infection, and distinguish between serum and cerebrospinal fluid, as might be encountered in exudates collected from the eye or ear, has been reported. Although this field is still in its infancy, the opportunities for developing improved biosensors are abundant. Devices based on handheld electronic nose devices may be among the key health monitoring technologies of the future. Further details are available in a number of references, for example: "Novel Materials and Applications of Electronic Noses and Tongues", Perena Gouma and Giorgio Sberveglieri, Materials Research Society Bulletin, p. 697-702, October 2004.

RPO: Human Research Program - JSC (HRP-JSC). Managed by JSC Code OB (ISS Vehicle Office)

Previous ISS Missions: None

Results Summary: Will be available after payload operations have been completed.

Results Publications: Will be available after payload operations have been completed.

Related Publications: Publications are available at the public website
< http://enose.jpl.nasa.gov/Tech_pubs.html >

Listing of representative recent ENose publications:

"Monitoring the Air Quality in a Closed Chamber with an Electronic Nose";
M.A. Ryan, M.L. Homer, M.G. Buehler, K.S. Manatt, F. Zee, and J. Graf
*Proceedings of the 27th International Conference on Environmental Systems*, Society of Automotive Engineers, (1997).

"Monitoring Space Shuttle Air for Selected Contaminants Using an Electronic Nose"
M.A. Ryan, M.L. Homer, M.G. Buehler, K.S. Manatt, B. Lau, D. Karmon and S. Jackson; *Proceedings of the 28th International Conference on Environmental Systems*, Society of Automotive Engineers, 981564 (1998).

"Results From The Space Shuttle STS-95 Electronic Nose Experiment"
M. A. Ryan, M .G. Buehler, M .L. Homer, K. S. Manatt, B. Lau, S. Jackson, and H. Zhou
Micro/NanoTechnology 99 Conference, Pasadena CA, (1999.).

"Operation of an Electronic Nose Aboard the Space Shuttle and Directions for Research for a Second Generation Device;" M. A. Ryan, M. L. Homer, H. Zhou, K. S. Manatt, V. S. Ryan and S. P. Jackson, *Proceedings of the 30th International Conference on Environmental Systems*, Society of Automotive Engineers, 00ICES-259 (2000).

"Polymer-Carbon-Composite Sensors for an Electronic Nose Air Quality Monitor;" M.A. Ryan, A.V. Shevade, H. Zhou and M.L. Homer; M.A. Ryan, A.V. Shevade, H. Zhou and M.L. Homer; *MRS Bulletin*, 29(10), 714 (2004).

**"Temperature Effects on Polymer-Carbon Composite Sensors: Evaluating the Role of Polymer Molecular Weight and Carbon Loading," M.L. Homer, J.R. Lim, K. Manatt, A. Kisor, L. Lara, A.D. Jewell, S.-P.S.Yen, H. Zhou, A.V. Shevade and M.A. Ryan, *Proceedings of IEEE Sensors Conference*, 2, 877-881 (2003).**

**"Using Temperature Effects on Polymer-Composite Sensor Arrays to Identify Analytes," M. L. Homer, J. R. Lim, K. Manatt, A. Kisor, L. Lara, A. D. Jewell, A. Shevade, S.-P. S. Yen, H. Zhou and M. A. Ryan, *Proc. IEEE Sensors Conf.*, 1, 144-147 (2003).**

**"Monitoring Space Shuttle Air Quality Using the JPL Electronic Nose," M. A. Ryan, H. Zhou, M. G. Buehler, K. S. Manatt, V. S. Mowrey, S. P. Jackson, A. K. Kisor, A. V. Shevade, and M. L. Homer, *IEEE Sensors Journal*, 4(3), 337 (2004).**

**"The Development of Temperature-Controlled Microanalytical Components for Space Exploration;" S. Semancik, R.E. Cavicchi, D.C. Meier, K.D. Benkstein, G. LI, M.A. Ryan, M.L. Homer, K. Manatt, A. Kisor and C.J. Taylor; *Proceedings of the International Meeting on Chemical Sensors-10* (2004).**

**"Expanding the Analyte Set of the JPL Electronic Nose to Include Inorganic Species;" M. A. Ryan, M. L. Homer, H. Zhou, K. Manatt, A. Manfreda, A. Kisor, A.V. Shevade, and S.P.S. Yen, *Proceedings of the 35$^{th}$ International Conference on Environmental Systems*, Society of Automotive Engineers, 2005-01-2880 (2005).**

**"Calorimetric measurements of heat of sorption in polymer films: A molecular modeling and experimental study;" A.V. Shevade, M.A. Ryan, M.L. Homer, A.K. Kisor, K.S. Manatt, B. Lin, J.-P. Fleurial, A.M. Manfreda and S.-P.S. Yen; *Analytica Chimica Acta*; 543 (1-2), 242 (2005).**

**"Nonlinear Least-Squares Based Method for Identifying and Quantifying Single and Mixed Contaminants in Air with an Electronic Nose;" Hanying Zhou, Margie L. Homer, Abhijit V. Shevade and Margaret A. Ryan; *Sensors*, 6, 1 (2006).**

**"Expanding the Capabilities of the JPL Electronic Nose for an International Space Station Technology Demonstration;" M. A. Ryan, A. V. Shevade, C. J. Taylor, M. L. Homer, A. D. Jewell, A. Kisor, K.S. Manatt, and S.P.S. Yen; M. Blanco and W. A. Goddard, III; *Proc. 36$^{th}$ International Conference on Environmental Systems* 2006-01-2179, SAE (2006).**

**"Correlating Polymer-Carbon Composite Sensor Response with Molecular Descriptors," A.V. Shevade, M.L. Homer, C.J. Taylor, H. Zhou, A.D. Jewell, K.S. Manatt, A.K. Kisor, S.P.S. Yen, and M.A. Ryan, *J. Electrochem. Soc.,* 153, H209-H216 (2006).**

**"Re-optimizing a sensor array for new target analytes;" M. L. Homer, H. Zhou, A. D. Jewell, C. J. Taylor, A. V. Shevade, A.K. Kisor, S.-P. S. Yen, B. H. Weiller and M. A. Ryan; *Proceedings of the International Meeting on Chemical Sensors-11* (2006).**

**Web Sites: http://enose.jpl.nasa.gov**

**Related Payloads: The First Generation ENose experiment flew a successful six day mission on board the Shuttle, STS-95 (1998). No related ISS payloads have flown.**

**Last Update: 5/31/2007**

**Acronym:** EPO

**Payload Title:** Education Payload Operations

**Principal Investigator(s):** Matthew Keil, Johnson Space Center, Houston, TX

**Contact(s):** PI – Matthew Keil, (281) 244-7657
Primary – Jonathan Neubauer, (281) 244-5016

**Payload Developer(s):**
Increment 4:
- Johnson Space Center, Houston, TX

Increment 5:
- Houston Museum of Natural Science, Houston, TX
- The Rice Space Institute, Rice University, Houston, TX
- Houston Independent School District, Houston, TX
- Miami University, Oxford, OH

Increments 7 - 9:
- Association of Science and Technology, Washington, DC
- Denver Museum of Nature and Science, Denver, CO
- Bishop Museum, Honolulu, HI
- St. Louis Science Center, St. Louis, MO
- Center of Science and Industry, Columbus, OH
- Maryland Science Center, Baltimore, MD
- Johnson Space Center, Houston, TX
- Canadian Space Agency, Saint-Hubert, Quebec
- Heinz, Ontario, Canada

Increments 10 - 16:
- Johnson Space Center, Houston, TX

**Increment(s) Assigned:** 4, 5, 7, 8, 9, 10, 12, 13, 14, 15, and 16

**Brief Research Summary (PAO):** Crew performs curriculum-based activities in space to demonstrate basic principles of science, math, physics, engineering, and geography. Most activities are designed to note differences between gravity and microgravity environments. Activities are videotaped and then used in classroom lectures, Internet, and to enhance existing education resources.

**Research Summary:**

- This activity uses the unique environment of human space flight to teach students about science, mathematics, technology and engineering principles in space.

- Activities help students discover how familiar objects may perform differently onboard ISS and learn ways that humans must adapt to use these objects in space.

**Detailed Research Description:** The objective of Education Payload Operations (EPO) investigation is to use toys, tools and other common items in the microgravity environment of the ISS to create educational video and multimedia products that inspire the next generation of engineers, mathematicians, physicists, and other scientists. The products are used for demonstrations and to support curriculum materials that are distributed across the United States and internationally. The individual EPO projects are designed to explore physical phenomena such as force, motion, and energy. Each ISS Expedition involves different on-orbit activities and themes, as well as different partners, such as museums, universities, and public school districts.

The EPO payloads are small, weighing less than 6.8 kg (15 lbs). When possible, the demonstrations will include hardware and objects already available on Station. Some of the activities cover physical properties, such as Newton's Laws of Motion or Bernoulli's Principle for air pressure, and others are specific to life in space, such as explaining how the ISS solar panels work or demonstrating extravehicular activities.

Increment specific activities are as follows:

- Increment 4 included demonstrations of "Weight versus Mass", "Tools in Space" and "Pouring Liquid into a Container".

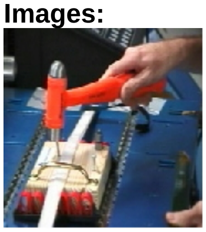
- Increment 5 focused on "International Toys", of particular interest were different ways to use the toys in microgravity.

- During Increment 9, Tomatosphere II, a project of four packets containing 1.5 million tomato seeds will be delivered to ISS. Following return from ISS on flight STS-114/LF1 the seeds will be distributed to classrooms throughout Canada. Students will measure the germination rates, growth patterns and vigor of growth of the seeds.

- Increments 7 - 14 include Education Payload Operation Demonstrations (EPO-Demos) that show students how familiar objects on Earth perform differently in microgravity and how humans adapt to use these objects in space. EDA demonstrations include activities such as, a tour of the Microgravity Science Glovebox (MSG), Extravehicular Activity (EVA)/Intravehicular Activity (IVA) Tools, Principles of Weight and Mass, and the concept of Center of Mass. Other demonstrations of operations of several items on ISS include a Blues Harp (harmonica), Bits and Pieces Puzzle and Crazy Maze, dexterity puzzles and balsa wood Wright Flyer.
- Increment 15 includes EPO-Educator, EPO-Kit C, and EPO-Demos. EPO-Educator involves 10,000,000 basil seeds that will be distributed to education facilities around the nation for science experiments and investigations. It also involves on-orbit still imagery and video. EPO-Kit C involves two plant growth chambers containing lettuce and basil seeds. A 20-day investigation will occur on-orbit including still imagery and video. Each payload is part a large ground-based education plan, including an engineering design challenge for students nationwide.

**Project Type:** Payload

**Images:**



Video screen shot of Expedition 8 Science Officer, Mike Foale, demonstrating the use of tools on ISS for an EPO event.

Video screen shot of Expedition 8 Science Officer Mike Foale uses small and large magnets to show the pull of the Earth's magnetic field on ISS for an EPO event.

Video screen shot of Expedition 9 Science Officer, Mike Fincke, demonstrating First Aid on ISS for an EPO event.

NASA Image: ISS009E15359 - Astronaut Mike Fincke holds a bag of tomato seeds for the EPO Tomatosphere II project in the SM during Expedition 9.

Video screen shot of ISS Expedition 9 Science Officer, Mike Fincke, performing the EPO Puzzles demonstration.

Video screen shot of ISS Expedition 9 Science Officer, Mike Fincke, performing the EPO Water Droplet demonstration.

**Operations Location:** ISS In-flight

**Brief Research Operations:**

- The crew will videotape demonstrations on orbit.
- The video is then used in developing education curriculum support materials for distribution to educators internationally.

**Operational Requirements:** EPO does not require power, telemetry, or specialized hardware. However, each demonstration requires several hours from at least two crew members, one of whom will operate the video equipment.

**Operational Protocols:** After setting up the demonstration, at least one crew member will perform the demonstration while another films it. Each demonstration will have its own props (e.g., toys or tools). The demonstration is then dismantled and returned to stowage. After the videos are returned to Earth, they will be used to develop teaching guides, project plans, and educational packages focusing on the physical sciences and technology.

**Review Cycle Status:** **PSO Reviewed**

**Strategic Objective:** Educating and inspiring the next generation to take the journey.

**Strategic Objective Mapping:** EPO educational outreach products meet national educational standards for scientific and technical literacy, introducing students to scientific concepts, such as Newton's First Law of Motion and centripetal force, helping them form hypotheses, and then guiding them through the process of proving or disproving their hypotheses.

**Space Applications:** EPO introduces the next generation of explorers to the environment of space.

**Earth Applications:** EPO is part of NASA's continuing effort to use space as a unique educational tool for K-12 students. Everyday items, such as toys and tools, are given a new twist by combining them with the allure of space flight and the unusual weightless environment to produce educational materials that inspire interest in science and technology and encourage curiosity and creativity.

**Manifest Status:** Ongoing

**RPO:** Space Operations

**Previous Missions:** EPO has flown on many Space Shuttle missions and ISS increments 4, 5, 7, 8, 9, 10 and 15.

**Results:** EPO has been a successful education program on ISS. Using simple objects and the microgravity environment, NASA is able to produce videos that demonstrate physical properties, such as force, motion, and energy, which may be obscured by gravity on Earth. To date many videos have been produced and distributed to schools throughout the United States.

**Results Status:** Pending More Information

**Results Publications:**
National Aeronautics and Space Administration Educational Product. International Toys in Space - Science on the Station DVD. ED-2004-06-001-JSC, 2004.

**Related Publications:**

**Web Sites:**
NASA Fact Sheet
Johnson Space Center Education and Student Programs
NASA Education Program
Central Operations of Resources for Educators (CORE)
Observatorium: Toys in Space
Tomatosphere
Engineering Design Challenge

**Related Payload(s):** ADVASC, EarthKAM, Education-SEEDS, SEM, EPO-Educator

**Last Update:** 8/13/2007

# <u>EXPRESS Rack 6</u>
## *EXpedite the PRocessing of Experiments to Space Station Rack 6*

Field Descriptions

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**Developer(s):** Marshall Space Flight Center, Huntsville, AL and Boeing, Huntsville, AL

**Sponsoring Agency:** National Aeronautics and Space Administration (NASA)

**Increment(s) Assigned:** 18 and subsequent

**Brief Facility Summary (PAO):** The EXPRESS Rack is a multiuse payload rack system that transports, stores and supports experiments aboard the International Space Station. The EXPRESS Rack system supports science payloads in any discipline by providing structural interfaces, power, data, cooling, water and other items needed to operate science experiments in space.

**Facility Summary:**

- The EXPRESS Rack provides simple standard interfaces to accommodate modular-type payloads.

- The EXPRESS Rack concept provides the capability for a simple and streamlined integration process.

**Detailed Facility Description:** With standardized hardware interfaces and streamlined approach, the EXPRESS Rack (ER) enables quick, simple integration of multiple payloads aboard the International Space Station (ISS). The system is comprised of elements that remain on ISS, as well as elements that travel back and forth between ISS and Earth via the Space Shuttle. ER's remain onorbit continually. Experiments are exchanged in and out of the ER as needed remaining on ISS for three months to several years, depending on the experiment's time requirements.

Payloads within an ER can operate independently of each other, allowing for differences in temperature, power levels and schedules. The ER provides stowage, power, data, command and control, video, water cooling, air cooling, vacuum exhaust, and nitrogen supply to payloads. Each ER is housed in an International Standard Payload Rack (ISPR), a refrigerator-size container that acts as the ER exterior shell.

Experiments contained within ERs may be controlled by the ISS crew or remotely by the Payload Rack Officer (PRO) on-duty at the Payload Operations and Integration Center at Marshall Space Flight Center in Huntsville, AL. Linked by computer to all payload racks aboard ISS, the PRO routinely checks rack integrity, temperature control and the proper working conditions of ISS research payloads.

EXPRESS Rack 6 is planned for launch on ULF2 with plans to support new science experiments along with Crew Galley hardware.

| | |
|---|---|
|  NASA Image: ISS009E06472 - EXPRESS Rack 5, in the Destiny/U.S. Laboratory, lower stowage compartments and Maintenance Work Area table during ISS Expedition 9.<br>(click to enlarge) |  NASA Image: ISS006E20960 - View of Expedite the Processing of Experiments to the Space Station (EXPRESS) Rack 5, LAB1S5 and MSS-1 in the U.S. Laboratory/Destiny during Expedition 6. Visible are the ARCTIC Supply, High Rate Frame Multiplexer, and PCS-1 on laptop computer.<br>(click to enlarge) |
| | |
| | |

**Brief Facility Operations:**

- Transported in Multi Purpose Logistics Module (MPLM) to orbit with partial subrack payload complement. Racks transferred to Destiny and installation checkout performed.

- Every increment, one ER is designated as continuously powered and remains powered for the entire increment. Other racks are powered on and off as needed by the payloads.

**Operations:** ER was developed to provide ISS accommodations for small subrack payloads. ER accepts ISS middeck locker type payloads and International Subrack Interface Standard (ISIS) Drawer payloads, allowing previously flown payloads an opportunity to transition to the International Space Station. The ER system also includes transportation racks to transport payloads to and from the ISS, Suitcase Simulators to allow a payload developer to verify ISS power and data interfaces at the development site, Functional Checkout Units to allow payload checkout at Kennedy Space Center (KSC) prior to launch, and trainer racks for the astronauts to learn how to operate the ERs prior to flight. Standard hardware and software interfaces provided by the ER simplify the analytical and physical integration processes and facilitate simpler ISS payload development. The ER has also formed the basis for the U.S. Life Sciences payload racks.

**Review Cycle Status:**

**Category:** Facilities

**Sub-Category:** Rack Facilities

**Manifest Status:** Planned ULF2

**Results Publications:**

**Related Publications:**

**Web Sites:**

**One-pager:**

**Payload(s) Supported:**

**Comments:**

**Last Update:** 06/18/07

# InSPACE-2
# Investigating the Structures of Paramagnetic Aggregates -2

**Principal Investigator(s): Dr. Eric Furst**

**Co-Investigator: Dr. Juan Agui**

**Contact(s):** PI –
Eric M. Furst
University of Delaware
Department of Chemical Engineering
Newark, DE 19716
**Phone Number:** (302) 813 0102
**Fax Number:** (302) 831 1048
**Email:** furst@che.udel.edu
Secondary **–**
Dr. Juan Agui
NASA Glenn Research Center
Research and Technology Directorate
Cleveland, Ohio 44135
Phone Number: (216- 433-5409)
Email: Juan.Agui@nasa.gov

**Category:** Human Research and Countermeasure Development for Exploration
Sub-Category**:** Bone and Muscle Physiology in Space

**Mailing Address:** above in contact info

**Payload Developer(s):** NASA Glenn Research Center and University of Delaware

**Sponsoring Agency:** NASA

**Increment(s) Assigned:** Increment 18

**Mission:**

**Brief Research Summary (PAO):** MR fluids are a class of smart materials capable of changing visco-elastic properties. Microgravity data of the internal particle structure and dynamics will provide an assessment of the viscous-elastic properties. These objectives improve limb and dextrous motion in robotic components and human-robotic interfaces for EVA suits.

**Research Summary:**

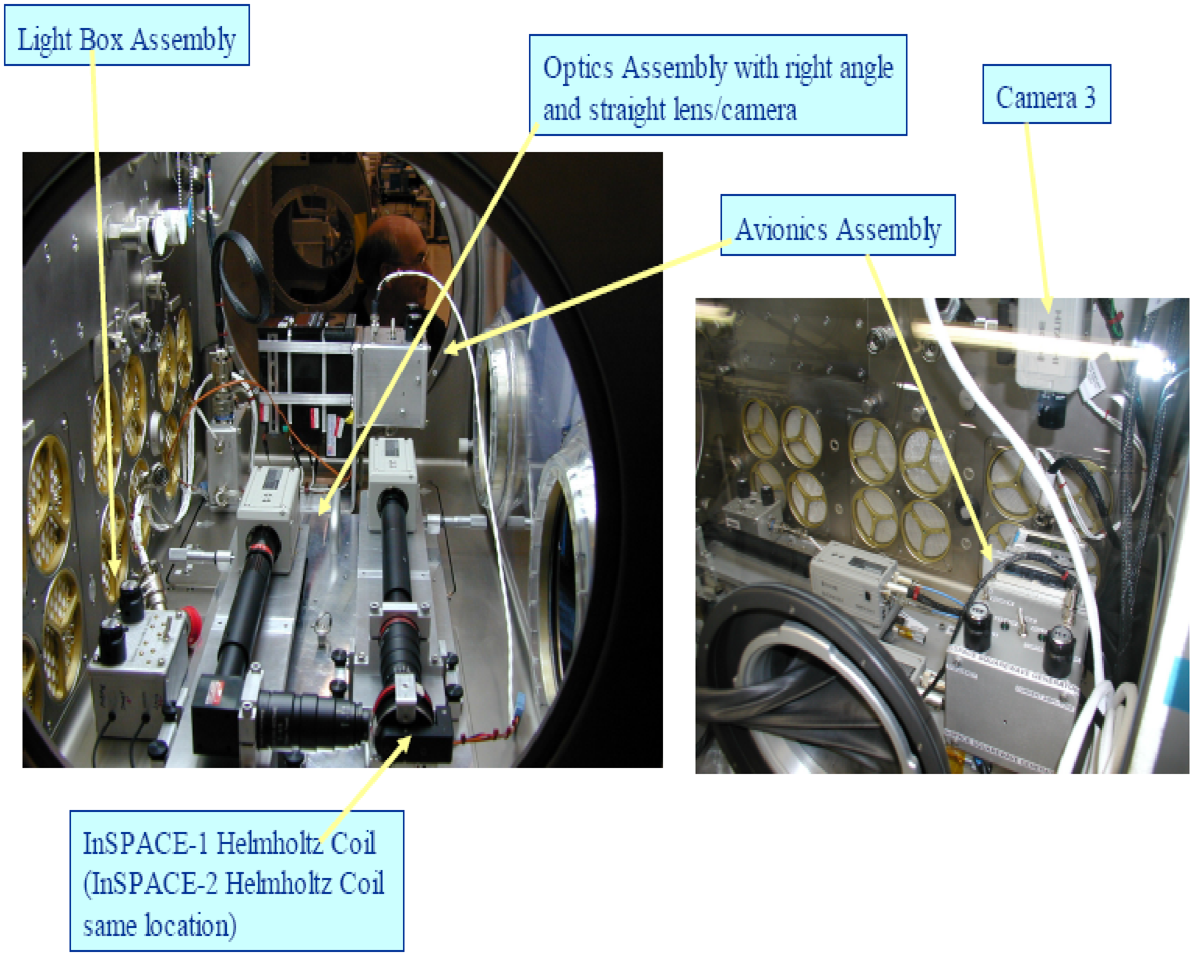
(1) To visually study the gelation transition in magneto-rheological fluids (MR) under steady and pulsed magnetic fields.
(2) Continue InSPACE-1 studies to determine the lowest energy configurations of the three dimensional structures of a magneto-rheological fluid in a pulsed magnetic field.
(3) Improved cell design allowing for multiple orientations and optically enhanced viewing of the aggregate structures increases the quality and quantity of the science data gathered.

**Detailed Research Description:**

Gravitational effects in MR fluids are manifested as variations in particle concentration and phase separation due to particle sedimentation, directly impacting rheological (visco-elastic) properties and application performance. Long duration microgravity time is needed to study the internal structural evolution in the MR fluids in the absence of these additional effects.

**Project Type:** Sub-payload

## InSPACE Hardware (in MSG)

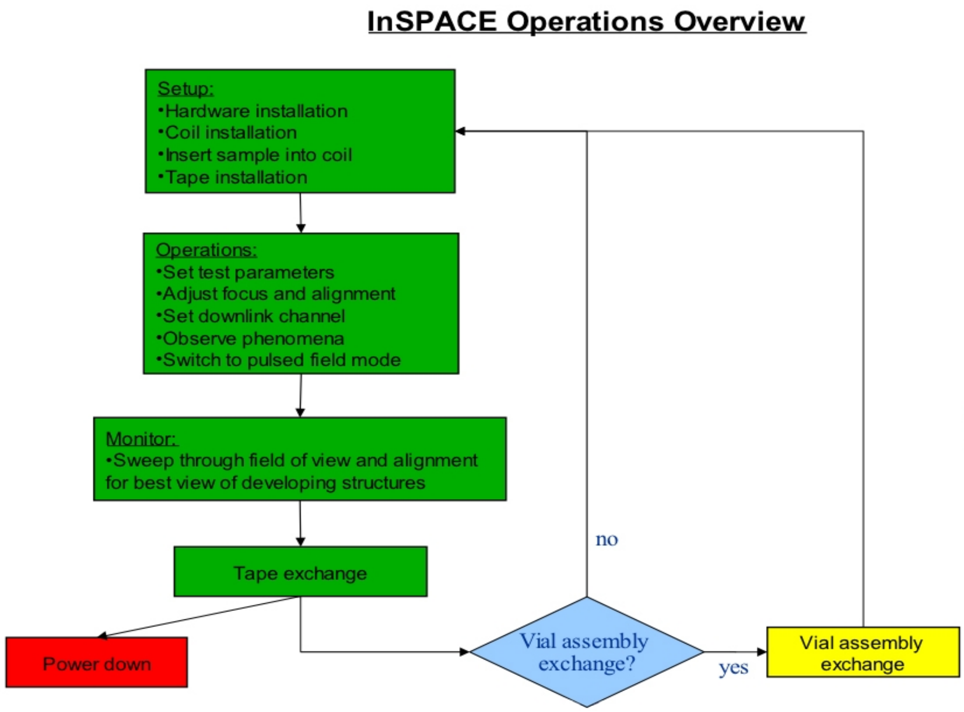





**Images and Captions:**

**Operations Location:** Microgravity Science Glovebox

**Brief Research Operations:**




**Operational Requirements**: Microgravity Science Glovebox

**Operational Protocols:**

- InSPACE is performed in the Microgravity Sciences Glovebox (MSG).
- After setting up the experiment hardware and inserting the sample cartridge the experiment is operated from Earth via ground commanding.
- Crew members must periodically change samples as well as data tapes.
- Video of MR fluids in varying magnetic fields, pulse frequency and particle size is recorded on data tapes for return to the principle investigator for analysis.

**Review Cycle Status:**

**Space Applications:** Understanding how to precisely control these properties and states will enable the use of MR fluids as a working fluid in exploration robots to produce a range of articulated motions ranging from delicate (as if picking up an egg) to firm response, and proper encapsulation pressure around bone fractures. Current robotic technology depends on conventional mechanical components (gears, dashpots, and clutches) while MR fluids interfaces can provide significantly faster response, strength, tunability, and physical flexibility to create robots more appropriate for aiding and working with humans. Versatile technologies that will help us in the development of the first Crew Exploration Vehicle, and for long term manned missions to the Moon and Mars. InSPACE is also relevant to Advanced Extra Vehicular Activity (AEVA) because of its potential for robotics and human-robotic interfaces that can assist the crew when it works on Station and on future surface operations on the Moon and Mars.

**Earth Applications:**

Automotive design engineers are investigating MR fluid in the area of driver feedback, or "feel" that is often not optimized in electric, by-wire systems. The trend in vehicle industries toward control-by-wire (steer-by-wire, shift-by-wire, throttle-by-wire, brake-by-wire, etc.) has created a requirement for highly controllable, rugged, cost-effective devices to provide realistic force-feedback sensations to the operator.
A number of groups are studying the use of MR fluids as externally activated "exoskeletons" that is, exterior materials that are flexible in the absence of a field and become rigid upon demand. Applications of these materials for the soldier include external splints for battlefield triage and exoskeletons for strength amplification for lifting, jumping and falling. One group is having success filling hollow fibers with MR fluids to meet the goals of these applications (ref Hatton, McKinley, Doyle, Institute for Soldier Nanotechnologies, MIT). These same applications and the need for materials having a high dynamic range of mechanical properties can be vital to the dev
elopment of NASA's Advanced EVA EMU's for space exploration. Current EMU limitations prevent their use on long duration EVA missions on extraterrestrial surfaces.

**RPO:** Life Support and Habitation – GRC (LSH-GRC)

**Previous ISS Missions:** InSPACE was operated on Increment 6/7

**Results Summary:**

InSPACE was performed during Increments 6, 7 and 13 in the Microgravity Science Glovebox (MSG). The final InSPACE tests were completed during ISS Increment 13. Many tests were performed for each Helmholtz coil. The collected data were used to test theoretical models of the microstructures. Furthermore, understanding the complex properties of the fluids and the interaction of the micro-particles will enable the development of more sophisticated methods for controlling and use of these fluids.

**Results Publications:**

Gast AP, Furst EM. Chain Dynamics in Magnetorheological Suspensions. Fourth Microgravity Fluid Physics and Transport Phenomena Conference, Cleveland, OH. Aug 12 - 14, 1998 .

**Web Sites:**

NASA Fact Sheet
InSPACE Research Objective

**Related Payloads:** PFMI

**Last Update: June 13, 2007**

# Field Descriptions
# ISS Program Science Database
# http://iss-science.jsc.nasa.gov

**Acronym:** Official acronym assigned to the payload.

**Payload Title:** Official name assigned to the payload.

**Principal Investigator(s):** Scientist(s) responsible for the experiment, institution affiliation and location. PI should always be listed as this person receives scientific credit for the experiment in public communications (i.e., do not list a coordinating organization or point of contact or experiment manager here). Format: John Smith, Ph.D., University, City, State

**Co-Investigator:** Individuals who are involved in the experiment. Please list name, affiliation and location. Format: Mary Smith, Ph.D., University, City, State.

**Contact(s):** Name, email address and phone number of the PI and the name, email address and phone number of the primary individual to contact in the absence of the PI.

**Category and Sub-Category:** Please select from one category and one sub-category from the following:

- Human Research and Countermeasure Development for Exploration
    - Bone and Muscle Physiology in Space
    - Cardiovascular & Respiratory Systems in Space
    - Human Behavior and Performance
    - Immune System in Space
    - Integrated Physiology Studies
    - Microbiology in the Space Environment
    - Neurological and Vestibular Systems in Space
    - Radiation Studies
- Observing the Earth and Educational Activities
    - Educational Activities
    - Observing the Earth
- Physical and Biological Sciences in Microgravity
    - Animal Biology in the Space Environment
    - Cellular Biology and Biotechnology
    - Physical Sciences
    - Plant Biology in Microgravity
    - Protein Crystal Growth
- Results from ISS Operations
    - Crewmember-Initiated Science
    - Environmental Monitoring of ISS
    - Medical Monitoring of ISS Crewmembers
- Technology Development for Exploration
    - Characterizing the Microgravity Environment on ISS
    - Environmental Monitoring on ISS
    - Picosattellites & Control Technologies
    - Spacecraft and Orbital Environments
    - Spacecraft Materials

- o Spacecraft Systems

**Mailing Address:** Mailing address for the Principle Investigator and Co-Investigators. This information will used for internal use only.

**Payload Developer(s):** NASA center, Space Agency and/or the company or institution where the investigation and hardware are developed.

**Sponsoring Agency:** Space agency responsible for launch the investigation. The options are as follows:
- Canadian Space Agency (CSA)
- European Space Agency (ESA)
- Federal Space Agency (FSA)
- Japan Aerospace Exploration Agency (JAXA)
- National Aeronautics and Space Administration (NASA)

**Increment(s) Assigned:** A list of increments that this payload has been or is scheduled to be performed.

**Mission:** This applies only if the payload was manifested as a Sortie mission. Please indicate the mission number. For Example: STS-121/ULF1.1

**Brief Research Summary (PAO):** Short, concise description of the payload (no more than 3 sentences) summarizing what is being done and why. Written for a public audience with minimal jargon.

**Research Summary:** Slightly more detailed than the PAO summary in a bulletized format to answer the following questions:
- why research is needed
- what will be accomplished
- what will be the impact

Information is available on the internal and public website, and is used to generate 1-pagers. (Shorter is better, absolutely no more than about 10 sentences, written on an 8$^{th}$ grade level).

**Detailed Research Description:** Provides a place for a more technical description of the objectives of an experiment aimed at an interdisciplinary scientific audience. May have several paragraphs as needed. May use technical terminology, but all terms should be defined or linked. This field will also include the description of hardware.

**Project Type:** Indicates type of project: Payload or Sub-payload

**Images and Captions:** Image of the investigation with a detailed caption. Image should be provided in .jpg format.

**Operations Location:** Indicates where the payload is performed: Pre/Postflight, Sortie or ISS Inflight.

**Brief Research Operations:** Brief summary of the operations used to perform activities for the payload, written in bulletized format for a general audience at and 8$^{th}$ grade level. This field becomes part of the 1-pager.

**Operational Requirements:** Defines constraints and requirements to be met to complete the experiment (numbers of subjects or observations, spacing of observations, downlink of data, return of samples, etc.). No more than 10 sentences.

**Operational Protocols:** Overview of what is done on orbit to complete the experiment so that a reader can imagine the procedure. No more than 10 sentences.

**Space Applications:** Information on how this experiment supports/benefits the space program.

**Earth Applications:** Information on how this experiment supports/benefits people on Earth.

Manifest Status:

**RPO:** Official name of organization in charge of the payload. The options are as follows:

- Applied Technology Flight Program – KSC (ATFP-KSC)
- Human Research Program – ARC (HRP-ARC)
- Human Research Program – JSC (HRP-JSC)
- Life Support and Habitation – GRC (LSH-GRC)
- Life Support and Habitation – MSFC (LSH-MSFC)
- Space Operations (SO)
- Canadian Space Agency (CSA)
- European Space Agency (ESA)
- Japan Aerospace Exploration Agency (JAXA)
- Space Operations-Italian Space Agency (SO-ASI)

**Previous Missions:** Missions that the payload was manifested on, prior to ISS, or related payloads already completed on ISS. Should include enough of a summary for understanding of the previous results and how they led by progression to this research.

**Results Summary:** Summarizes the progress of the investigation to date. Information provided only after payload operations have begun or are completed onboard ISS/Sortie. The first paragraph should summarize the number of subjects, samples or sessions completed over the number of increments performed. Following paragraphs contain an overview of information contained in 30-day Postflight reports, 1-year Postflight reports, presentations or publications. The final paragraph summarizes what the investigation means in terms of future application.

**Results Publications:** Citation listing of publications resulting from the operation of the investigation on ISS.

**Related Publications:** Citation listing of publications related to the investigation. Publications that set the stage for the planned research, including background on the topic, and publications describing the experiment preflight. Information is available on the public website.

**Web Sites:** Listing of public websites with information regarding the investigation.

**Related Payloads:** Other payloads that are currently on or have flown on ISS that have similar objectives.

**Last Update:** This field will indicate when the last update was made to the investigation information.

# Integrated Immune
## *Validation of Procedures for Monitoring Crewmember Immune Function*

**Principal Investigator(s):** Clarence Sams, Ph.D, Johnson Space Center, Houston, TX

**Co-Investigator(s):**
Brian Crucian, Ph.D., Wyle Laboratories, Houston, TX
Raymond Stowe, Ph.D., Microgen Labs, La Marque, TX
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**Collaborators:**
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**Payload Developer(s):** Johnson Space Center, Human Research Program, Houston, TX

**Sponsoring Agency:** National Aeronautics and Space Administration (NASA)

**Increment(s) Assigned:** 16, 17

**Brief Research Summary (PAO):** Validation of Procedures for Monitoring Crew Member Immune Function (Integrated Immune) will assess the clinical risks resulting from the adverse effects of space flight on the human immune system and will validate a flight-compatible immune monitoring strategy. Changes in the immune system will be monitored by collecting and analyzing blood and saliva samples from crew members during flight and blood, urine, and saliva samples before and after spaceflight.

**Research Summary:**

- There is ample post-flight evidence to suggest that spaceflight has a negative effect on the immune system however, little in-flight data has been collected. The in-flight data that exists suggests immune dysregulation occurs during flight. There are several possible causes ranging from microgravity to stress to radiation. Complications arising from an immune system dysregulation have the potential to pose a clinical risk for exploration class space missioins..

- In order to develop a countermeasures to reduce in-flight immune dysfunction, a monitoring strategy must be developed.

- The objective of this study is to validate a monitoring strategy that will allow future countermeasures to be developed.

**Detailed Research Description:** The objective of this Supplemental Medical Objective (SMO) is to develop and validate an immune monitoring strategy consistent with operational flight requirements and constraints. There are no procedures currently in place to monitor immune function or its influence on crew health. Immune dysregulation has been demonstrated to occur during spaceflight, yet precious little in-flight immune data has been generated to assess this clinical problem. This SMO assesses the clinical risks resulting from the adverse effects of space flight on the human immune system and will validate a flight-compatible immune monitoring strategy. Characterization of the clinical risk and the development of a monitoring strategy are necessary prerequisite activities prior to validating countermeasures.

Preflight, in-flight and postflight assessments will be performed. The in-flight samples will allow a distinction between legitimate in-flight alterations and the physiological stresses of landing which are believed to alter landing day assessments. The overall status of the immune system during flight (activation, deficiency, dysregulation) and the response of the immune system to specific latent virus reactivation (known to occur during space flight) will be thoroughly assessed.

Following completion of the SMO, the data will be evaluated to determine the optimal set of assays for routine monitoring of crewmember immune system function. It is intended that the determined set of relevant assays will be incorporated into the Clinical Status Evaluation (CSE) and utilized to monitor the effectiveness of human medical countermeasures related to immune function (exercise, medication, diet regulation-supplementation, immune modulators, etc.). In addition, the assays validated here will have significant benefit for the routine monitoring of crewmember's immune system status with regard to diagnosis and prognosis of immune-related disease states.

**Project Type:** Payload

The image above is the kit that contains all the items the crew will need for taking blood samples.
(click to enlarge)

Pictured here is the kit that will be used to collect the saliva samples. In the upper left of the image the rolled gaze is seen; this will be place into the mouth to absorb saliva.
(click to enlarge)

**Operations Location:** ISS In-flight

**Brief Research Operations:**

- Pre and postflight activities include collecting blood, urine and saliva samples at certain timepoints depending on whether the crewmembers are participating on short- or long-duration missions.

- Shuttle crewmembers will collect a saliva sample every other day for the duration of their mission with a blood draw occurring on the day before they land.

- ISS crewmembers will perform three sessions (early, mid and late mission) in which they will collect blood and saliva samples.

- For both Shuttle and ISS subjects, all in-flight samples are returned to the ground for analysis.

**Operational Requirements:** Preflight: Each subject performs two sessions: one at L-180 (launch minus 180) days and another at either L-10 days (Shuttle) or L-30 days (ISS). Each session consists of four liquid saliva collections (performed every other day), with the blood draw, 24-hour urine and dry book saliva sample collection occurring on the day between the 2nd and 3rd liquid saliva collection.

Postflight:

- Shuttle subjects collect:
    - a liquid saliva sample every other day from R+0 (Return plus 0) to R+14 days
    - blood and 24-hour urine samples collected on R+0 and R+14 days.
    - Dry book saliva samples are collected on R+1 and R+14 days.

- ISS subjects collect in two sessions:
    - Session one occurs at R+0 collecting four liquid saliva samples are collected every other day starting on R+0 in conjunction with a blood draw and 24 hour urine collection.
    - Session two occurs at R+ 30 days collecting four liquid saliva samples are collected (performed every other day) with a blood draw and 24-hour urine collection occurring on the day between the 2nd and 3rd liquid saliva collections.
    - Dry book saliva samples are collected on R+1 and R+ 30 days.

In-flight, only blood and saliva samples are collected for ISS and Shuttle subjects. There is no urine sample requirement for in-flight operations.

- Shuttle subjects provide a liquid saliva sample every other day for the duration of the mission such that the final sample is collected on R-1. Also dry book saliva samples are collected on Flight Day 2 and on R-1. One blood sample is collected on R-1 in conjunction with the final liquid saliva sample and 2nd dry book saliva sample.

- ISS subjects perform three sessions in-flight: early, mid and late increment. Each session consists of four liquid saliva collections (performed every other day), with a blood draw and dry book saliva sample collection occurring on the last day of the liquid saliva collections. For the late increment session, the final liquid saliva sample, the blood draw and dry book saliva sample collections occur on R-1. Blood samples are required to be returned for ground analysis within 48 hrs. of collection, therefore, the blood draws must occur in conjunction with a Shuttle or Soyuz flight to ISS.

**Operational Protocols:** Operations for this experiment consist of three types of sample collections: blood, urine and saliva. There are two types of saliva samples collected. Liquid saliva samples require the subject to soak a piece of cotton with saliva and place the cotton in a salivette bag. Dry book saliva samples are collected on filter paper bound in a small, specialized book at certain time intervals throughout the collection day. For pre- and postflight BDC only, 24-hour urine collections require the subject to collect all urine starting with the first void of the day and continuing for a full 24-hour period.

**Review Cycle Status:** PI Reviewed

**Category:** Human Research and Countermeasure Development for Exploration

**Sub-Category:** Immune System in Space

**Space Applications:** The study will result in the validation of a monitoring strategy that will allow the development of effective countermeasures, which, when implemented, will safeguard the health of the crew during long duration space missions.

**Earth Applications:** The data collected during this investigation may lead a greater understanding of how the immune system is affected by different factors from stress to the environment. This data could potentially be used to help develop new treatments and preventative measures for immune dysfunctions.

**Manifest Status:** Planned

**RPO:** Human Research Program - JSC (HRP-JSC)

**Previous Missions:** Increment 16 will be the first mission for Integrated Immune.

**Results Status:**

**Web Sites:**
International Space Station Medical Project (ISSMP)
**One-pager:** Integrated Immune

**Related Payload(s):** Epstein-Barr

**Comments:**

**Last Update:** 08/17/2006

# Journals

## *Behavioral Issues Associated with Isolation and Confinement: Review and Analysis of ISS Crew Journals*

**Principal Investigator(s):** Jack W. Stuster, Ph.D., Anacapa Sciences, Inc., Santa Barbara, CA

**Contact(s):** PI - Jack Stuster

**Mailing Address:**
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301 East Carrillo Street

**Payload Developer(s):** Johnson Space Center, Human Research Program, Houston, TX

**Sponsoring Agency:** National Aeronautics and Space Administration (NASA)

**Increment(s) Assigned:** 8, 9, 10, 11, 12, 13, 14, 15, 16

**Brief Research Summary (PAO):** Behavioral Issues Associated with Isolation and Confinement: Review and Analysis of Astronaut Journals (Journals) is studying the behavioral effects of life in isolation and confinement using surveys and journals kept by the crew. By quantifying the importance of behavioral issues to long-duration crews, the study will help NASA design equipment and procedures to allow astronauts to best cope with isolation and long-duration spaceflight.

**Research Summary:**

- Isolation and confinement on long duration space missions can affect crew health and morale, which are important factors that can influence mission success.

- This study converts behavioral and human factors data contained in journal entries into quantitative data on the importance of the various behavioral issues involved in long duration isolation and confinement.

- Systematically analyzing the content of astronaut journals will allow us to design procedures and equipment to support human performance during exploration of the Moon and Mars.

**Exploration Talking Points:** Journals, ISS Crews as Research Subjects, The Teaching From Space Project

**Detailed Research Description:** A previous content analysis of journals maintained during long-duration expeditions on Earth (e.g., to the Antarctic) provided quantitative data on which to base a rank-ordering of behavioral issues in terms of importance. Journals uses the same content evaluation techniques on journals kept by ISS crewmembers. The objective is to identify equipment, habitat, and procedural features that can help humans when adjusting to isolation and confinement while ensuring they remain effective and productive during future long-duration space flights.

While on orbit, crewmembers make journal entries at least three times a week in a personal journal. In format, their journal can be either electronic (i.e., using an ISS laptop) or paper. In addition to the journal entries, participating crewmembers complete a brief electronic questionnaire at the mid-point of their Expeditions.

Studies on Earth have shown that analyzing the content of journals and diaries is an effective means of identifying issues that are most important to the person recording his or her thoughts. The method is based on the assumption that the frequency that an issue is mentioned in a journal reflects the importance of that issue or category to the writer. The tone of each entry (positive, negative, or neutral) and phase of the Expedition are also variables of interest. Study results will lead to recommendations for the design of equipment, facilities, procedures, and training to help sustain behavioral adjustment and performance during long-duration Expeditions on ISS, or to the moon, Mars, and beyond. These studies can also assist on Earth with Antarctic missions, service on submarines, etc., anywhere humans choose to work in confinement or isolation.

**Project Type:** Payload

Crewmembers participating in Journals use laptops aboard the ISS to make entries of their thoughts for the day (NASA Image: ISS013E07975).
(click to enlarge)

The primary focus of the Journals investigation is to help NASA design equipment and procedures to allow astronauts to best cope with isolation during long-duration exploration (NASA Image: ISS015E10579).
(click to enlarge)

The primary focus of the Journals investigation is to help NASA design equipment and procedures to allow astronauts to best cope with isolation during long-duration exploration (NASA Image: ISS013E05853).
(click to enlarge)

**Operations Location:** ISS Inflight

**Brief Research Operations:**

- Crewmembers complete a journal (electronic or paper) with their thoughts and experiences for 15 minutes at least three times a week.

- A questionnaire is also completed prior to launch, midway through the expedition and several days following return to Earth.

**Operational Requirements:** While on orbit, crewmembers will make journal entries at least 3 times per week in a personal journal. The journal will be downlinked to the PI on the last Monday of each month and one final time at the end of the increment via encrypted transmission. A total of ten crewmembers are needed as subjects in the Journals investigation.

**Operational Protocols:** The journal can either be electronic (e.g. using a laptop) or it can be a paper journal (e.g. using a Green Record Book). In addition to the journal entries, the crewmembers will also complete a very brief questionnaire at the mid-point of their expeditions. The questionnaire only exists in an electronic form.

**Review Cycle Status** PI Reviewed

**Category:** Human Research and Countermeasure Development for Exploration

**Sub-Category:** Human Behavior and Performance

**Space Applications:** Studies conducted on Earth have shown that analyzing the content of journals and diaries is an effective method for identifying the issues that are most important to a person. The method is based on the reasonable assumption that the frequency that an issue or category of issues is mentioned in a journal reflects the importance of that issue or category to the writer. The tone of each entry (positive, negative, or neutral) and phase of the expedition also are variables of interest. Study results will lead to recommendations for the design of equipment, facilities, procedures, and training to help sustain behavioral adjustment and performance during long-duration space expeditions to the ISS, Moon, Mars, and beyond.

**Earth Applications:** Results from this study could help to improve the behavioral performance of people living and working under similar isolated conditions here on Earth.

**Manifest Status:** Ongoing

**RPO:** Human Research Program - JSC (HRP-JSC)

**Previous Missions:** Journals have been performed continuously on ISS since Expedition 8.

**Results:** Data collection is ongoing, and the results will be analyzed when all of the journals are available.

**Results Status:** Pending More Information

**30-Day Post Flight Report(s):**

- Exp_11_Journals_30-Day_Postflight_Report.pdf
- Exp_13_Journals_30-Day_Postflight_Report.pdf
- Exp_8_HLS_Summary_30-Day_Postflight_Report.pdf
- Exp_8_Journals_30-Day_Postflight_Report.pdf
- Exp_9_Journals_30-Day_Postflight_Report.pdf

**Web Sites:**
International Space Station Medical Project (ISSMP)
Bold Endeavors: Lessons from Polar and Space Exploration
Anacapa Sciences, Inc.
CNN.com - Scientist snoops in astronauts' journals
**One-pager:** Journals

**Related Payload(s):** Interactions

**Comments:** PAO summary was updated to reflect the updated information in the 13A PAO Package. 01/23/2007 - tlt

**Last Update:** 01/23/2007

# LOCAD-PTS
## *Lab-on-a-Chip Application Development-Portable Test System*

**Principal Investigator(s):** Norman R. Wainwright, Ph.D., Charles River Endosafe, Charleston SC

**Co-Investigator(s):** Jake Maule, Ph.D., Carnegie Institution of Washington, Washington, DC

**Payload Developer(s):**
Marshall Space Flight Center, Huntsville, AL
Charles River Endosafe, Charleston, SC

**Sponsoring Agency:** National Aeronautics and Space Administration (NASA)

**Increment(s) Assigned:** 14, 15, 16, 17, 18

**Brief Research Summary (PAO):** LOCAD-PTS is a handheld device for rapid detection of biological and chemical substances onboard the International Space Station (ISS). Astronauts will swab surfaces within the cabin, dispense the collected sample into the LOCAD-PTS and obtain results on a display screen within 15 minutes.

**Research Summary:**

- LOCAD-PTS is a handheld device for rapid detection of biological onboard the International Space Station (ISS).
- LOCAD-PTS analysis is immediate. Effectively providing an early warning system to enable crew to take remedial measures if necessary to protect themselves on board ISS.
- Current testing focuses on detecting bacteria and fungi. Other sample cartridges can be developed to detect chemical substances of concern to crew safety on ISS (hydrazine, ammonia, etc.) and proteins in urine, saliva and blood for aiding medical diagnoses.

**Detailed Research Description:** The Lab-on-a-Chip Application Development – Portable Test System (LOCAD-PTS) is a handheld device, enabling crew to perform complex laboratory tests on a thumb-sized cartridge with a press of a button. Every thumb-sized plastic cartridge has 4 channels and each channel contains a dried extract of horseshoe crab blood cells and colorless dye. In the presence of bacteria and fungi, the dried extract reacts strongly to turn the dye a green color. Therefore, the more green dye, the more microorganisms there are in the original sample.

Tests by LOCAD-PTS will become increasingly specific with the advent of new cartridges. Current cartridges target bacteria and fungi. New cartridges, to be launched on subsequent flights, will target bacteria only, then groups of bacteria and eventually individual species or strains that pose a specific risk to crew health. Cartridges can also be adapted to detect chemical substances of concern to crew safety on ISS (e.g. hydrazine, ammonia and certain acids) and proteins in urine, saliva and blood of astronauts to provide added information for medical diagnosis. A phrase that summarizes this mode of operation is “same instrument, just change the cartridge”.

**Project Type:** Payload

The LOCAD-PTS Reader, cartridge (below Reader) and swabbing unit (to the right). These three components are all that is required to collect a surface sample, dissolve and analyze it to obtain quantitative levels of LPS and beta-1, 3-glucan (with a sensitivity of a single bacterial cell per milliliter).
(click to enlarge)

Operation of LOCAD-PTS swabbing unit during simulated surface extravehicular activity (EVA) at Meteor Crater, Arizona, as part of NASA's Desert Research and Technology Study (RATS) in September 2005. It has been proposed that future versions of the LOCAD-PTS be used outside the spacecraft during lunar expeditions in 2018 and beyond to monitor biological contamination of the surface associated with human activities. Understanding how we bio-contaminate planetary surfaces will be essential when we prepare human expeditions to search for life on Mars.
(click to enlarge)

LOCAD-PTS project scientist Dr. Jake Maule from Carnegie Institution of Washington, DC (left) and principal investigator Dr. Norm Wainwright from Charles River Labs (right) test the LOCAD-PTS in zero-g during parabolic flight of NASA's DC-9 aircraft in April 2006. Every aspect of LOCAD-PTS procedures, especially the fluid handling tests, were thoroughly evaluated in a zero-g environment before flight to ISS.
(click to enlarge)

LOCAD-PTS project scientist Dr. Jake Maule hikes into the active Crater of Mutnovsky volcano in Kamchatka, Russia, with the LOCAD PTS during a NASA Astrobiology Institute (NAI) expedition in 2004. Many interesting forms of microbial life exist in such extreme environments, but when removed from their ambient conditions many die during transport to the laboratory. LOCAD-PTS eliminates this problem by enabling researchers to analyze samples on-site, immediately after sample collection. LOCAD-PTS will return to Kamchatka in September 2006, when Dr. Maule will lead a joint NAI/Russian expedition to Klyuchevsky volcano, one of the most active volcanoes in the world.
(click to enlarge)

Dr. Andrew Steele and LOCAD-PTS project scientist Dr. Jake Maule of the Carnegie Institution of Washington analyze ice samples with LOCAD PTS at the peak of Sverefjell volcano in Spitsbergen, Arctic, during the NASA-funded Arctic Mars Analog Svalbard Expedition (AMASE) in 2004. Both will return to this site in August 2006, this time with new LOCAD-PTS cartridges for the detection of protein as well as lipid molecules.
(click to enlarge)

Dr. Lisa Monaco examines a microfluidic chip. This chip can be thought of as the 'next generation' of LOCAD-PTS cartridge. It is miniaturized even further to allow many more tests to be completed simultaneously. This will save crew time and allow more sophisticated types of analyses to be performed, ranging from medical tests to monitoring potentially hazardous chemicals onboard.
(click to enlarge)

**Operations Location:** ISS Inflight

**Brief Research Operations:**

- A specialized swabbing unit will be used to sample microorganisms that exist on ISS surfaces. The swabbing unit will then dissolve the sample in ultra-clean water, mix and dispense the liquid sample into a cartridge where it will react with a formulation that turns green in the presence of most microorganisms.

- This green color is measured by the LOCAD-PTS reader and is proportional to the amount of microorganisms present. The entire procedure, from sampling to results, takes 5-10 minutes.

**Operational Requirements:** The LOCAD-PTS will be located and operated in the pressurized volume on ISS. The unit will interface to an ISS laptop for power. A swabbing unit has been designed for sampling surfaces, dissolving the sample with water, and delivering precise volumes of sample to the LOCAD-PTS cartridge for analysis. Crew members will use this device to swab various surfaces on board ISS in two phases. In Phase I, the LOCAD-PTS will be used to establish operational correlation between the output from the LOCAD-PTS Reader and culture growth (as determined with agar-based media slides) for various sites in the crew environment. In Phase II of the investigation, PTS results will be compared to the data obtained from the established culture-dependent protocol used for periodic microbial monitoring on the ISS. Results from the analyses will be digitally recorded and downloaded from ISS to ground. No sample return is necessary.

**Operational Protocols:** Microorganisms at various sites on the ISS (e.g. panels and air vents) will be sampled with the swabbing unit, dissolved with water and then dispensed into the LOCAD-PTS cartridge (previously inserted into the LOCAD-PTS Reader). Once the crew has dispensed the sample into the inserted cartridge, pumps in the Reader will draw the dissolved sample into the cartridge where a reaction will take place that produces a green dye in the presence of most microorganisms. The LOCAD-PTS Reader will then measure the absorbance intensity of this green color, compare it with an in-built calibration curve and then display on the screen a quantitative value of -1,3-glucan (collectively also known as endotoxin)βlipopolysaccharide (LPS)/ ranging from 5 to 0.05 endotoxin units (EU)/ml. The sensitivity limit of 0.05 EU/ml correlates to a few bacterial cells per ml. After test completion, the cartridge is removed from the Reader and discarded. If media slides have been used during procedures (such as in Phase I), they will be incubated for 3 days and then photographed, with the images down-linked to ground.

**Review Cycle Status:** PI Reviewed

**Category:** Human Research and Countermeasure Development for Exploration

**Sub-Category:** Microbiology in the Space Environment

**Space Applications:** This commercial, off-the-shelf technology will help assess the applicability of this technology in many areas relative to microbial detection, crew health diagnostics, and environmental monitoring. The drastic reduction in time for detection (minutes versus days) will provide a capability on ISS that does not currently exist and may help risk mitigation in the event that some type of microbial build-up is observed. Eventually, it is planned that LOCAD-PTS be used to assess water, air, and food supplies in addition to surfaces. Other cartridges are being developed to perform limited crew health diagnostics, monitor other biological molecules such as protein and peptidoglycan, and specific chemicals of potential hazard to the crew e.g. hydrazine and ammonia.

**Earth Applications:** Currently, the technology is being used to assess fluids used in pharmaceutical processing. The technology has been used to swab the Mars Exploration Rovers (MER), for planetary protection, and to assess microbial contamination in the NEEMO (NASA Extreme Environment Mission Operations) project. This technology will provide quick medical diagnostics in clinical applications. It will also provide environmental testing capabilities that may serve homeland security.

**Manifest Status:** Planned

**RPO:** Life Support and Habitation - MSFC (LSH-MSFC)

**Previous Missions:** LOCAD-PTS is a new investigation for space research.

**Web Sites:**
LOCAD-PTS
NASA Article
**One-pager:** LOCAD-PTS

**Last Update:** 6/18/07

Acronym: MAMS

Payload Title: Microgravity Acceleration Measurement System

Principal Investigator: Not Applicable

**Project Manager:** Robert Hawersaat, Glenn Research Center, Cleveland, OH

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

**Sponsoring Agency:** National Aeronautics and Space Agency (NASA)

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

**Brief Research Summary (PAO):** This 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 space station 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.

**Exploration Talking Points:** The Teaching From Space Project

**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

NASA Image: ISS003E6010 - Culbertson poses with MAMS hardware in the U.S. Laboratory during Expedition Three.
(click to enlarge)

**Operations Location:** ISS Inflight

**Brief Research Operations:**

- Activation/deactivation as necessary. Crew interface: move hardware to alternate application locations when the microgravity environment for other payloads need to be measured. Filter cleaning/change out as required.

**Operational Requirements:** Crew time is 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 for Exploration

**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:** Reserve Operations

**RPO:** Life Support and Habitation - GRC (LSH-GRC)

**Previous Missions:** None

**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.

**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.

**30-Day Post Flight Report(s):**

- Exp_2_MAMS&SAMS_30-Day_Postflight_Report.pdf
- Exp_3_MAMS&SAMS_30-Day_Postflight_Report.pdf
- Exp_5-6_MAMS&SAMS_30-Day_Postflight_Report.pdf

**Web Sites:**

PIMS

NASA Fact Sheet

NASA Glenn Research Center - MAMS

**One-pager:** MAMS

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

**Last Update:** 06/08/2007

# Summary Template
# ISS Program Science Database

**Acronym: MDCA/FLEX**

**Payload Title: Multi-User Droplet Combustion Apparatus/Flame Extinguishment Experiment**

**Principal Investigator(s):**
Forman A. Williams, University of California, San Diego

**Co-Investigator:**
Michael Hicks, NASA Glenn Research Center
Vedha Nayagam, National Center for Space Exploration Research
Mun Y. Choi, Drexel University
Frederick L. Dryer, Princeton University
Benjamin D. Shaw, University of California, Davis

**Contact(s):** PI –
Primary – Michael Hicks/216-433-6576/ Michael.C.Hicks@nasa.gov
Secondary – Vedha Nayagam/216-433-8702/ vedha.nayagam-1@nasa.gov

**Payload Developer(s):**
NASA Glenn Research Center & ZIN Technologies

**Sponsoring Agency:**
NASA

**Increment(s) Assigned:**
18 & 19

**Brief Research Summary (PAO):**
The FLEX experiment utilizes the spherically-symmetric geometry of droplet combustion as a model environment for quantifying the efficacy of gaseous suppressants. The first and main element is a flight experiment that will provide detailed experimental data over a range of independent variables relevant to fire suppression. The second element uses the data from the experiment to develop, refine and validate predictive numerical codes. These codes will in turn be used to develop sub-models of chemistry, radiation and transport for inclusion in more practical models of fire suppression. The third element of the proposed project is a comprehensive groundbased program that includes normal and reduced gravity testing to refine and optimize the test matrix for the flight experiment, and also to obtain benchmark droplet combustion data at a small subset (smaller length and time scales) of the relevant environments.

**Research Summary:**

The combustion and extinction characteristics of liquid fuel droplets in microgravity are determined by the complex interaction of fuel vapor and oxidizer transport, fuel vaporization, conductive, convective and radiative heat loss and chemical kinetics. All of these phenomena are critical in real fire scenarios and thus in understanding the complex issues involved in the design of an effective fire suppression system. The simplicity of the droplet geometry lends itself to detailed theoretical and numerical studies. By comparing the results of the experiments to these detailed treatments it is possible, with today's computational resources, to develop validated chemical kinetic and heat and mass transport mechanisms for liquid fuels. From these fundamental mechanisms it becomes possible to develop validated, predictive, reduced-scale mechanisms that are appropriate for modeling real fire suppression scenarios aboard future spacecraft. The FLEX program, when integrated with the rest of the ground-based and possible flight fire suppression program will yield both a quantitative measure of the effectiveness of various suppression agents and more importantly a set of predictive tools that will allow the effective, efficient design of future spacecraft fire suppression systems.

From a practical perspective, the droplet geometry is again ideally suited for fire suppression studies aboard ISS. With the burning droplet, it is relatively easy to construct the diagram in Fig. 1. For solid fuel studies, construction of this diagram typically requires many tests to determine the branches of the curve, essentially iterating between the flammable and non-flammable regions to define a single point on the curve. The droplet, however, intrinsically moves from the flammable region to the non-flammable region which means that each test defines a point on the curve. Furthermore, the design of the droplet combustion insert in the CIR allows for the conduct of a large range of droplet combustion experiments, orders of magnitude more than in solid surface experiments. This allows validation of physical and chemical kinetic mechanisms over a much larger range of ambient conditions, thus improving the predictive capability of the detailed and reduced mechanisms.

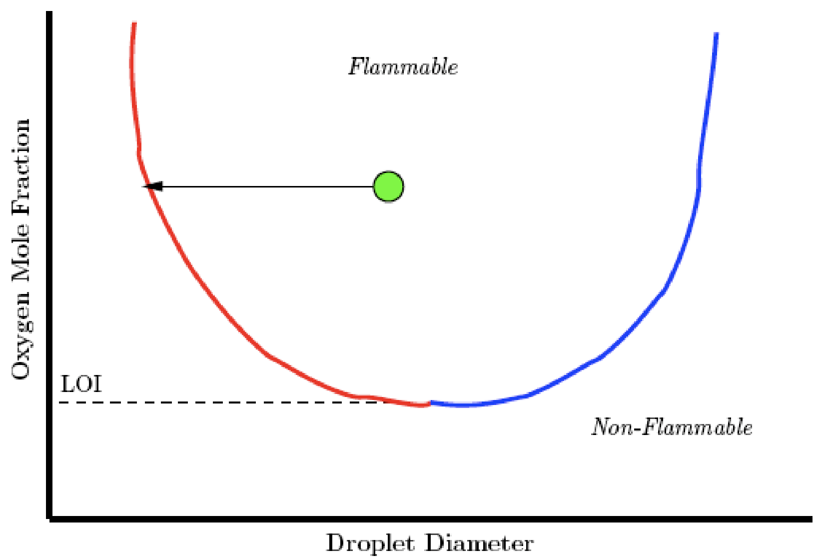



Figure 1: A conceptual flammability map for a single droplet burning in an infinite ambient. The red curve represents the extinction caused by 'blowoff' of the flame (Law, 1975), while the blue curve represents the radiative extinction branch (Chao et al., 1990). The Limiting Oxygen Index (LOI) is the lowest oxygen concentration which will support combustion.

**Detailed Research Description:**

The specific objectives of the program (flight and ground-based) are:
1. Map the flammability boundaries for liquid fuel combustion in reduced gravity.
2. Quantify the suppressant efficacy of various gaseous suppressants over the range of candidate atmospheric pressures and $O_2$ concentrations.
3. Develop predictive theoretical/numerical codes and chemical kinetic schemes to model flammability boundaries as a function effective gravitational acceleration on the unique ambient conditions encountered in space exploration applications.
The development and validation of these model will require detailed spatially and temporally resolved measurements of droplet burning rate, flame extinction, flame radiation, soot concentration, soot temperature, etc.
4. Develop improved and validated reduced (simplified) theoretical/numerical sub-models of important physical processes (chemical kinetics, radiation, soot formation/destruction) that can be used in simulations of large scale, 'realistic' fires.

Independent Experiment Variables:

**Oxygen Mole Fraction**: The ambient oxygen mole fraction in a typical space environment can vary from high concentrations in EVA pre-breathing environments down to that typically found in air. At high oxygen concentrations, however, the chemical times are small enough (relative to the characteristic flow times) such that the droplets will burn to completion rather than exhibiting flame extinction. Therefore, it is also necessary to study low oxygen concentrations, down to the Limiting Oxygen Index (LOI). It is also important to determine the LOI in order to verify the chemical mechanisms. The oxygen mole fractions in the present study will vary from 0.10 to 0.50. The chamber must also be large enough such that there is no significant decrease in ambient oxygen mole fraction during an experiment (i.e. the droplet burns in an essentially constant ambient).

**Diluent (non-suppressant)**: The ambient mixture will consist of oxygen mixed with a suppressant and the balance of an inert diluent gas. The diluent gas for these studies will be primarily $N_2$ since that is the typical diluent on earth and expected in space. There will be a small number of tests with a He diluent gas. The reason is primarily for baseline comparisons with the Droplet Combustion Experiment, which used He as the diluent gas and also to vary the physical properties of the diluent gas.

**Suppressant Type**: The tests will examine candidate gaseous suppressants that have widely varying physical, chemical and radiative properties. This will enable model and sub-model development and validation over a wide range of ambient conditions to improve the predictive capabilities of the models. The suppressants are $CO_2$ and He . The expected concentrations range from 0.00 mole fraction to the limit where no flame can exist (0.70 expected for the least active suppressant).

**Pressure:** Ambient pressure does not significantly influence the droplet burning rate, but does influence chemistry at sufficiently low values. In addition, one strategy for extinguishing a fire is to isolate the habitat where it exists and vent the cabin to space. It is therefore beneficial to have verified suppressant data at low pressures. The pressure for the tests will range from 0.5 to 1.0 atm. As with the oxygen mole fraction, it is important that the test chamber be sufficiently large so that the pressure is essentially constant during an experiment (i.e. the droplet burns in a constant pressure ambient).

**Fuel Type**: The advantage of the droplet geometry is that the fuel is relatively simple and better characterized than typical fuels in fire safety studies (e.g. PMMA or paper). This is also a disadvantage since it does not represent a practical fuel. The study will use two typical hydrocarbon fuels, an alcohol, methanol ($CH_3OH$ ) and an alkane, heptane ($C_7H_{16}$ ). There is a relatively large experience base with these fuels. $CH_3OH$ has a fuel-bound oxygen atom, and burns with a very dim blue flame (not much soot production) with a small standoff distance, so it has widely different radiative characteristics than $C_7H_{16}$ . Therefore, studying these two fuels gives a wide range of fire scenarios to verify model and sub-model performance over.

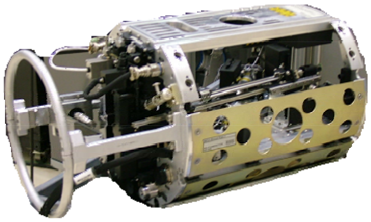
**Droplet Diameter**: Figure 1 shows the hypothetical flammability map, and diagrams how a droplet combustion experiment is conducted. The droplet is ignited in the flammable region and then burns in a constant oxygen mole fraction ambient until flame extinction. Under the assumption of quasisteady burning, the initial droplet size should not significantly influence the determination of the extinction droplet size. Transient influences, however, will be present, so some variation in initial droplet diameter is necessary to determine the deviation from quasi-steady behavior. The initial droplet size in the proposed study will vary between 2 and 5 mm.

**Project Type:**

Physical Sciences

**Images and Captions:**

Image of a burning droplet from the Droplet Combustion Experiment



Multi-User droplet Combustion Apparatus (MDCA) Chamber Insert Assembly (CIA)

**Operations Location:**

This experiment will be operated in the Combustion Integrated Rack inside the US Lab

**Brief Research Operations:**

5.1.7 Operational Requirements

The chamber shall be filled with the appropriate atmosphere, which depending on the test point, will vary in pressure from 0.5 atm to 3.0 atm, will vary in $O_2$ concentration from 0.1 to 0.4 mole fraction, and will vary in suppressant concentration from 0 to 0.7 mole fraction. A settling time of approximately 2 minutes will elapse prior to initiating the test in order to ensure that the temperature and pressure of the chamber gases have stabilized. This settling time will be followed by the dispensing of a predetermined amount of fuel (based on the target droplet size) onto the support fiber. When sufficient fuel has been dispensed the dispensing needles will be retracted and a dwell period of at least 10 seconds will be allowed for the droplet internal fluid motion induced by deployment to subside. This will then be followed by initiating power to the igniter for a selectable amount of time ranging from 1 seconds to 5 seconds after which the igniter will be retracted from the field of view. If the flow field is to be generated by translating the droplet then droplet motion

would commence at the same time that the igniter is retracted. A "near real-time" download of the color camera video will be required in order to verify successful droplet deployment, ignition, and overall progress of the experiment. Pressure and temperature data of the chamber environment will also be required in "near real time".

Gas stabilization time: allow at least 2 minutes after filling chamber to ensure that the chamber gas temperature and pressure has stabilized.

Droplet dwell time: at least 10 seconds to ensure all droplet motion imparted by droplet deployment and needle retraction has subsided.

Real time downlink: a 'near real time' downlink of the color camera video and the chamber gas, pressure and temperature shall be provided.

Chamber Purity: fuel vapor mole fraction of $< 0.005$ in the atmosphere for tests without $CO_2$ ; $<$ 0.02 mole fraction (each species) of CO, $CO_2$ and other products.

**Operational Requirements:**

| | |
|---|---|
| Accommodation (carrier) | Combustion Integrated Rack |
| Upmass (kg)<br>(w/o packing factor) | 254 kg |
| Volume ($m^3$)<br>(w/o packing factor) | 0.48 $m^3$ |
| Power (kw)<br>(peak) | 0.73 Kw |
| Crew Time (hrs)<br>- Initial configuration of CIR Rack<br>- Change-outs during experiment | <br>8.5 hrs<br>8.3 hrs |
| Launch/Increment | ULF-2/Increment 18/19 |

**Previous ISS Missions:**

The present project builds on extensive ground-based droplet combustion experiments conducted in the drop-towers at NASA Glenn Research Center as a part of the previously planned flight experiments (DCE-2, BCDCE, SDCE, and DDCE) as well as three flight experiments conducted onboard the space shuttle, namely FSDC (Fiber Supported Droplet Combustion Experiment), DCE (Droplet Combustion Experiment), and FSDC-2. Though these experiments were primarily focused on the fundamental aspects of droplet combustion, the fundamentals addressed by these experiments are essential to the fundamentals that impact fire sensing and suppression technologies applicable to space exploration environments. In the following, the relevance of these experiments to the proposed effort is described briefly.

**Results Summary:**

**Results Publications:**

**Related Publications:**

**Web Sites:**

**Related Payloads:**

**Last Update:**

# Field Descriptions
# ISS Program Science Database
http://iss-science.jsc.nasa.gov

**Acronym:** Official acronym assigned to the payload.

**Payload Title:** Official name assigned to the payload.

**Principal Investigator(s):** Scientist(s) responsible for the experiment, institution affiliation and location. PI should always be listed as this person receives scientific credit for the experiment in public communications (i.e., do not list a coordinating organization or point of contact or experiment manager here). Format: John Smith, Ph.D., University, City, State

**Co-Investigator:** Individuals who are involved in the experiment. Please list name, affiliation and location. Format: Mary Smith, Ph.D., University, City, State.

**Contact(s):** Name, email address and phone number of the PI and the name, email address and phone number of the primary individual to contact in the absence of the PI.

**Category and Sub-Category:** Please select from one category and one sub-category from the following:

- Human Research and Countermeasure Development for Exploration
    - Bone and Muscle Physiology in Space
    - Cardiovascular & Respiratory Systems in Space
    - Human Behavior and Performance
    - Immune System in Space
    - Integrated Physiology Studies
    - Microbiology in the Space Environment
    - Neurological and Vestibular Systems in Space
    - Radiation Studies
- Observing the Earth and Educational Activities
    - Educational Activities
    - Observing the Earth
- Physical and Biological Sciences in Microgravity
    - Animal Biology in the Space Environment
    - Cellular Biology and Biotechnology
    - Physical Sciences
    - Plant Biology in Microgravity
    - Protein Crystal Growth
- Results from ISS Operations
    - Crewmember-Initiated Science
    - Environmental Monitoring of ISS
    - Medical Monitoring of ISS Crewmembers
- Technology Development for Exploration
    - Characterizing the Microgravity Environment on ISS
    - Environmental Monitoring on ISS

- Picosattellites & Control Technologies
- Spacecraft and Orbital Environments
- Spacecraft Materials
- Spacecraft Systems

**Mailing Address:** Mailing address for the Principle Investigator and Co-Investigators. This information will used for internal use only.

**Payload Developer(s):** NASA center, Space Agency and/or the company or institution where the investigation and hardware are developed.

**Sponsoring Agency:** Space agency responsible for launch the investigation. The options are as follows:

- Canadian Space Agency (CSA)
- European Space Agency (ESA)
- Federal Space Agency (FSA)
- Japan Aerospace Exploration Agency (JAXA)
- National Aeronautics and Space Administration (NASA)

**Increment(s) Assigned:** A list of increments that this payload has been or is scheduled to be performed.

**Mission:** This applies only if the payload was manifested as a Sortie mission. Please indicate the mission number. For Example: STS-121/ULF1.1

**Brief Research Summary (PAO):** Short, concise description of the payload (no more than 3 sentences) summarizing what is being done and why. Written for a public audience with minimal jargon.

**Research Summary:** Slightly more detailed than the PAO summary in a bulletized format to answer the following questions:

- why research is needed
- what will be accomplished
- what will be the impact

Information is available on the internal and public website, and is used to generate 1-pagers. (Shorter is better, absolutely no more than about 10 sentences, written on an 8$^{th}$ grade level).

**Detailed Research Description:** Provides a place for a more technical description of the objectives of an experiment aimed at an interdisciplinary scientific audience. May have several paragraphs as needed. May use technical terminology, but all terms should be defined or linked. This field will also include the description of hardware.

**Project Type:** Indicates type of project: Payload or Sub-payload

**Images and Captions:** Image of the investigation with a detailed caption. Image should be provided in .jpg format.

**Operations Location:** Indicates where the payload is performed: Pre/Postflight, Sortie or ISS Inflight.

**Brief Research Operations:** Brief summary of the operations used to perform activities for the payload, written in bulletized format for a general audience at and 8$^{th}$ grade level. This field becomes part of the 1-pager.

**Operational Requirements:** Defines constraints and requirements to be met to complete the experiment (numbers of subjects or observations, spacing of observations, downlink of data, return of samples, etc.). No more than 10 sentences.

**Operational Protocols:** Overview of what is done on orbit to complete the experiment so that a reader can imagine the procedure. No more than 10 sentences.

**Space Applications:** Information on how this experiment supports/benefits the space program.

**Earth Applications:** Information on how this experiment supports/benefits people on Earth.

Manifest Status:

**RPO:** Official name of organization in charge of the payload. The options are as follows:

- Applied Technology Flight Program – KSC (ATFP-KSC)
- Human Research Program – ARC (HRP-ARC)
- Human Research Program – JSC (HRP-JSC)
- Life Support and Habitation – GRC (LSH-GRC)
- Life Support and Habitation – MSFC (LSH-MSFC)
- Space Operations (SO)
- Canadian Space Agency (CSA)
- European Space Agency (ESA)
- Japan Aerospace Exploration Agency (JAXA)
- Space Operations-Italian Space Agency (SO-ASI)

**Previous Missions:** Missions that the payload was manifested on, prior to ISS, or related payloads already completed on ISS. Should include enough of a summary for understanding of the previous results and how they led by progression to this research.

**Results Summary:** Summarizes the progress of the investigation to date. Information provided only after payload operations have begun or are completed onboard ISS/Sortie. The first paragraph should summarize the number of subjects, samples or sessions completed over the number of increments performed. Following paragraphs contain an overview of information contained in 30-day Postflight reports, 1-year Postflight reports, presentations or publications. The final paragraph summarizes what the investigation means in terms of future application.

**Results Publications:** Citation listing of publications resulting from the operation of the investigation on ISS.

**Related Publications:** Citation listing of publications related to the investigation. Publications that set the stage for the planned research, including background on the topic, and publications describing the experiment preflight. Information is available on the public website.

**Web Sites:** Listing of public websites with information regarding the investigation.

**Related Payloads:** Other payloads that are currently on or have flown on ISS that have similar objectives.

**Last Update:** This field will indicate when the last update was made to the investigation information.

# Midodrine

## *Test of Midodrine as a Countermeasure Against Post-flight Orthostatic Hypotension*

**Principal Investigator(s):** Steven Platts, Ph.D., Johnson Space Center, Houston, TX

**Contact(s):** PI - Steven Platts, Ph.D., 281.483.8177

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**Payload Developer(s):** Johnson Space Center, Human Research Program, Houston, TX

**Sponsoring Agency:** National Aeronautics and Space Administration (NASA)

**Increment(s) Assigned:** 5 (Pre/Post Only), 14, 15, 16

**Brief Research Summary (PAO):** Test of Midodrine as a Countermeasure Against Post-Flight Orthostatic Hypotension (Midodrine) measures the ability of the drug midodrine, as a countermeasure, to reduce the incidence or severity of orthostatic hypotension (low standing blood pressure) that many astronauts experience upon returning to the Earth's gravity. This can be a problem for landing on other planets as well. This experiment measures the ability of the drug midodrine, when used as a countermeasure, to reduce the incidence and/or severity of orthostatic hypotension.

**Research Summary:**

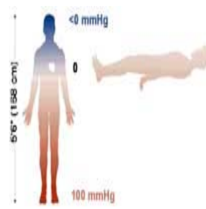
- This study is designed to evaluate the effectiveness of the drug midodrine at preventing low blood pressure (hypotension) that some astronauts experience upon returning to Earth.
- For short-duration subjects, minimal in-flight work involves astronauts ingesting a dose of Midodrine between Time of Ignition (TIG) and landing. Immediately after exiting the vehicle an Op tilt test will be performed.
- For long-duration subjects, an in-flight ECG must be performed approximately 96 hours prior to TIG, followed by the same in-flight protocol as the short-duration subjects.

**Exploration Talking Points:** Blood pressure in microgravity-the Midodrine and Card investigations

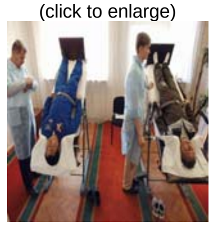
**Detailed Research Description:** Many astronauts experience postflight orthostatic hypotension, a condition where the blood pressure drops when an individual stands up, resulting in presyncope (lightheadedness) or syncope (fainting). Approximately 20-30% of crews on short-duration (less than 20 days) missions and 83% of crews on long-duration missions experience some degree of orthostatic intolerance after return to Earth. To date, the countermeasures tested, such as fluid loading, the use of lower body negative pressure (LBNP), and Fluronef, have not successfully eliminated postflight orthostatic hypotension.

On Earth, the drug midodrine has been used extensively to treat low blood pressure. This investigation studies the effectiveness of midodrine for the treatment of postflight orthostatic hypotension, leading to dizziness or faintness. Midodrine has been previously tested as a pharmaceutical countermeasure by shuttle and ISS crewmembers, during a preflight/ postflight only study.

**Project Type:** Payload




Blood pressure gradient in someone with orthostatic hypotension: In a prone position, blood is evenly distributed throughout the body. When the individual stands (a position called orthostasis), however, their blood pressure is too low to pump sufficient amounts of blood above the level of the heart. Blood collects in the lower part of the body, temporarily depriving the brain, causing lightheadedness and possibly fainting. Astronauts may experience orthostatic hypotension for several days after landing.
(click to enlarge)



NASA Image: JSC2004E44665 - Astronaut Leroy Chiao (left), Expedition 10 commander and NASA International Space Station (ISS) science officer, and Russian Federal Space Agency cosmonaut Yuri Shargin (right) undergo physical testing on a mechanized tilt table at crew quarters in Baikonur, Kazakhstan, October 8, 2004, in preparation for launch to ISS. The tilt table is used to condition the crewmembers' cardiovascular system against the effects of weightlessness once on orbit. A similar tilt table will be used for the tilt tests in the Midodrine investigation.
(click to enlarge)

NASA Image: JSC2005E15226 - View of European Space Agency (ESA) astronaut Roberto Vittori and cosmonaut Sergei K. Krikalev during tilt table tests on April 11, 2005 in Baikonur, Kazakhstan.
(click to enlarge)

NASA Image: JSC2005E15228 - View of astronaut John L. Phillips during a tilt table test on April 11, 2005, in Baikonur, Kazakhstan.
(click to enlarge)

**Operations Location:** Pre/In/Postflight

**Brief Research Operations:**

- Preflight **-** A tilt test will be performed on launch minus 10 days (L-10) and a brief questionnaire is completed by the crewmember before leaving the test room.
- In-flight **-** Between TIG and landing, the subject will ingest 10 mg of Midodrine. For long-duration subjects, an in-flight ECG is also required approximately 96 hours prior to TIG.
- Postflight - After landing a tilt test will be performed on the Crew Transfer Vehicle (CVT).

**Operational Requirements:** Shuttle crewmembers will ingest 10 milligrams of midodrine between Time of Ignition (TIG) and landing.

**Operational Protocols:** Approximately 90 days before flight, the participants will undergo a drug tolerance test for Midodrine and will participate in a drug familiarization session. An operational tilt test will be conducted 10 days prior to launch, and the participants will complete a brief questionnaire before they leave the testing room.

**Review Cycle Status:** PI Reviewed

**Category:** Human Research and Countermeasure Development for Exploration

**Sub-Category:** Cardiovascular & Respiratory Systems in Space

**Space Applications:** Orthostatic hypotension (low blood pressure while standing) is a significant problem to astronauts returning from even short-term space flight, and the symptoms are more prevalent with longer-term flights. Often when returning home, an astronaut's body is unable to maintain blood pressure above the heart, which leads to decreased blood flow in the brain, resulting in lightheadedness and even fainting. Currently used countermeasures to the problem, such as increasing blood volume with saline, have not proven completely effective. If effective, post-flight midodrine administration may provide a relatively simple method for preventing a significant obstacle to long-term space flight, especially exploratory trips to the Moon and Mars. Astronauts in this study, aside from being test subjects, are also control subjects for studies on Earth, as orthostatic hypotension in astronauts is temporary and they are otherwise healthy.

**Earth Applications:** In addition to benefits for astronauts, millions of people on Earth suffer from orthostatic hypotension and may benefit from information gained from this experiment.

**Manifest Status:** Ongoing

**RPO:** Human Research Program - JSC (HRP-JSC)

**Previous Missions:** Midodrine has been studied as a preflight/postflight only protocol for STS-108, STS-110, STS-111, STS-112, STS-113 and ISS Expedition 5.

Midodrine has been completed for one short duration crewmember on STS-116.

**Results:** Midodrine has been shown to successfully reduce orthostatic hypotension in patients on Earth, as orthostatic hypotension affects people other than astronauts. To date, this investigation has been performed on some space shuttle crewmembers and on an Expedition 5 crewmember. Further Expeditions will involve testing on more subjects before conclusive results can be determined.

**Results Status:** Pending More Information

**Related Publications:**


Ramsdell CD, Mullen TJ, Sundby GH, Rostoft S, Sheynberg N, Aljuri N, Maa M, Mukkamala R, Sherman D, Toska K, Yelle J, Bloomfield D, Williams GH, Cohen RJ. Midodrine prevents orthostatic intolerance associated with simulated spaceflight. Journal of Applied Physiology. 2001 ;90(6):2245-2248.

Shi S-J, Garcia KM, Meck JV. Temazepam, but not zolpidem, causes orthostatic hypotension in astronauts after spaceflight. Journal of Cardiovascular Pharmacology. 2003 ;41(1):31-39.

Waters WW, Ziegler MG, Meck JV. Postspaceflight orthostatic hypotension occurs mostly in women and is predicted by low vascular resistance. Journal of Applied Physiology. 2002 ;92(2):586-594.

Meck JV, Reyes CJ, Perez SA, Goldberger AL, Ziegler MG. Marked exacerbation of orthostatic intolerance after long- vs. short-duration spaceflight in veteran astronauts. Psychosomatic Medicine. 2001 ;63(6):865-873.

Tuday EC, Meck JV, Hyhan D, Shoukas AA, Berkowitz DE. Microgravity induced changes in aortic stiffness and its role in orthostatic intolerance. Journal of Applied Physiology. 2007 ;102(3):853-8.


**30-Day Post Flight Report(s):**

- Exp_5_Midodrine_30-Day_Postflight_Report.pdf

**Web Sites:**
Science @ NASA
Life Sciences Data Archive
International Space Station Medical Project (ISSMP)
OBPR Space Research
**One-pager:** Midodrine

**Related Payload(s):** Xenon1

**Comments:** Updated the PAO summary with the summary used for the STS-117/13A PAO package. Updated PAO Summary to reflect the summary from the Expedition 15 Press Kit on 02/21/2007.tlt

6/4/2007 - Updated the summary based on updates from the HRP-JSC office. jmt

**Last Update:** 06/14/2007

# <u>Nutrition</u>
## *Nutritional Status Assessment*

**Principal Investigator(s):** Scott M. Smith, Ph.D., Johnson Space Center, Houston, TX

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Joanne Lupton, Ph.D., Texas A&M University, College Station, TX

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**Payload Developer(s):** Johnson Space Center, Human Research Program, Houston, TX

**Sponsoring Agency:** National Aeronautics and Space Administration (NASA)

**Increment(s) Assigned:** 14, 15, 16, 17

**Brief Research Summary (PAO):** Nutritional Status Assessment (Nutrition) is the most comprehensive inflight study done by NASA to date of human physiologic changes during long-duration space flight; this includes measures of bone metabolism, oxidative damage, nutritional assessments, and hormonal changes. This study will impact both the definition of nutritional requirements and development of food systems for future space exploration missions to the Moon and Mars. This experiment will also help to understand the impact of countermeasures (exercise and pharmaceuticals) on nutritional status and nutrient requirements for astronauts.

**Research Summary:**

- Currently a Clinical Nutritional Assessment is a medical requirement for all U.S. astronauts. This includes collection of blood and urine samples preflight and postflight. Nutrition will expand this protocol by capturing inflight samples and an additional postflight sample. Furthermore, additional biochemical measurements will be included for samples from all sessions, including additional markers of bone metabolism, vitamin status, and hormone and antioxidant/oxidative damage tests.

- The results will be used to better understand the efficacy of countermeasures (e.g. exercise or pharmaceuticals) as well as characterize their impact on nutritional status and nutrient requirements.

**Exploration Talking Points:** "Nutrition Status Assessment" is a lot more than Nutrition, Expedition 14 Accomplishments

**Detailed Research Description:** The Clinical Nutritional Assessment profile (MR016L) has been implemented with two Mir and all ISS US crewmembers and nominally consists of two pre-flight and one post-flight analysis of nutritional status, as well as an in flight assessment of dietary intake using a Food Frequency Questionnaire. This project seeks to expand the MR016L testing in three ways:

- Include in flight blood and urine collection
- Expand nominal testing to include additional normative markers of nutritional assessment
- Add a return plus 30-day (R+30) session to allow evaluation of post-flight nutrition and implications for rehabilitation

To date, it has not been possible to assess nutritional status during flight because blood and urine could not be collected, stowed frozen, and returned during ISS missions. The altered nutritional status findings for several nutrients postflight are of concern, and require the ability to monitor the status of these nutrients during flight to determine if there is a specific impetus or timeframe for these decrements. In addition to monitoring crew nutritional status during flight, in-flight sample collection would allow for better assessment of countermeasure effectiveness. This protocol is also designed to expand the current MR016L to include additional normative markers for assessing crew health and countermeasure effectiveness, and extend the current protocol to include an additional postflight blood and urine collection (R+30). Several nutritional assessment parameters are altered at landing, but it is not known whether the changes are still apparent after 30 days.

Additional markers of bone metabolism (helical peptide, OPG, RANKL, IGF-1) will be measured to better monitor bone health and countermeasure efficacy. New markers of oxidative damage will be measured (8-iso-prostaglandin F2a, protein carbonyls, oxidized and reduced glutathione) to better assess the type of oxidative insults during space flight. The array of nutritional assessment parameters will be expanded to include serum folate, plasma pyridoxal 5'-phosphate, and homocysteine to better understand changes in folate, vitamin B6 status, and related cardiovascular risk factors during and after flight. Additionally, stress hormones and hormones that affect bone and muscle metabolism will also be measured (DHEA, DHEA-S, cortisol, testosterone, estradiol). This additional assessment would allow for better health monitoring, and more accurate recommendations to be made for crew rehabilitation. These additional parameters were added due to the recommendation of an extramural panel that met to define nutritional standards and requirements in 2005.

The protocol entails:

- Collection of blood and urine samples preflight, postflight and inflight
- Biochemical analysis of these samples at the Johnson Space Center using standard laboratory methods
- Statistical analysis of the analytical results to detect differences in nutritional status

**Project Type:** Payload

The Nutrition blood and urine collection kits for inflight sample collection on board ISS.
(click to enlarge)

NASA Image: ISS007E07832 - Expedition 7 Science Officer Ed Lu prepares to add garlic paste to a food packet while preparing a meal in the galley area of the Zvezda Service Module. A can of green peas and eating utensils are visible on the table in front of him. A balanced meal is important to the overall nutrion and healt of teh crew during long duration exploration.
(click to enlarge)

NASA Image: ISS007E06700 - Food cans and packets floating freely on board ISS during Expedition 7. A balanced meal is important to the overall nutrion and healt of teh crew during long duration exploration.
(click to enlarge)

NASA Image ISS013E13224 - Flight engineer Jeffrey Williams unpacks bags containing food and containers in the U.S. Laboratory, Destiny hatch area. A balanced meal is important to the overall nutrition and health of the crew during long duration exploration.
(click to enlarge)

Screenshot of ISS Expedition 14 Commander Michael Lopez-Alegria preparing the centrifuge for the blood samples taken for the Nutrition investigation. The blood sample can be seen in the test tube at the lower left of the image.
(click to enlarge)

Screenshot of ISS Expedition 14 Commander Michael Lopez-Alegria standing in front of the centrifuge after the insertion of the test tubes containing the blood samples drawn for the Nutrition investigation.
(click to enlarge)

NASA Image: ISS014E05124 – Expedition 14 Commander and NASA Astronaut Michael Lopez-Alegria inserts blood and urine samples into the Minus Eighty Degree Laboratory Freezer for ISS (MELFI) until they can be returned to Earth for analysis.
(click to enlarge)

In this screenshot, ISS Expedition 14 Commander Michael Lopez-Alegria labeling a urine collection syringe (lower right of image) that will be used to place urine in the Urine Collection Device (UCD), floating in the foreground of the image.
(click to enlarge)

NASA Image: ISS015E10555 - Astronaut Suni Williams, Expedition 14/15 Flight Engineer, configures her blood samples in the Human Research Facility-2 (HRF-2) Refrigerated Centrifuge, preparing to separate the cellular and liquid components of blood to facilitate sample analysis on the ground.
(click to enlarge)

**Operations Location:** ISS Inflight

**Brief Research Operations:**

- Blood and urine samples are collected preflight, inflight and postflight from astronauts.
- Inflight, crewmembers will perform five blood draws and 5 days of urine collection throughout their mission onboard the ISS.
- The blood samples are processed in the Human Research Facility (HRF) refrigerated centrifuge and all samples (blood and urine) are stored in the Minus Eighty-Degree Laboratory Freezer for ISS (MELFI).
- Upon return to Earth the samples are analyzed for vitamins, minerals and other nutritional/physiological markers.

**Operational Requirements:** Samples will be collected on 12 crewmembers. Sample sessions will occur on Flight Days 15 (+/-5 days), and 30, 60, 120, 180 (+/-14 days). Samples will be returned to Earth for analysis within a year of the sampling date.

**Operational Protocols:** The crew subject will draw blood and collect urine samples on the five days designated. The blood samples will be processed in the refrigerated centrifuge and then stored in the MELFI. Urine will be collected void-by-void for twenty-four hours and samples stored in the MELFI.

**Review Cycle Status:** I Reviewed

**Category:** Human Research and Countermeasure Development for Exploration

**Sub-Category:** Integrated Physiology Studies

**Space Applications:** The inclusion of in flight blood/urine collections and expansion to include additional parameters to better monitor nutritional status is required to better understand the role of nutrition in bone health, changes in body composition, oxidative damage, and defining nutritional requirements for space flight. Maintaining and monitoring nutritional status are important for ensuring crew health during space flight, and will be critical as we embark on longer duration exploration missions in the future.

**Earth Applications:** Increased understanding of the role of nutrition in physiological adaptation to space flight has broader application on Earth, for one example, relationship of nutrition to bone loss has potential value for patients suffering bone loss on Earth.

**Manifest Status:** Ongoing

**RPO:** Human Research Program - JSC (HRP-JSC)

**Previous Missions:** Although this is the first mission for Nutrition, a subset of this protocol, Clinical Nutritional Status Assessment Medical Requirement has been performed on two *Mir* missions and ISS Expeditions 1 - 13.

**Results Status:**

**Related Publications:**
Smith S, Zwart SR, Block G, Rice BL, Davis-Street JE. The nutritional status of astronauts is altered after long-term space flight aboard the International Space Station. Journal of Nutrition. 2005 ;135(3):437-443.

Smith SM, Davis-Street JE, Rice BL, Nillen JL, Gillman PL Block G. Nutritional status assessment in semi-closed environments: ground-based and space flight studies in humans. Journal of Nutrition. 2001 ;131:2053-2061,

Smith SM, Davis-Street JE, Fesperman JV, Smith MD, Rice BL, Zwart SR. Nutritional assessment during a 14-d saturation dive: the NASA Extreme Environment Mission Operations V project. Journal of Nutrition. 2004; 134:1765-1771.

Smith SM, Wastney ME, O'Brien KO, Morukov BV, Larina IM, Abrams SA, Davis-Street JE, Oganov V, Shckelforf LC. Bone Markers, Calcium Metabolism, and Calcium Kinetics During Extended-Duration Space Fligt in the Mir Space Station. Journal of Bone Mineral Research. 2005 20(2); 208-218.

Paddon-Jones D. Interplay of Stress and Physical Inactivity on Muscle Loss: Nutritional Countermeasures. The Journal of Nutrition. 2006 ;136: 2123-2126.

**Web Sites:**
Human Adaptation and Countermeasures Division
International Space Station Medical Project (ISSMP)
**One-pager:** Nutrition

**Related Payload(s):** Clinical Nutrition Assessment

**Comments:** PAO summary was updated to reflect the updated information in the 13A PAO Package. 01/23/2007 - tlt

5/29/2007: Updated summary per emal from HRP-JSC. jmt

**Last Update:** 5/29/2007

**Acronym: Repository**

**Payload Title: NASA Biological Specimen Repository**

**Curator: Kathleen A. McMonigal, M.D.**
**NASA/JSC**
**Houston, TX**

**Repository Coordinators: Robert A. Pietrzyk, M.S.**
**Wyle Laboratories, Life Sciences Group**
**Houston, TX**

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**Category: Human Research and Countermeasure Development for Exploration**

**Sub-Category: N/A**

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**Payload Developer(s):** Johnson Space Center, Houston, TX

**Sponsoring Agency:** National Aeronautics and Space Administration (NASA)

**Increment(s) Assigned:** 16, 17

**Mission: N/A**

**Brief Research Summary (PAO):** The implementation of this protocol establishes the NASA Biological Specimen Repository. A repository is a storage bank that is used to maintain biological specimens over extended periods of time and under well-controlled conditions. Samples from the ISS, including blood and urine, will be collected, processed and archived during the pre-, in- and postflight phases of ISS missions. This facility has been developed to archive biosamples for use as a resource for future spaceflight-related research.

**Research Summary:**

- The International Space Station (ISS) provides a platform to investigate the effects of microgravity on human physiology prior to lunar and exploration class missions. The storage of crewmember samples from many different ISS flights in a single repository will be a valuable resource with which researchers can validate clinical hypotheses, study space-flight related changes, and investigate physiological markers.

- The development of the NASA Biological Specimen Repository will allow for the collection, processing, storage, maintenance, and ethical distribution of biosamples to meet goals of scientific and programmatic relevance to the space program. Archiving of the biosamples will provide future research opportunities including investigating patterns of physiological changes, analysis of components unknown at this time or analyses performed by new methodologies

**Detailed Research Description:**

Blood samples will be collected by venipuncture during the preflight, in-flight and postflight phases of this protocol. One 5 ml plasma tube and one 5 ml serum tube will be collected from each participating crewmember during each of the scheduled sessions. These sessions are scheduled once preflight, in-flight on flight days 15, 30, 60, 120 and 180 and during two sessions scheduled for 3-5 days and 30 days following landing.

Void-by-void urine will be collected and pooled into a 24 hr pool. Urine will be collected during the same session times as scheduled for the blood draws. Biosample collections will be coordinated with the existing medical requirements or research activities to minimize the number of needle sticks, urine collections and inconveniences to the crewmember. All samples will be stored at ultra low temperatures to maintain the highest quality and integrity possible. The overall project philosophy is to collect, process and store samples to ensure the widest possible range of analyses can be carried out on samples in the future.

**Project Type:** Payload

**Images and Captions:**

Figure 1. Image of ISS refrigerated centrifuge used during blood processing.

Figure 2. Flight hardware used for blood and urine collection.

**Operations Location:** ISS, pre-, -in and postflight

**Brief Research Operations:**

- Preflight, crewmembers will provide 10 ml (2 x 5ml tubes) of whole blood and a 24-hr urine collection (L-30 to 45 days).

- In flight, crewmember subjects will setup the blood and urine collection hardware. Crewmembers will then perform the morning fasting blood collection (2 x 5 ml tubes) and begin the 24-hr urine collection. The blood is processed and all samples are recorded and the samples stored in the ISS Minus Eighty Laboratory Freezer for ISS (MELFI) for return to earth.

- Postflight, crewmembers will provide 10 ml (2 x 5ml tubes) of whole blood and a 24-hr urine collection during two postflight sessions (one session occurring approximately R+3-7 and at R+30 days).

**Operational Requirements:**

All ISS crewmembers are eligible to participate in this protocol. Sample sessions will occur on Flight Days 15 (+/-5 days), and 30, 60, 120, and 180 (+/-14 days). Blood collection will occur following an overnight fast. Samples will be returned to Earth for storage in the repository.

**Operational Protocols:**

The crewmember will draw blood and collect urine samples during the scheduled sessions. The blood samples will be processed in the refrigerated centrifuge and then stored in the MELFI. Urine will be collected void-by-void for twenty-four hours and samples stored in the MELFI. Samples will be identified via bar codes and the data downlinked to earth.

**Review Cycle Status:** Program/Project reviewed

**Space Applications:**

The development of the NASA Biological Specimen Repository will allow for the collection, processing, storage, maintenance, and ethical distribution of biosamples to meet goals of scientific and programmatic relevance to the space program. Archiving of the biosamples will provide future research opportunities including investigating patterns of physiological changes, analysis of components unknown at this time or analyses performed by new methodologies.

**Earth Applications:**

Advances in space biomedical research often lead to medical advances to better serve terrestrial patients. Future research investigations to help ensure the health and safety of crewmembers and enable exploration class missions may provide significant health benefits to patients on earth.

**RPO:** Human Research Program - JSC (HRP-JSC)

**Previous ISS Missions:** Implementation of this protocol is scheduled to begin with ISS Increment 16.

**Results Summary:** This protocol creates the NASA Biological Specimen Repository. The repository will collect, store and distribute samples to future investigators involved in spaceflight-related human life sciences investigations. Results from these investigations will be provided directly from these investigations.

**Results Publications:** N/A

**Related Publications:** N/A

**Web Sites:**

**Related Payloads:** N/A

**Last Update:** June 2007

Acronym: SAMS

Payload Title: Space Acceleration Measurement System

**Principal Investigator(s):** Not Applicable

Project Manager: Robert Hawersaat, Glenn Research Center, Cleveland, OH

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

**Sponsoring Agency:** National Aeronautics and Space Agency (NASA)

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

**Brief Research Summary (PAO):** 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 Space Acceleration Measurement System-II, SAMS-II, detects transient accelerations and vibrations, 0.01 to 400 Hz, present while the space station is operational.
- Vibrations exist on the space station for a variety of reasons: equipment operation, structural motion, crew movement, and thermal expansion are but a few.
- Multiple sensors are positioned in various locations in the US Lab and are designed to measure the accelerations electromechanically.

**Exploration Talking Points:** The Space Acceleration Measurement System (SAMS)

**Detailed Research Description:** SAMS-II will measure vibrations from vehicle acceleration, systems operations, crew movements, and thermal expansion and contraction. Multiple Remote Triaxial Sensor (RTS) systems are used to monitor individual experiments requiring direct monitoring. Each RTS is capable of measuring between 0.01 Hz to beyond 300 Hz of vibration, also known as g-jitter. The RTSs consist of two components: the RTS sensor enclosure (SE) and the RTS electronics enclosure (EE). The RTS-SE, placed as close to the experiment as possible, will translate the g-jitter into a digital signal. The RTS-EEs provides power and command signals for up to 2 RTS-SEs and receives the g-jitter data from the RTS-SEs.

The RTSs are linked together by the Interim Control Unit (ICU), which coordinates the various RTS systems being used throughout the Station. Eventually, the ICU will be replaced by a full-fledged Control Unit (CU), which will allow onboard data analysis and direct feedback and will permit crew to control the measurement parameters. The main component of the ICU is a computer. Once the ICU receives the measurements from the RTS systems, it checks the data for completeness, and the computer sends the data to the SAMS-II Ground Operations Equipment at Glenn Research Center.

**Project Type:** Payload

NASA Image: ISS004E8406 - SAMS sensor head mounted near top of EXPRESS rack 2 in U.S. Lab taken during Expedition 4.
(click to enlarge)

NASA Image: ISS008E11936 - SAMS-II in EXPRESS rack 4 in U.S. Lab during Expedition 8.
(click to enlarge)

**Operations Location:** ISS Inflight

**Brief Research Operations:**

- Install and remove sensor heads and cables to payloads.
- Crew may observe data stream. Filter cleaning/change out as required.

**Operational Requirements:** The SAMS-II RTS is installed in Rack 1, drawers 1 and 2, away from the Active Rack Isolation System (ARIS) in Rack 2, which could cause disruptions to measurements. The ICU was installed in Rack 2, drawer 1 up through Increment 3. At the end of Increment 3, it was transferred to EXPRESS Rack 4. Once installed and activated, SAMS-II operates automatically.

**Operational Protocols:** Because SAMS-II measures subtle vibrations that affect only certain types of experiments, SAMS-II will not be operational all the time. Instead, it will be operated from the Glenn Research Center Telescience Support Center as needed. The ICU laptop has the capacity to save up to 10 hours of data from five sensors working at maximum frequency range. This capacity is meant to act as a backup if downlink services are interrupted.

**Review Cycle Status:** PI Reviewed

**Category:** Technology Development for Exploration

**Sub-Category:** Characterizing the Microgravity Environment on ISS

**Space Applications:** The residual acceleration environment of an orbiting spacecraft in low earth orbit is a complex phenomenon. Many factors, such as experiment operation, life-support systems, crew activities, aerodynamic drag, gravity gradient, rotational effects and the vehicle structural resonance frequencies (structural modes) contribute to form the overall reduced gravity environment. Weightlessness is an ideal state, which cannot be achieved in practice because of the various sources of acceleration present in an orbiting spacecraft. SAMS-II will record acceleration disturbances caused by the ISS, its crew, and equipment. A complete understanding of the vibration environment will help researchers develop methods to minimize disturbances. It also allows other principal investigators to design their payloads with the vibration environment in mind.

**Earth Applications:** SAMS-II provides environmental data for scientific experiments that are conducted onboard the ISS. Any degree of acceleration disturbance can ruin their science. In fluid physics and crystal growth, SAMS-II detects the vibration disturbances that cause the microstructures to form undefined and disfigured. The liquid - solid transition is difficult when the amount of disturbances is high.

**Manifest Status:** Reserve Operations – as requested

**RPO: Life Support and Habitation – GRC (LSH-GRC)**

**Previous Missions:** SAMS, the precursor to SAMS-II was flown on numerous shuttle flights since STS-40 and on *Mir*. SAMS-II was operated continually on ISS from expedition 2 - 12.

**Results:** The Space Acceleration Measurement System (SAMS) is a continuously operating space flight experiment. Operation began with Expedition Two and will continue throughout the life span of the ISS. SAMS-II is used in microgravity and non-microgravity modes of ISS operations to measure vibratory acceleration disturbances. Current data indicates that the ISS is not meeting its microgravity mode design requirement and no clear benefit to perform payload operations during crew sleep periods.

**Results Publications:**
DeLombard R, Hrovat K, Kelly EM, Humphreys B. Interpreting the International Space Station Microgravity Environment. Proceedings of the 43rd AIAA Aerospace Sciences Meeting and Exhibit, Reno, NV. 2005 ;AIAA 2005-0727.

**Related Publications:**
DeLombard R. Disturbance of the microgravity environment by experiments. Proceedings of the AIP Conference. Jan 19, 2000 ;504(1):614-618.

**30-Day Post Flight Report(s):**

- Exp_2_SAMS&MAMS_30-Day_Postflight_Report.pdf
- Exp_3_SAMS&MAMS_30-Day_Postflight_Report.pdf
- Exp_5-6_SAMS&MAMS_30-Day_Postflight _Report.pdf

**Web Sites:**
PIMS
NASA Fact Sheet
Microgravity Science Division at Glenn Research Center - SAMS-II
SpaceRef.com - End of an Era for SAMS

**One-pager:** SAMS-II

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

**Last Update:** 06/08/2007

# Summary Template
# ISS Program Science Database

**Acronym:** SEITE

**Payload Title:** Shuttle Exhaust Ion Turbulence Experiments

**Principal Investigator(s):** Paul A. Bernhardt, Ph.D., Naval Research Lab, Washington D.C.

**Contact(s):**
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Secondary - Douglas Doehring, 1st Lt, USAF (281) 483-3506

**Category:** Physical and Biological Sciences in Microgravity

**Sub-Category:** Physical Sciences

**Mailing Address:**

DoD Space Test Program
2101 NASA Parkway JSC-WR1
Houston, TX 77058-3607

**Payload Developer(s):**

US Department of Defense Space Test Program
US Naval Research Laboratory

**Sponsoring Agency:** NASA

**Increment(s) Assigned:** Inc 18, 19, 20

**Mission:** STS-125, STS-126, and subsequent Shuttle missions

**Brief Research Summary (PAO):** The SEITE experiments will use space based sensors to detect the ionospheric turbulence inferred from the radar observations from a previous shuttle OMS burn experiment using ground-based radar.

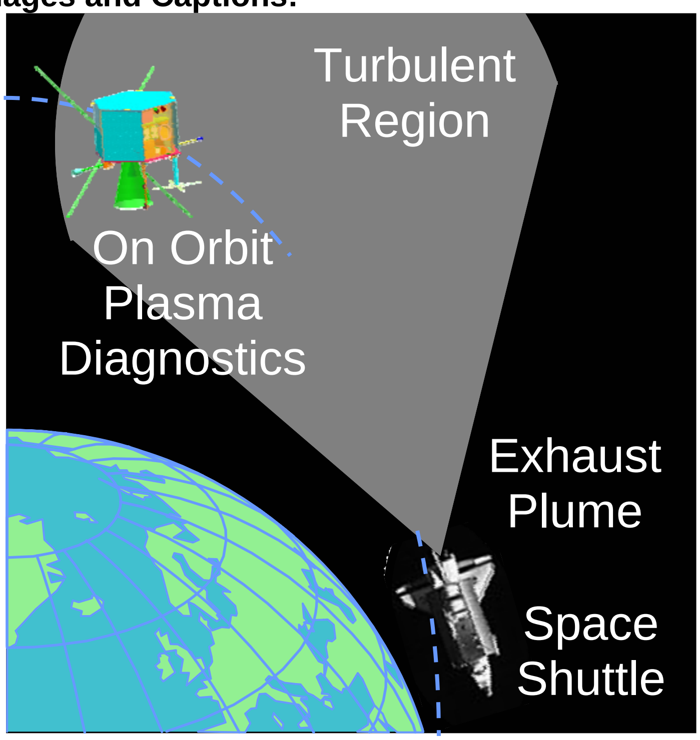
**Research Summary:**
- SEITE research will enhance
    - Surveillance of Space
    - Real-Time Characterization
    - Detection and Tracking

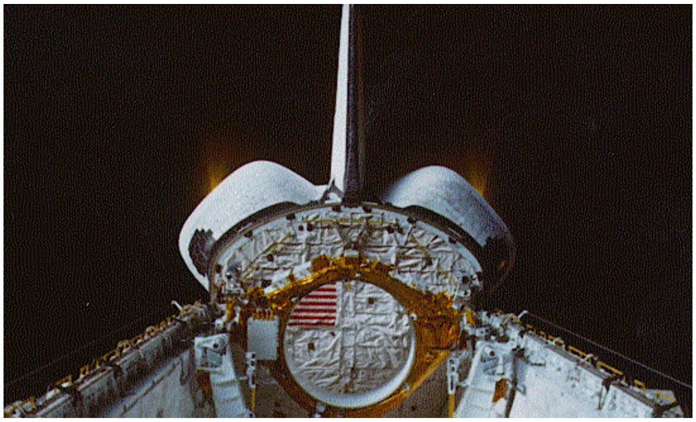
- Timely Surveillance of High Interest Objects
- The *In Situ* Data will complement the data acquired during SIMPLEX
- The purpose for SEITE is for space based diagnostics of ionospheric turbulence utilizing Shuttle OMS exhaust

**Detailed Research Description:** SEITE uses instrumentation on several satellites for in situ observations of density and electric field disturbances caused by the Space Shuttle OMS engine exhaust plume. SEITE satellite instrumentation will observe and measure the plasma turbulence produced by the OMS exhaust plume and measure electric fields, plasma waves, plasma densities, and magnetic fields. The C/NOFS, FalconSat-3, and ePOP/CASSIOPE satellites have the correct instrumentation for the measurements. The satellite sensors for the measurements provide data on the following: Neutral Flows, Electron and Ion Distributions, Electric Fields and Plasma Waves, Radio Scintillations. The satellite needs to be within 300 km of the ignition point for the measurements. On average there is an opportunity for an observation once every 5 days for each satellite while the Shuttle is in orbit.

**Project Type:** Payload

**Images and Captions:**





Symmetrical Dual OMS Burn in Daylight

**Operations Location:**

The following on-orbit assets will be used for SEITE observations
C/NOFS
FalconSat-3
ePOP/CASSIOPE

**Brief Research Operations:**

Commander and Pilot perform OMS engine burns at a precise time, location and direction so the engine plume and on-orbit satellites will achieve conjunction. The satellite will pass through OMS engine plumes and take measurements using onboard sensors.

**Operational Requirements:** Astronauts initiate a 10-second dual OMS engine burn at a point where the far field exhaust plume will intersect with the flight path of one of the satellites particpating with SEITE. NASA provides orbit updates for coordination with the SEITE diagnostic satellite. Knowledge of Shuttle and SEITE satellite orbits prior to a conjunction with 10 km accuracy and 1 second resolution. After Shuttle burn is performed need actual ignition point with 1 km accuracy and engine attitude to 5 degrees accuracy. The satellites will only passively observe the plume and will not perform a maneuver.

**Operational Protocols:** Commander and Pilot perform OMS engine burns

**Review Cycle Status:** DoD Reviewed

**Space Applications:** Artificially created plasma turbulence can disrupt military navigation and communications using radio systems.

**RPO:** Space Operations (SO)

**Previous ISS Missions:** None

**Results Summary:** N/A

**Results Publications:** N/A

**Related Publications:**

Bernhardt, P.A., RT Tsunoda, C.J. Heinselman, DL Hysell, AJ Coster, Triggering of Plasma Instabilities with a Space Shuttle Burn in the Equatorial Ionosphere, submitted to Nature, 2006.

Bernhardt, P.A., P. J. Erickson, F.D. Lind, J.C. Foster, B. Reinisch, Artificial Disturbances of the Ionosphere over the Millstone Hill Radar during Dedicated Burns of the Space Shuttle OMS Engines, J. Geophys. Res., 110, A05311, 2005.

Bernhardt, P.A., M.P. Sulzer, Incoherent Scatter Measurements of Ion Beam Disturbances Produced by Space Shuttle Exhaust Injections into the Ionosphere, J. Geophys. Res., 109, A02303, 2004.

Bernhardt, P.A., J.D. Huba, E. Kudeki, R F Woodman, L. Condori and F. Villanueva, The Lifetime of a Depression in the Plasma Density over Jicamarca Produced by Space Shuttle Exhaust in the Ionosphere, Radio Science, 1209-1220, 2001.

Bernhardt, P.A.,J.D. Huba, W.E Swartz, M.C. Kelley, Incoherent scatter from Space Shuttle and Rocket engine Plumes in the ionosphere, J. Geophys. Res., 103, 2239-2251, 1998.

Bernhardt, P.A., G. Ganguli, M.C. Kelley, and W.E. Swartz, Enhanced radar backscatter from space shuttle exhaust in the ionosphere, J. Geophys. Res., 100, 23,811-23,818, 1995.

**Web Sites:**
http://www.space.gc.ca/asc/eng/satellites/cassiope.asp
www.kirtland.af.mil/shared/media/document/AFD-070404-094.pdf

**Related Payloads:** MAUI, RAMBO, SIMPLEX

**Last Update:** 1 August 2007

**Acronym:** SHERE

**Payload Title:** SHEAR HISTORY EXENTIONAL RHEOLOGY EXPERIMENT

**Principal Investigator(s):**
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**Co-Investigator:** N/A

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**Category and Sub-Category:**
- Physical and Biological Sciences in Microgravity
    - Physical Sciences

**Payload Developer(s):**
Glenn Research Center, Cleveland, OH and ZIN Technologies, Inc., Cleveland, OH

**Sponsoring Agency:** National Aeronautics and Space Agency (NASA)

**Increment(s) Assigned:** 18

**Brief Research Summary (PAO):** A non-Newtonian fluid will undergo preshearing ("rotation") for a specified period of time and then elongation ("stretching"). This combination of shearing and extensional deformations is common in many earth-based polymer processing and manufacturing operations such as extrusion, blow-molding and fiber spinning. However, in order to accurately predict the flow behaviour of polymeric fluids under such deformation histories, an accurate knowledge of the extensional viscosity of a polymer system and its variation with strain rate is critical and will be measured during this experiment.

**Research Summary:**
- This fluid science experiment is designed to investigate the effect of preshearing on the stress/strain response of a polymeric liquid being stretched in microgravity.
- This experiment will generate previously unattainable scientific data for dilute viscoelastic polymer solution in a broad subclass of transient uniaxial extensional flows.
- Understanding extensional rheology is key in understanding how to process thermoplastic elastomers (flexible elastic polymeric materials), which are very resilient and can be made very thin, and hence, lightweight.
- SHERE can provide data for engineering design tools that are part of computer-assisted manufacturing (CAM) systems to ensure the rheological properties of polymer parts have not been impacted in a variable gravity environment.

**Detailed Research Description:**

Unlike Newtonian fluids, complex fluids such as polymers cannot be characterized by a single material parameter such as the Newtonian viscosity, $\mu$. Instead, they exhibit non-linear and time-dependent responses to imposed deformations. Constitutive models have shown the extensional function of non-

Newtonian fluids are not constant but depend on both the rate of deformation and the total strain experienced by a fluid element. A class of dilute polymer solutions collectively referred to as “Boger fluids,” have become a popular choice for fundamental rheological studies of non-Newtonian fluids and will be used in this experiment.

Gravitational body forces cause appreciable sagging of thin fluid filaments. This sagging is most notable for low deformation rates where strain-hardening is not significant. Removing these perturbative forces will allow one to probe a wider parametric range of strain rates while simultaneously measuring the total stress and velocity field (shape and diameter) in the deforming fluid element. These measurements will provide an idealized data set for comparison with theoretical models and will serve as a gold standard for ground-based extensional rheometry.

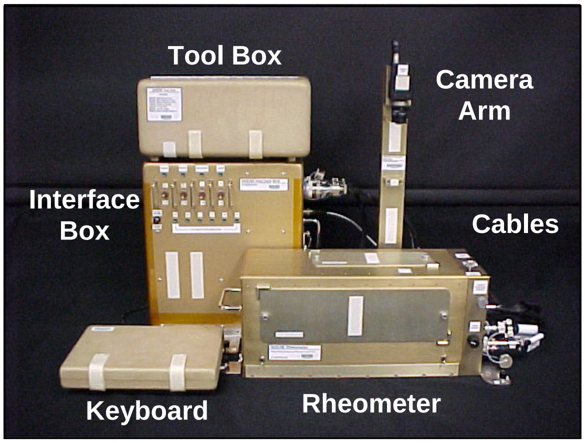
The experiment will be performed inside the microgravity Science Glovebox (MSG) on the International Space Station (ISS). On-orbit operations will consist of crew installation, hardware turn-on and checkout, fluid sample installation, experiment execution, and fluid sample removal. During experiment execution a test point is selected (with specified preshear and strain rates), and the experiment will then automatically execute. The fluid is presheared and stretched according to a pre-programmed exponential velocity profile. The stretch is stopped abruptly at 194 mm in length, and the tensile stress in the fluid thread is allowed to relax. Each experiment lasts approximately 5 minutes, most of which is spent waiting for the fluid column to drain to the end plates, and the fluid filament eventually breaks in the middle. Several key measurements will be made during the experiment. They include measuring the axial force induced due to shearing and stretching of the elastic fluid, axial displacement history of the translation stage, axial midplane diameter of the fluid filament, temperature of the fluid, and fluid filament shape and evolution. Afterwards, the translation slider is repositioned to the starting position, and the fluid column is reconstituted. If it is reusable (based on a criteria of temperature, bubble contamination, and previous strain encountered), then another test can be performed with the same fluid sample. Otherwise, the fluid sample is removed, and the next one is installed or the hardware is powered down.

The SHERE hardware consists of the Rheometer, Interface Box, Camera Arm, Keyboard, Toolbox, Fluid Module Stowage Tray, and cabling.

- The Rheometer is the heart of the SHERE experiment and is where the preshear and elongational deformation of each fluid sample are performed. The Rheometer has a cover that opens to allow the fluid sample installation and closes to prevent accidental escape of the fluid during the test. Two windows allow the fluid to be observed inside the Rheometer. Inside the Rheometer are a rotational stepper motor mounted on a linear translation stage (slider), axial position sensor, laser micrometer, force transducer, electroluminescent panel, X-Y positioning stage, zeroing potentiometer, and thermistors.
- The Interface Box provides power distribution, control, and data storage for all components.
- The Camera Arm attaches to the back of the Rheometer, and a black and white video camera is mounted to the top of the arm to allow viewing down through the top window of the Rheometer.
- The Keyboard is used by the crew for data entry and experiment parameter selection and initiation.
- The Tool Box contains miscellaneous parts and tools used during the setup and operation of the experiment.
- The Fluid Module Stowage Tray contains twenty-five (25) Fluid Modules, each of which contain identical samples of a well-characterized model non-Newtonian fluid (a ‘Boger’ fluid). The Fluid Modules are cylindrical containers with two layers. A split outer shell protects an inner shroud, which is manually retracted to deploy the fluid column between two coaxial disk-shaped end plates.
- There are seven cables providing power and signal interconnections between the Rheometer, Interface Box, Camera Arm, Keyboard, and MSG.

**Project Type:** Payload

**Images and Captions:**




The SHERE hardware, pictured above, consists of the Rheometer, Interface Box, Camera Arm, Keyboard, Toolbox, Fluid Module Stowage Tray (not pictured), and cabling. A summary of each part is listed in the Detailed Research Description section.



The pictures above show a Fluid Module in various configurations.
Left: Fluid Module with outer shell in place; Middle photo: Fluid Module with shell halves removed to show the middle cylindrical container which houses the fluid sample; Right photo: The inner shroud is retracted to expose the two flat plates between which the fluid is supported.

**Operations Location:** ISS Inflight

**Brief Research Operations:**
- The crew will perform Hardware Installation in MSG, Hardware Turn-on, Hardware Checkout, Fluid Sample Installation and Experiment Execution.
- Following end of testing, the crew will perform Hardware Shutdown, and when all tests are completed, the crew will perform Hardware Removal from MSG.

**Operational Requirements:**
- SHERE will be conducted inside the MSG work volume.
- Fluid samples need to be kept at 20 deg C for 24 hours prior to the start of testing. The crew will place the Fluid Module Stowage Tray inside the Commercial Generic Bioprocessing Apparatus (CGBA) testing order to control their temperature.
- Twenty-five (25) tests will be performed in groups of 5 tests per group. Each test will nominally use one Fluid Module.

- Data downlink will be performed after each group of 5 tests, and the results will be analyzed before the next group is run.
- There is no time limit between tests or groups, but testing once a Fluid Module has been removed from the CGBA should be as expedient as possible to prevent heating of the fluid sample above the cutoff temperature of 25 deg C.
- Sample return of the Fluid Modules is desired but not required.
- Data will also be stored on up to 25 digital video tapes for later return to the ground for more complete analysis.

**Operational Protocols:**
The crew will install the hardware into the MSG, power up the hardware, and perform hardware check-out using calibration tools from the Tool Box. A Fluid Module is then installed into the Rheometer by attaching its two ends to the force transducer and preshear motor/slider respectively. The crew then deploys the fluid by removing the outer shell and sliding back the inner shroud. The experiment's execution automatically occurs once the crew has selected a test point on the Keyboard. The fluid is presheared at a steady rotation rate and then stretched according to an exponentially-increasing velocity profile. Following the completion of a test, the fluid column is recombined by bringing the Fluid Module halves back together again. If possible, another test can be performed using the same sample (provided no bubbles are present within the fluid and the sample temperature remains below 25 deg C). If not, the Fluid Module is sealed, removed, and a new Fluid Sample is prepared for testing or the hardware is powered down. Upon completion of testing, the hardware is removed from the MSG.

**Review Cycle Status:** PI Reviewed

**Space Applications:** Understanding the extensional rheology of a complex fluid such as a liquid polymer is key for *containerless processing* because the absence of the bounding walls of a container or vessel removes the shearing component of the deformation which typically dominates earth-based processing operations. The resulting flow is thus shear-free or extensional in character. Containerless processing is a central component in the development of *in-situ fabrication technology*, such as a means of producing new parts on demand or replacing existing parts or tools. This represents a critical element in the evolution of an autonomous exploration capability. In-situ fabricated parts, which may include both new and recycled materials, will be composed of plastics, filled polymers, metals, ceramics and composites. SHERE plays a role in this area by measuring, in microgravity conditions, a material property that has a direct connection to in-situ manufacturing and fabrication of polymeric parts. In-situ manufacturing operations can occur in microgravity or reduced gravity levels (e.g. on the Moon or Mars) and may include for example, the extrusion and processing of thermoplastic elastomer films, which are very resilient and can be made thin and lightweight. These elastomeric materials may form the basis of adhesives and fillers utilized in a wide variety of repair applications, especially under a reduced gravity environment, such as the repair of space suits or other similar materials. Understanding and exploiting the ability to fabricate new parts in-situ from a limited number of precursor components is critical in future space missions where weight plays a critical role in the overall cost of a mission. Additionally, in-situ repair provides a means of maintaining systems during transport and while on the Moon, Mars, and other extraterrestrial bodies.

**Earth Applications:** Fundamental understanding and measurement of the extensional rheology of complex fluids also allows earth-based manufacturing processes to be controlled and improved. Ground-based work done by Professor Gareth McKinley using variants of the Filament Stretching Rheometer includes studies of 'spinnability' and the investigations of cohesive and adhesive instabilities which manifests themselves in adhesion and tackiness of materials. It has lead to the development of a 'Resin-spinning' technology that allows the formation of ultra-fine elastic threads analogous to spider -silks. Control of the fluid shear history and extensional rheology of test fluid is essential and to optimizes the ultimate 'web' properties.  Extensional rheology is of critical importance in optimization of polymer processing operations that involve ‘complex flows’, i.e. flows that contain both shearing (”rotation”) and elongation (“stretching”) components. Examples of recent industrial collaborations with the P.I. include:

Dr. D. Rajagopalan (Dupont CR&D, Wilmington, DE): Transient extensional rheology of polyolefins (polypropylene, polyethylene) and Nylon;
Dr. P. Pakdel (Bridgestone/Firestone Research, Akron, OH): Transient extensional rheology of unfilled and filled tire elastomers;
Dr. M.L. Sentmanat (Goodyear, Xpansion Instruments); transient extensional rheology of polyethylenes
Dr. P. Whittingstall (TA Instruments, New Castle, DE): Elastocapillary breakup study of seven different adhesive formulations supplied by Adhesives and Sealants Council
Dr. S. Sheppard (Schlumberger, Cambridge, UK): Extensional properties of EHAC worm-like surfactant solutions used in fracturing and oil recovery
Dr Abe Vaynberg (Hercules, Wilmington, DE): Elastocapillary breakup of filled adhesive precursors and sprays
Dr. C. Servais (Nestlé, Lausanne, CH) : Extensional rheology and shear-sensitivity of hydrocolloids and gelled foods (e.g. yogurts)

**Manifest Status:** Candidate

**RPO:** Life Support and Habitation – GRC (LSH-GRC)

**Previous Missions:** None

**Results Summary:** N/A

**Results Publications:** N/A

**Related Publications:**
[1]McKinley, G.H. “Elastocapillary Breakup of Complex Fluids”, Annual Rheology Reviews, British Society of Rheology, Aug. 2005.

[2]McKinley, G.H. and Sridhar, T., “Filament Stretching Rheometry of Complex Fluids,” *Annual Review of Fluid Mechanics*, Vol. 34, Annual Reviews Press, Palo Alto, 2002, 375–415.

[3]McKinley, G.H. “Preshear History and Uniaxial Elongation in a Microfilament Extensional Rheometer”—A proposal to GMX/MIM Program, NASA Lewis Research Center, January 30, 1997.

**Web Sites:** N/A

**Related Payload(s):** N/A

**Last Update:** 06/18/07

# Sleep-Short

## *Sleep-Wake Actigraphy and Light Exposure During Spaceflight-Short*

**Principal Investigator(s):** Charles A. Czeisler, M.D., Ph.D., Brigham and Women's Hospital, Harvard Medical School, Boston, MA

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**Payload Developer(s):** Johnson Space Center, Human Research Program, Houston, TX

**Sponsoring Agency:** National Aeronautics and Space Administration (NASA)

**Increment(s) Assigned:** 11, 13, 14, 15, 16

**Mission:** STS-104/7A, STS-111/UF-2, STS-112/9A, STS-113/11A, STS-114/LF1, STS-121/ULF1.1, STS-115/12A, Soyuz TMA-1/5S Odissea, STS-116/12A.1, STS-118/13A.1, STS-120/10A, STS-122 (1E)

**Brief Research Summary (PAO):** Sleep-Wake Actigraphy and Light Exposure During Spaceflight - Short (Sleep-Short) will examine the effects of spaceflight on the sleep-wake cycles of the astronauts during space shuttle missions. Advancing state-of-the-art technology for monitoring, diagnosing and assessing treatment of sleep patterns is vital to treating insomnia on Earth and in space.

**Research Summary:**

- Previous research on Space Shuttle crewmembers has shown that sleep-wake patterns are disrupted on orbit.
- A wrist-worn Actiwatch will record the activity of the crewmembers and the ambient light they experience.
- Results will be used to evaluate the crewmembers' subjective evaluation of the amount and quality of their sleep.

**Detailed Research Description:** The success and effectiveness of manned spaceflight depends on the ability of crewmembers to maintain a high level of cognitive performance and vigilance while operating and monitoring sophisticated instrumentation. Astronauts during short space flights, however, commonly experience sleep disruption and may experience misalignment of circadian phase during spaceflight. Both of these conditions are associated with insomnia, and impairment of alertness and cognitive performance.

Relatively little is known of the prevalence or cause of spaceflight induced insomnia in short duration missions. This experiment will use state of the art ambulatory technology to monitor sleep-wake activity patterns and light exposure in crewmembers aboard the Space Shuttle. Subjects will wear a small, light-weight activity and light recording device (Actiwatch) for the entire duration of their mission. The sleep-wake activity and light exposure patterns obtained in-flight will be compared with baseline data collected on Earth before and after spaceflight. The data collected should help us better understand the effects of spaceflight on sleep as well as aid in the development of effective countermeasures for short duration spaceflight.

**Project Type:** Payload

This image shows an Actiwatch Activity Monitor next to a ruler to demonstrate the size of the Actiwatch.
(click to enlarge)

NASA Image: S104E5114 - Astronaut, Janet Kavandi on STS-104 wearing an Actiwatch on her right wrist for recording activities.
(click to enlarge)

**Operations Location:** Sortie

**Brief Research Operations:**

- The crewmembers will wear Actiwatches (that will record wrist activity, allowing estimation of sleep-wake cycles and also records the light exposure of the crewmember).

- Crewmembers will complete daily sleep logs.

**Operational Requirements:** Short-duration (Space Shuttle) crewmembers are needed as subjects for the experiment. This is on a volunteer basis, obtaining as many volunteers as possible until the Space Shuttle program is retired. Baseline data for each subject must be collected for two weeks between L-120 (launch minus 120 days) and L-75 and from L-11 through L-0. Recovery in sleep patterns after spaceflight will be assessed from R+0 (return plus 0 days) through R+7.

**Operational Protocols:** Crewmembers will don Actiwatches as soon as possible upon entry into orbit (FD1) and wear the Actiwatches continuously throughout the flight. Sleep logs will be completed each day within 15 minutes of awakening. On the last day of the mission, crewmembers will doff and stow the Actiwatches.

**Review Cycle Status:** PI Reviewed

**Category:** Human Research and Countermeasure Development for Exploration

**Sub-Category:** Human Behavior and Performance

**Space Applications:** The information derived from this study will help to better understand the effects of spaceflight on sleep-wake cycles. The countermeasures that will be developed will improve sleep cycles during missions which in turn will help maintain alertness and lessen fatigue of the Space Shuttle astronauts.

**Earth Applications:** A better understanding of insomnia is relevant to the millions of people on Earth who suffer nightly from insomnia. The advancement of state of the art technology for monitoring, diagnosing, and assessing treatment effectiveness is vital to the continued treatment of insomnia on Earth. This work could have benefit the health, productivity and safety of groups with a high prevalence of insomnia, such as shift workers and the elderly.

**Manifest Status:** Ongoing

**RPO:** Human Research Program - JSC (HRP-JSC)

**Previous Missions:** Sleep-Short was previously operated on several Space Shuttle missions including STS-107, which was lost in 2003.

**Results Status:** Pending More Information

**Related Publications:**
Dijk D, Neri DF, Wyatt JK, Ronda JM, Riel E, Ritz-De Ceccoa A, Hughes RJ, Elliott AR, Prisk GK, West JB, Czeisler CA. Sleep, performance, circadian rhythms, and light-dark cycles during two space shuttle flights. American Journal of Physiology Regulatory Integrative Comparative Physiology. 2001 ;281:R1647-R1664.

Monk TH, Buysse DJ, Billy BD, DeGrazia JM. Using nine 2-h delays to achieve a 6-h advance disrupts sleep, alertness, and circadian rhythm. Aviation Space and Environmental Medicine. 2004 ;75:1049-1057.

Mallis MM, DeRoshia CW. Circadian Rhythms, Sleep, and Performance in Space. Aviation, Space, and Environmental Medicine. 2005 ;76(6 Suppl): B94-107.

Monk TH, Buysse DJ, Billy BJ. Using daily 30-min phase advances to achieve a 6-hour advance: Circadian rhythm, sleep, and alertness. Aviation Space and Environmental Medicine. 2006 ;77(7): 677-686.

**30-Day Post Flight Report(s):**
- Exp_13_Sleep-Short_30-Day_Postflight_Report.pdf

**Web Sites:**
Sleep Medicine at Harvard Medical School
International Space Station Medical Project (ISSMP)
**One-pager:** Sleep-Short

**Related Payload(s):** Sleep-Long

**Comments:** PAO Summary Updated to reflect the summary in the Expedition 15 Press Kit on 02/21/2007 tlt.

Changes made based on information provided by HRP team via email on 2/13/07. jmt

**Last Update:** 2/28/2007

**Acronym: SPICE**

**Payload Title: S**moke **P**oint **I**n **C**o-flow **E**xperiment

**Principal Investigator:** David L. Urban, Ph. D., NASA Glenn Research Center
**Co-Investigator:** Peter B. Sunderland, Ph.D. University of Maryland,
**Project Scientist:** Zeng-guang Yuan, National Center for Space Exploration Research

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**Category and Sub-Category:**

- Physical and Biological Sciences in Microgravity
    - Physical Sciences

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**Payload Developer(s):**
Glenn Research Center, Cleveland, Ohio
ZIN Technologies, Cleveland, Ohio

**Sponsoring Agency:** NASA

**Increment(s) Assigned:** Increment 18

**Mission:** N/A

**Brief Research Summary (PAO):**
The SPICE experiment determines the point at which gas-jet flames (similar to a butane-lighter flame) begin to emit soot. This phenomenon is a property of the fuel chemistry and the flow conditions and has been shown to be strongly and uniquely affected by gravity. This transition to a soot emitting flame is important in understanding the ability of unwanted fires to spread and in control of soot in practical combustion systems.

**Research Summary:**

Motivation:

- ♦ Soot dominates the heat emitted from flames in normal gravity and in spacecraft fires. Control of this heat emission is critical for prevention of the spread of unwanted fires and in the design of efficient combustion systems (jet engines and power generation boilers).

Approach:

- ♦ The onset of soot emission form small gas jet flames (similar to a butane-lighter flame) will be determined to provide a data-base that can be used to assess the interaction between fuel chemistry and flow conditions on soot formation. These results will be used to support combustion theories and to assess fire behavior in low-gravity.

Impact:

- ♦ Improved design of practical combustors through improved control of soot formation.
- ♦ Improved design of future space experiments using validated flame shape models and smoke height predictions.
- ♦ Support for the laminar flamelet hypothesis validation by the LSP experiment.
- ♦ Improved understanding of and ability to predict heat release, soot production and emission in microgravity fires.
- ♦ Improved flammability criteria for selection of materials for use in spacecraft.

**Detailed Research Description:**

Soot processes in flames are a major unsolved combustion problem having significant relevance to society:

- Particulate soot emissions from flames are responsible for more deaths than any other pollutant
- Carbon monoxide emissions caused by soot emissions are mainly responsible for deaths due to unwanted fires
- Soot radiation causes undesirable combustor heat loads and the spread of unwanted fires in earth and in spacecraft
- Limited understanding of soot chemistry is a major impediment to developing computational combustion
- The smoke point is an important predictor of the heat emission from fires and is used to correlate the results from material flammability tests.

Recent results from the Laminar Soot Processes (LSP) investigation revealed that the smoke height phenomenon in microgravity can be substantially different form that seen in normal gravity. The removal of buoyancy induced acceleration can cause the smoke point phenomenon to be dominated by radiative losses for conditions of low overall flame velocity. Under these conditions the flame tip extinguishes allowing soot to be emitted. In spite of this effect, it is still possible to have flames that either emit soot along all stream lines or do not emit soot anywhere, for conditions where radiation losses do not dominate. The emission of soot is controlled by the interplay between chemical kinetics, heat losses and convective mixing. Removal of buoyancy strongly changes the convective mixing and enables more precise variation of the mixing rate.

Unfortunately, while the laminar smoke-point properties of buoyant jet diffusion flames at normal gravity (ng) are well known, corresponding information for non-buoyant flames is limited and questionable. Thus, the measurements of the laminar smoke-point properties proposed here would also reduce the risk of future experiments involving hydrocarbon-fueled laminar jet diffusion flames in spacecraft.

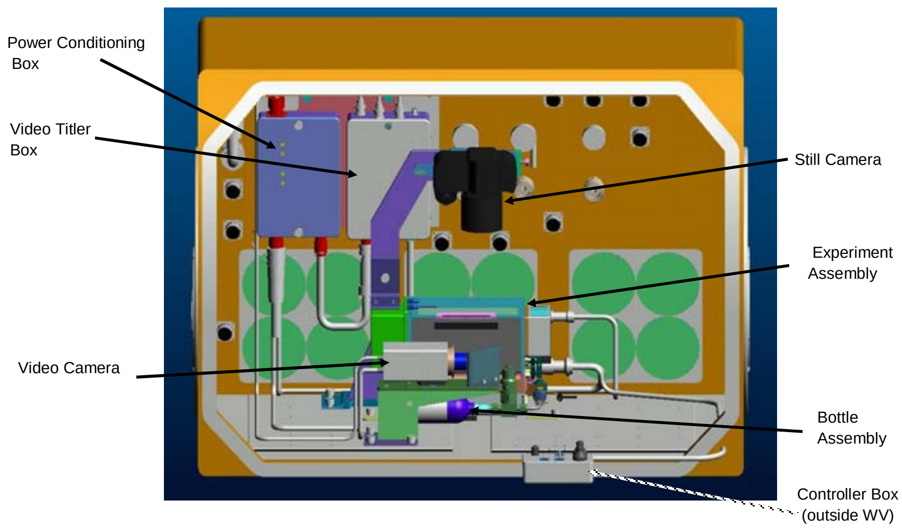
SPICE will continue this study of fundamental phenomena related to understanding the mechanisms controlling the stability and extinction of jet diffusion flames. SPICE will stabilize an enclosed laminar flame in a co-flowing oxidizer, measure the overall flame shape to validate the theoretical and numerical predictions, measure the flame stabilization heights, and measure the temperature field to verify flame structure predictions.

The objective of the SPICE experiment is to find the laminar smoke point properties of non-buoyant jet diffusion flames (i.e., the properties of the largest laminar jet diffusion flames that do not emit soot) for several fuels under different nozzle diameter/ co-flow velocity configurations. Luminous flame shape measurements would also be made to verify models of the flame shapes under co-flow conditions.  The soot point is a simple measurement that has been found useful to study the influence of flow and fuel properties on the sooting propensity of flames. This information would help support current understanding of soot processes in laminar flames and by analogy in turbulent flames of practical interest.

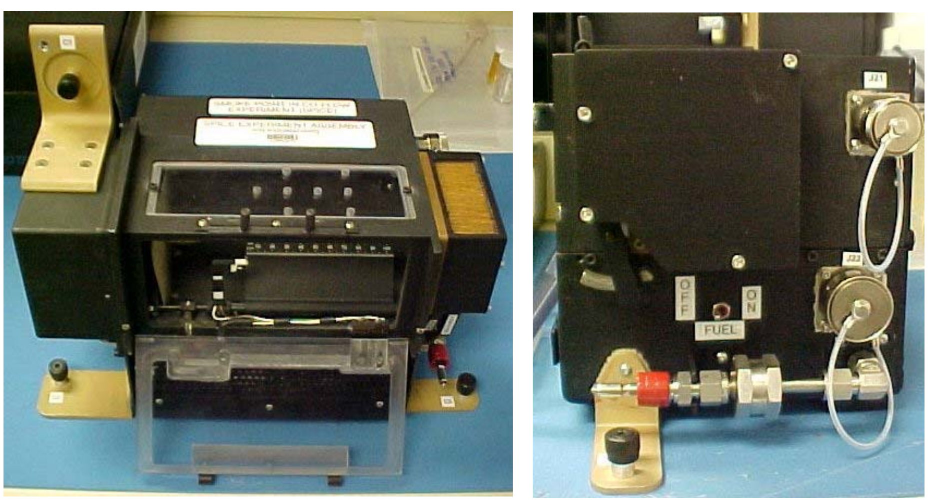
**Project Type:** Payload

**Images and Captions:**

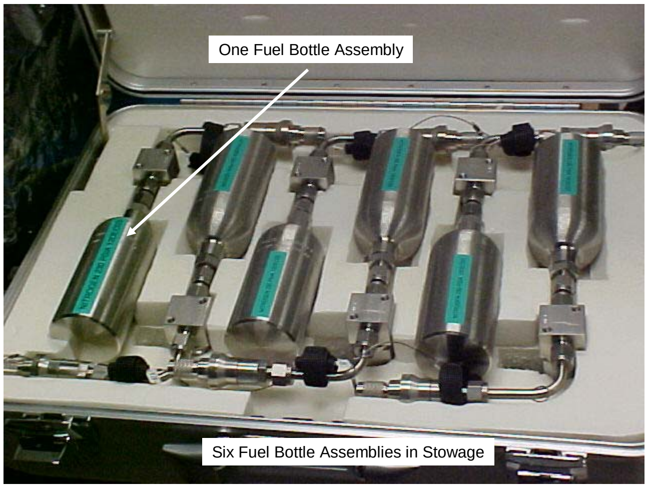
SPICE Mounted in MSG



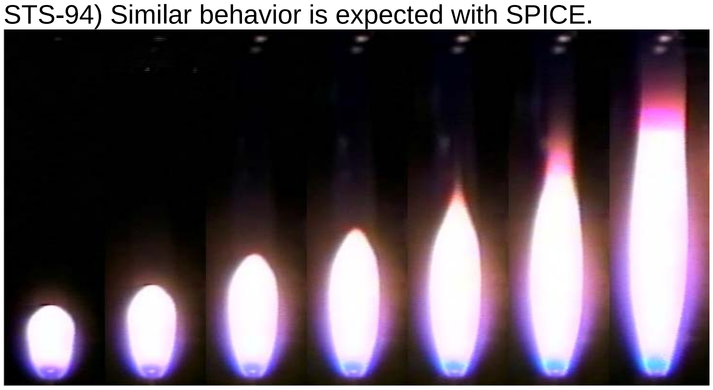

SPICE Experiment Assembly



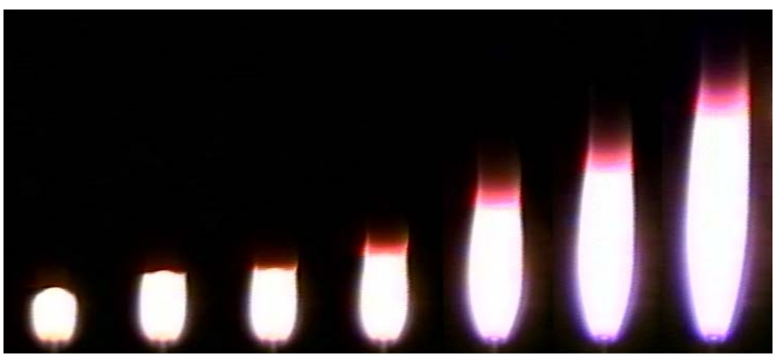
SPICE Fuel Bottle Assembly




Onset of the closed-tip smoke point for flames in quiescent ambient from the LSP experiment ( STS-94) Similar behavior is expected with SPICE.



Onset of the open-tip smoke point for flames in quiescent ambient from the LSP experiment ( STS-94)



**Operations Location:** ISS In-flight

**Brief Research Operations:**

- Crew will unstow and assemble the SPICE hardware on the base plate within the MSG working volume and connect electrical and data harnesses.

- During course of experiment, the crew will install/exchange fuel bottles, exchange burner tubes, control fuel flow and flame ignition.
- For each test point the crew will set the burner diameter and air flow before ignition. After ignition, the crew will adjust the fuel flow rate until the flame is at the smoke point.
- Crew will control video and still camera functions – some photos down-linked for near-real time coordination with PI.
- Crew will uninstall experiment from MSG and stow hardware.

**Operational Requirements:**

- SPICE will be conducted inside the sealed MSG work volume.
- Crew involved throughout the experiment – no autonomous operations
    - Load fuel bottles, initiate test, ignite fuel, adjust flame to smoke point, monitor and record data, exchange burner tubes, exchange fuel bottles, replace igniter
- Six test sequences covering six different fuels with three different burner tubes – total of fifty four (54) test points with periodic repeat points desired (time available)
- Data downlinks (no uplinks required)
    - Video downlink ASAP during or immediately after each flame test
    - Digital photos downlink ASAP after selected flame tests for ground confirmation before proceeding.
- Testing conducted during periods when no major reboost or docking procedures are underway

**Operational Protocols:**

The crew first installs the SPICE hardware in the MSG work volume. The SPICE hardware consists of a small flow duct with an igniter and a small nozzle. Outside the flow duct are 2 cameras, the fuel supply bottle and various electronic boxes. Each test is conducted by the crew member who installs the correct diameter nozzle and sets the air flow rate through the duct before igniting the flame. When the flame is ignited, (it will look similar to a butane-lighter flame) the crew member adjusts the flame size (by controlling the fuel flow rate) until the flame is just at the smoke point (the size where the flame just begins to emit a small stream of soot from the tip). After triggering the high resolution camera, the crew member turns off the fuel and prepares for the next test. The science team on the ground will monitor the video down link to assist the crew in determining the smoke point and will review the sensor data overlaid on the video image. Between sets of runs the crew will change the fuel bottle to a different fuel (six will be tested). Upon completion of the tests the crew stows the hardware and the stored images and data are returned to earth for analysis.

**Review Cycle Status:** PI Reviewed

**Space Applications:**
Current NASA spacecraft materials selection is based upon a simplified test method (NASA-STD-6001 Test 1) that segregates material based upon 1-g behavior without real consideration of low-g effects. A critical element of this understanding is the radiative heat emission from the flame. This heat emission is strongly influenced by the extent of soot formation. Improved understanding of soot formation and thereby the heat release from low-g fires will allow more complete and effective utilization of the flammability test results. These results can be used in first-order models and predictions of heat release in spacecraft fires and as a means to extend heat release data from tests like the NASA cone-calorimeter test (NASA-STD-6001 Test 2) to low-gravity fires to a performance based material selection process.

**Earth Applications:**

The smoke-point phenomena is a classical metric in the understanding of the heat release and spread rate of fires. It is commonly used in 1-g fire modeling and to understand the soot growth and emission by flames. The dominant characteristics of many flames of practical interest are nonbuoyant. The LSP experiment has shown that the onset of the microgravity smoke point in a quiescent environment is very different from that seen in normal gravity. SPICE seeks to extend our understanding by looking at the interaction of ambient flow with the smoke point, enabling us to better predict heat release from non-buoyant flames in practical combustors (e.g. jet engines and furnaces)

**RPO:** Life Support and Habitation – GRC (LSH-GRC)

**Previous ISS Missions:** N/A

**Results Summary:** N/A

**Results Publications:** N/A

**Related Publications:**


1. C. Aalburg, F.J. Diez, G.M. Faeth, P.B. Sunderland , D.L. Urban, Z.-G. Yuan, "Shapes of nonbuoyant round hydrocarbon-fueled laminar-jet diffusion flames in still air" Combustion and Flame 142 (2005) 1–16
2. Urban, D.L., Z.G. Yuan, P.B. Sunderland, K.C., Lin, Z. Dai, and G.M. Faeth, "Smoke-Point Properties of Nonbuoyant Round Laminar Jet Diffusion Flames," proceedings of the *Twenty-Eighth Symposium (International) on Combustion* 28:1965-1972 (2000).
3. Sunderland, P.B., B.J. Mendelson, Z.G. Yuan, and D.L. Urban, "Shapes of Buoyant and Nonbuoyant Laminar Jet Diffusion Flames," *Combustion and Flame*, 116:376-386 (1999).
4. Urban, D.L., Z.G. Yuan, P.B. Sunderland, G.T. Linteris, J.E. Voss, K.C. Lin, Z. Dai, K. Sun, and G.M. Faeth, "Structure and Soot Properties of Nonbuoyant Ethylene/Air Laminar Jet Diffusion Flames, *AIAA Journal*, 36:1346-1360 (1998).
5. Sunderland, P.B., S. Mortazavi, G.M. Faeth and D.L. Urban, "Laminar Smoke Points of Nonbuoyant Jet Diffusion Flames," *Combustion and Flame*, 96:97-103.
6. Lin, K.C., G.M. Faeth, P.B. Sunderland, D.L. Urban, and Z.G. Yuan, "Shapes of Nonbuoyant Round Luminous Hydrocarbon/Air Laminar Jet Diffusion Flames," *Combustion and Flame*, 116:415-431 (1999).


**Web Sites: N/A**
Related info at LSP website http://microgravity.grc.nasa.gov/combustion/lsp/lsp_index.htm

**Related Payloads:** N/A

**Last Update:** 06/18/07

**ISS Program Science Database Instructions**

The summary you are providing will be posted on the ISS Program Science Toolbox (http://iss-science.jsc.nasa.gov/) with a subset of fields used for public distribution on the NASA portal. If the payload has flown in the past, please check the summary on the website for accuracy. Please submit any changes to Tracy Thumm (tracy.thumm-1@nasa.gov) or Judy Tate (judy.tate-1@nasa.gov).

If the payload has not flown before, please provide a summary using the template below. Please use the descriptions of the fields as a guide when writing. Should you have any questions or comments, please contact Judy or Tracy.

Thank you,

Julie A. Robinson, Ph.D.
Deputy Program Scientist
International Space Station
281-483-5582
julie.a.robinson@nasa.gov

# Summary Template
# ISS Program Science Database

**Acronym: VCAM**

**Payload Title: Vehicle Cabin Atmosphere Monitor**

**Principal Investigator(s): Ara Chutjian, Ph. D., California Institute of Technology/Jet Propulsion Laboratory, Pasadena, CA**

**Co-Investigator: Murray Darrach, Ph. D., California Institute of Technology/Jet Propulsion Laboratory, Pasadena, CA**

**Contact(s): PI – Ara Chutjian, Ara.Chutjian@jpl.nasa.gov, 818-354-7012**
Primary – Murray Darrach, **mdarrach@jpl.nasa.gov**, 818-393-2689
Secondary – Dan Karmon, **Dan.Karmon@jpl.nasa.gov**, 818-354-9700

**Category:** Technology Development for Exploration

**Sub-Category:** Environmental Monitoring on ISS

**Mailing Address:** Ara Chutjian, MS 121-104, Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91109

**Payload Developer(s):** Jet Propulsion Laboratory

**Sponsoring Agency:** National Aeronautics and Space Administration (NASA)

**Increment(s) Assigned:** 18, 19, 20

**Mission:** ULF2

**Brief Research Summary (PAO):** VCAM identifies gases that are present in minute quantities in the ISS breathing air that could harm the crew's health. If successful, instruments like VCAM could accompany astronauts living on the Moon or traveling to Mars.

**Research Summary:**

- **Operating VCAM on the ISS will validate it (as a miniature gas chromatograph / mass spectrometer) as a viable sensor for the ISS, the Moon, and Mars missions**
- **Use an earth-like analytical instrument to detect chemicals at the spacecraft maximum allowable concentration**

**Developing sensors that**

**Detailed Research Description:**
VCAM can provide a means for monitoring the air within the enclosed environments of the Space Station, the CEV, a Lunar Habitat, or a vehicle traveling to Mars. Its miniature preconcentrator, gas chromatograph, and mass spectrometer can provide unbiased detection of a large number of organic species; VCAM's software can identify whether the chemicals are on a targeted list of

hazardous compounds and their concentration. Its performance and reliability on orbit and the ground team's assessment of its raw data and analysis results will validate its technology for future use and development.

VCAM pulls in air from the ISS Cabin through an inlet port embedded in its front panel; the air passes through a particulate filter and over a Carboxen sorbant bed; a fraction of the air molecules ingested over two to five minutes are adsorbed onto the room-temperature preconcentrator. Valves are actuated which flow helium over the bed which is warmed to remove oxygen and water. The preconcentrator is heated sharply and the desorbed gases are collected in a micro-machined injector, compressed, and impinged as a short pulse in time onto the gas chromatographic (GC) column. The GC's active phase material (DB wax) on the inner wall's of the 10-meter capillary causes molecules to be slowed in their transit of the column in a manner to separate them into multi-second slugs over the course of a twenty-minute elution. As the air exits the GCit is pumped into the mass spectrometer in which it is ionized by 70-volt electrons, the ions are held by the spectrometer's ion trap and ejected in time as a function of their mass-to-charge ratio. The hyperboloidal Paul Ion Trap geometry and a digitally generated radio-frequency (475 kHz) are used to store ions from a mass/charge ratio of 28 ($N_2$) through a ratio of 350. A channeltron electron multiplier detects the arrival of each ion and creates a pulse which can then be amplifier and counted. Over the twenty minutes that it takes the gases that were inject4ed into the GC over a few seconds, the mass spectrometer takes fifty 4096-channel spectra each second; they are averaged over a second, stored, analyzed, and sent to the ground.

Onboard software evaluates the total number of ions counted each second to find peaks of eluting material. It analyzes the set of spectra that make up the peak – comparing the location (mass/charge) and amplitude of the peaks to standard mass-fraction patterns to probabilistically identify a species. This technique is very reproducible and has been captured by the National Institute of Standards and Technology in mass-fractionation patterns for tens of thousands of chemicals. VCAM engineers have recast NIST's Automated Mass Spectral Deconvolution and Identification System (AMDIS) code into a compact set of C commands with a library consisting of the compounds that the JSC Toxicologist knows could be present in ISS and present a hazard to the crew. The number of ions in the peak and the instrument's sensitivity to each of the targeted compounds are used to determine the concentration of that species in the ISS air. A VCAM Calibration gas is used to periodically quantify how the PC, GC, and MS are actually performing. The raw data, calibration data, and analysis results are all sent to the ground for further assessment to validate the instrument's detection, identification, and quantification results.

The VCAM system is a stand-alone instrument that operates autonomously but can be commanded by either crew or ground personnel. It carries its own gas supplies for sampling operations, cleaning, and calibration. Its several processors control the measurement and analysis processes, monitor housekeeping sensors, and actuate the valves that control the flow of gas. Commercial backing and turbo-molecular drag pumps maintain the vacuum required to do ion-based mass spectroscopy. The microwave-sized payload weighs 25 kg and requires 70 to 180 W of power for its operation. VCAM will be installed in one of ISS' Expedite the Processing of Experiments on Space Station (EPXRESS) Racks and operate for at least twelve months; it will use the rack's conditioned air for heat dissipation and its Ethernet link for receiving commands from the ground and transmitting data. VCAM's front panel provides the instrument's operational interface with the crew: an LED display showing the instrument status (not data) and a multi-button system for navigating its control menus; an access door enables the crew to replace the VCAM gas Supply Orbital Replacement Unit after twelve months of nominal operations.

**Project Type:** Payload

**Images and Captions:**

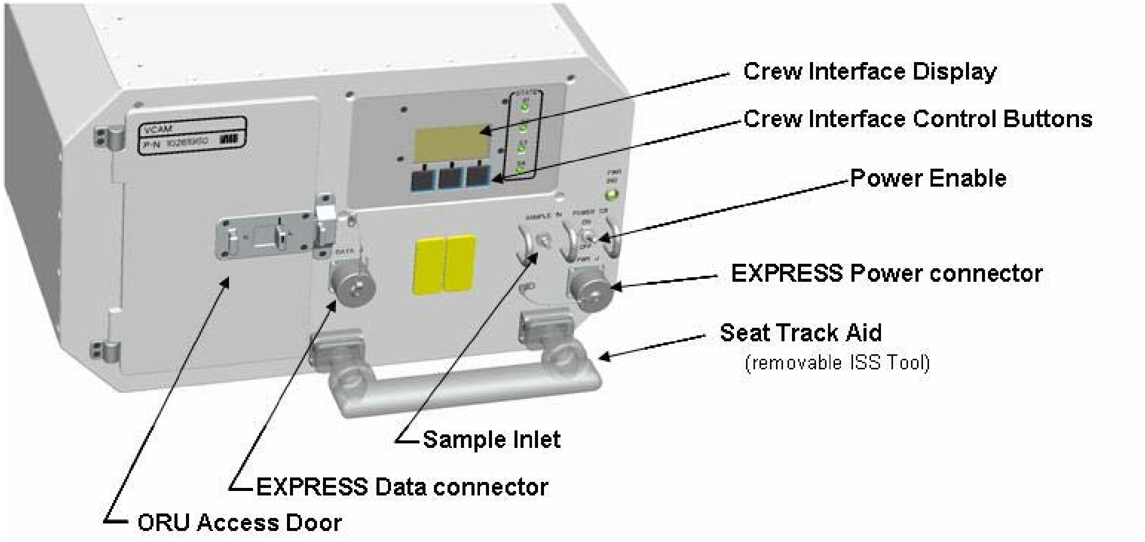



**Figure 1. Rendering of the VCAM Front Panel**

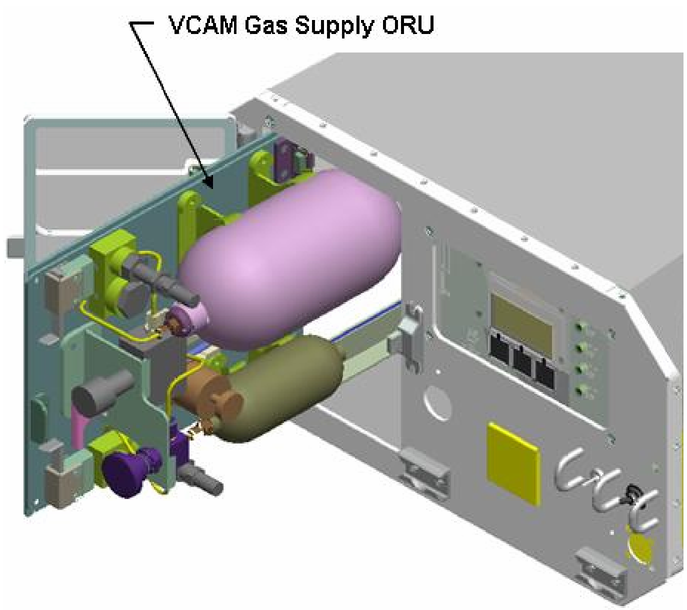



**Figure 2. VCAM Gas Supply ORU Replacement**

**Operations Location:** ISS Inflight

**Brief Research Operations:**

- The Crew installs VCAM into EXPRESS Rack; turns it on
- VCAM operates on an internal schedule, taking an air measurement from the air in front of the instrument once each day; about 40 minutes will be required for the sampling and analysis.

- The resulting science data (mass spectra) are analyzed on board and gases are identified
- The raw instrument data, the analyzed data, and housekeeping data are sent to the ground for assessment
- VCAM uses an internal calibration gas to regularly self-characterize its instrument components
- The crew can use a sample bag to collect an air sample from further away and attach it to the VCAM front panel for analysis
- The instrument can be controlled by crew or ground personnel.
- After twelve months the crew can replace the internal gases used to operate, clean, and calibrate the instrument.

**Operational Requirements:** VCAM will collect an air sample on overage once per day. The raw data and on-board analysis, as well as housekeeping data, will be sent to the ground for assessment. VCAM's internal gas supply have been sized to last for twelve months; less frequent measurements will result in slightly longer operational periods.

**Operational Protocols:** VCAM pumps cabin air into its Pre-concentrator (PC), a charcoal bed to which many of the chemicals in the air stick (adsorb). After several minutes the PC is warmed slightly to remove nitrogen, oxygen, and water; then it is heated very quickly to drive the chemicals off into a flow of pure helium gas. This puff of gas mixture flows through a 10-meter capillary with a special internal coating (gas chromatographic column, GC) that separates the chemical families from each other over a twenty minute period. The gas is pulled into the mass spectrometer where it is ionized by an electron beam; the resulting ions are held in the Ion Trap and then ejected based upon their mass-to-charge ratio; the charged mass fractions, characteristic of the original gas, are collected by a high-voltage detector. Fifty mass spectra are collected each second and averaged; the total number of ions ejected each second (over the twenty minutes of gas flow resulting for the original puff of gas) produces a chromatogram. Software in VCAM compares these two pieces of raw data to its standard library to identify the chemical and uses the number of ions to determine the concentration is the air.

**Review Cycle Status:** PDR completed; CDR in process

**Space Applications:** VCAM will protect the astronauts by informing them of the slow build up of potentially harmful chemical in their breathing air. While VCAM's library contains species that engineers know to be present in the various life-support systems, VCAM can provide data that allows ground scientists to identify compounds that were not expected. These same functions of detection, identification, and quantification can be brought to bear in the event of a chemical spill or release.

**Earth Applications:** Instruments larger than VCAM monitor the air in enclosed systems on Earth (e.g., submarines). Small portable units are used in the field to monitor the environment.

**RPO:** ISS Vehicle Program Office

**Previous ISS Missions:**

**Results Summary:**

**Results Publications:**

**Related Publications:**

- "Trace Gas Analyzer for Extra-Vehicular Activity," T. Abbasi, M. Christensen, M. Villemarette, M. Darrach, A. Chutjian, *SAE Technic. Paper Ser. 2001-10-2405* (SAE, Warrendale, PA 2001).
- "A Compact, High-Resolution Paul Ion Trap Mass Spectrometer with Electron-Impact Ionization," O. J. Orient and A. Chutjian, *Rev. Sci. Instr. 73,* 2157 (2002).
- "Miniaturized Gas Chromatograph-Paul Ion Trap System: Applications To Environmental Monitoring," B. J. Shortt, M. R. Darrach, Paul M. Holland, and A. Chutjian, *SAE Technical Paper Series 2005-00-0000* (SAE, Warrendale, PA, in press).

**Web Sites:**

**Related Payloads:** The Volatile Organics Analyzer (VOA, not a payload and not associated with VCAM or its PI) has demonstrated both the importance and the challenges of monitoring the ISS air for trace amounts of organic compounds. Lessons learned from it development and operation have aided VCAM.
The Trace Gas Analyzer (TGA, not a payload, but the PI is part of the development team) employs a different mass spectrometer to work in the vacuum outside the ISS to check for leaks. Mass spectrometers can provide a powerful and compact instrument for detecting small amount of material whether in vacuum or in an atmosphere.

**Last Update:** June 18, 2007

# Field Descriptions
# ISS Program Science Database
# http://iss-science.jsc.nasa.gov

**Acronym:** Official acronym assigned to the payload.

**Payload Title:** Official name assigned to the payload.

**Principal Investigator(s):** Scientist(s) responsible for the experiment, institution affiliation and location. PI should always be listed as this person receives scientific credit for the experiment in public communications (i.e., do not list a coordinating organization or point of contact or experiment manager here). Format: John Smith, Ph.D., University, City, State

**Co-Investigator:** Individuals who are involved in the experiment. Please list name, affiliation and location. Format: Mary Smith, Ph.D., University, City, State.

**Contact(s):** Name, email address and phone number of the PI and the name, email address and phone number of the primary individual to contact in the absence of the PI.

**Category and Sub-Category:** Please select from one category and one sub-category from the following:

- Human Research and Countermeasure Development for Exploration
    - Bone and Muscle Physiology in Space
    - Cardiovascular & Respiratory Systems in Space
    - Human Behavior and Performance
    - Immune System in Space
    - Integrated Physiology Studies
    - Microbiology in the Space Environment
    - Neurological and Vestibular Systems in Space
    - Radiation Studies
- Observing the Earth and Educational Activities
    - Educational Activities
    - Observing the Earth
- Physical and Biological Sciences in Microgravity
    - Animal Biology in the Space Environment
    - Cellular Biology and Biotechnology
    - Physical Sciences
    - Plant Biology in Microgravity
    - Protein Crystal Growth

- Results from ISS Operations
    - Crewmember-Initiated Science
    - Environmental Monitoring of ISS
    - Medical Monitoring of ISS Crewmembers
- Technology Development for Exploration
    - Characterizing the Microgravity Environment on ISS

- Environmental Monitoring on ISS
  - Picosattellites & Control Technologies
  - Spacecraft and Orbital Environments
  - Spacecraft Materials
  - Spacecraft Systems

**Mailing Address:** Mailing address for the Principle Investigator and Co-Investigators. This information will used for internal use only.

**Payload Developer(s):** NASA center, Space Agency and/or the company or institution where the investigation and hardware are developed.

**Sponsoring Agency:** Space agency responsible for launch the investigation. The options are as follows:

- Canadian Space Agency (CSA)
- European Space Agency (ESA)
- Federal Space Agency (FSA)
- Japan Aerospace Exploration Agency (JAXA)
- National Aeronautics and Space Administration (NASA)

**Increment(s) Assigned:** A list of increments that this payload has been or is scheduled to be performed.

**Mission:** This applies only if the payload was manifested as a Sortie mission. Please indicate the mission number. For Example: STS-121/ULF1.1

**Brief Research Summary (PAO):** Short, concise description of the payload (no more than 3 sentences) summarizing what is being done and why. Written for a public audience with minimal jargon.

**Research Summary:** Slightly more detailed than the PAO summary in a bulletized format to answer the following questions:

- why research is needed
- what will be accomplished
- what will be the impact

Information is available on the internal and public website, and is used to generate 1-pagers. (Shorter is better, absolutely no more than about 10 sentences, written on an 8$^{th}$ grade level).

**Detailed Research Description:** Provides a place for a more technical description of the objectives of an experiment aimed at an interdisciplinary scientific audience. May have several paragraphs as needed. May use technical terminology, but all terms should be defined or linked. This field will also include the description of hardware.

**Project Type:** Indicates type of project: Payload or Sub-payload

**Images and Captions:** Image of the investigation with a detailed caption. Image should be provided in .jpg format.

**Operations Location:** Indicates where the payload is performed: Pre/Postflight, Sortie or ISS Inflight.

**Brief Research Operations:** Brief summary of the operations used to perform activities for the payload, written in bulletized format for a general audience at and 8th grade level. This field becomes part of the 1-pager.

**Operational Requirements:** Defines constraints and requirements to be met to complete the experiment (numbers of subjects or observations, spacing of observations, downlink of data, return of samples, etc.). No more than 10 sentences.

**Operational Protocols:** Overview of what is done on orbit to complete the experiment so that a reader can imagine the procedure. No more than 10 sentences.

**Space Applications:** Information on how this experiment supports/benefits the space program.

**Earth Applications:** Information on how this experiment supports/benefits people on Earth.

Manifest Status:

**RPO:** Official name of organization in charge of the payload. The options are as follows:

- Applied Technology Flight Program – KSC (ATFP-KSC)
- Human Research Program – ARC (HRP-ARC)
- Human Research Program – JSC (HRP-JSC)
- Life Support and Habitation – GRC (LSH-GRC)
- Life Support and Habitation – MSFC (LSH-MSFC)
- Space Operations (SO)
- Canadian Space Agency (CSA)
- European Space Agency (ESA)
- Japan Aerospace Exploration Agency (JAXA)
- Space Operations-Italian Space Agency (SO-ASI)

**Previous Missions:** Missions that the payload was manifested on, prior to ISS, or related payloads already completed on ISS. Should include enough of a summary for understanding of the previous results and how they led by progression to this research.

**Results Summary:** Summarizes the progress of the investigation to date. Information provided only after payload operations have begun or are completed onboard ISS/Sortie. The first paragraph should summarize the number of subjects, samples or sessions completed over the number of increments performed. Following paragraphs contain an overview of information contained in 30-day Postflight reports, 1-year Postflight reports, presentations or publications. The final paragraph summarizes what the investigation means in terms of future application.

**Results Publications:** Citation listing of publications resulting from the operation of the investigation on ISS.

**Related Publications:** Citation listing of publications related to the investigation. Publications that set the stage for the planned research, including background on the topic, and publications describing the experiment preflight. Information is available on the public website.

**Web Sites:** Listing of public websites with information regarding the investigation.

**Related Payloads:** Other payloads that are currently on or have flown on ISS that have similar objectives.

**Last Update:** This field will indicate when the last update was made to the investigation information.