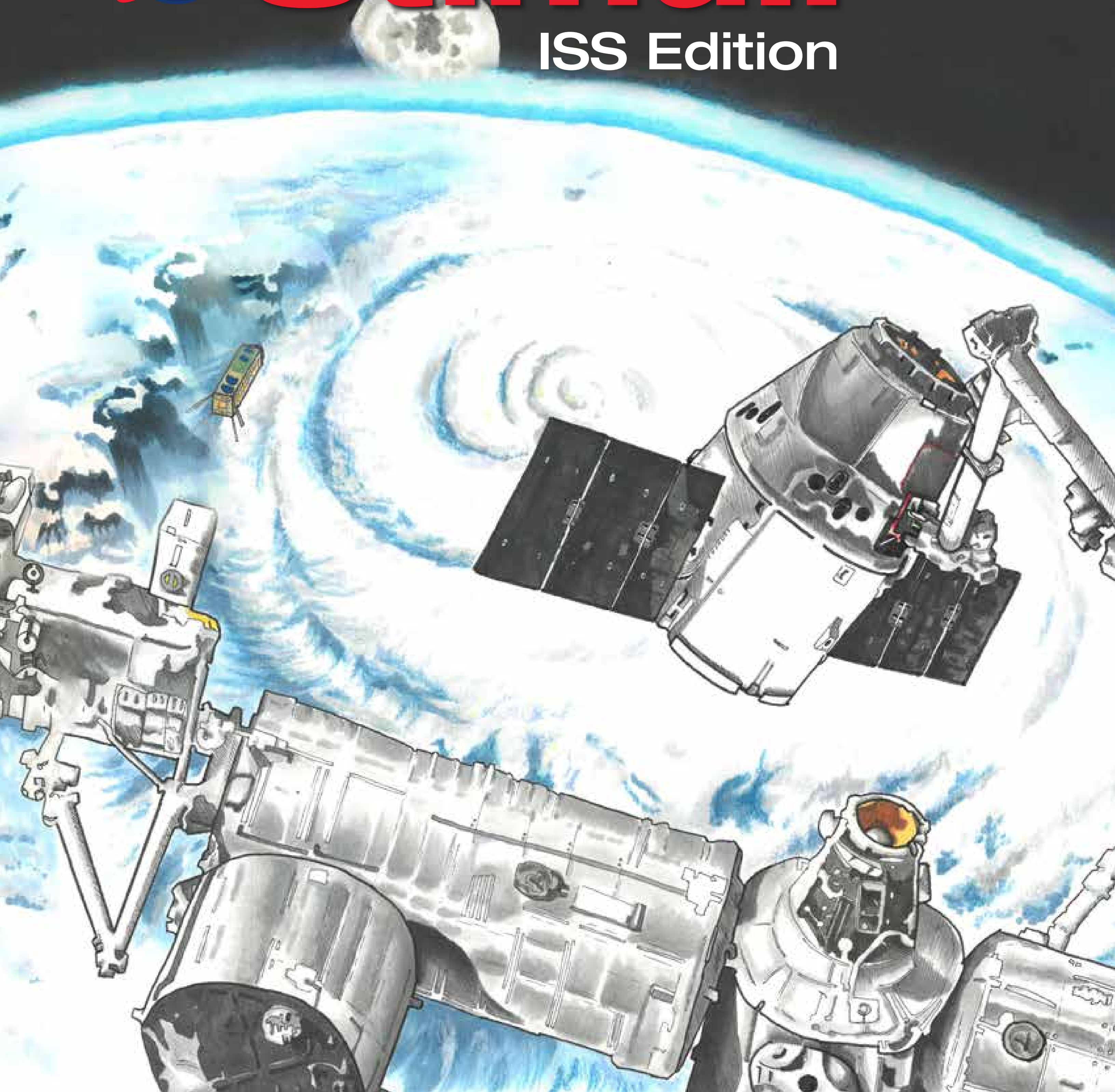
National Aeronautics and Space Administration

NASA EPSCoR Stimuli

ISS Edition



NASA EPSCoR

National Aeronautics and Space Administration

Headquarters
Washington, DC 20546-0001

November 1, 2018

Reply to Attn of: Office of STEM Engagement

Greetings,

In 1957, Sputnik, the first satellite to orbit the Earth was only the size of a grapefruit, yet important enough to cause a space race and within a year later, the creation of NASA. Sixty years later NASA is celebrating by looking back on its history of amazing accomplishments from the early days of Mercury, Gemini, and Apollo, the Space Shuttle Program, and finally to the largest spaceship ever to orbit the Earth, the International Space Station, often referred to as the ISS.

The ISS is an international research lab dedicated to the advancement of science for all humanity. In 2005 the NASA Authorization Act designated the US segment of ISS as a national lab. Recently, the NASA Office of STEM Engagement's EPSCoR program and the ISS Research Integration Office joined together to establish the EPSCoR ISS Flight Opportunity Project. This unique project allows the EPSCoR researchers to test or demonstrate their research in a microgravity environment. Thus far, the project has demonstrated a wireless leak detection and location system; tested self-healing materials exposed to open space; launched CubeSats to test communications, navigation, radiation hardening; and is getting ready to test re-entry heat shield materials with a possible Mars application.

As you browse through this ISS issue of Stimuli note the people, the diversity, and the results of their labor. The research is highly technical and although it is being flown to prove its space application, it also has the potential to benefit and improve life on Earth.

The Office of STEM Engagement is pleased to produce and dedicate this issue of Stimuli to the ISS Research Integration Office to showcase the important contributions the two offices are making through shared cost, shared resources, and shared expertise of the people. Together, our teams will continue to make important contributions to NASA's next 60 years.

Sincerely,

Michael A. Kincaid
Associate Administrator for Office of STEM Engagement

National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
2101 NASA Parkway
Houston, Texas 77058-3696

Reply to Attn of: OZ-18-122

The primary mandate of the International Space Station (ISS) is that it be used for space based research. Whether it is taking advantage of the microgravity environment or the exposure to the thermosphere the ISS flies through or using ISS as an observation or deployment platform, the overarching goal is to accomplish as much research as possible in space. As one step in fulfilling this mandate, the ISS University Research Program contacted the Established Program to Stimulate Competitive Research, also known as EPSCoR, and after several meetings, EPSCoR was invited by to develop a program to fly university research projects on the ISS.

The ISS University Research Program and the EPSCoR project office jointly developed the ISS Flight Opportunity solicitation which was released in 2014. Five research projects were initially selected for flight on the ISS. Since that time, 17 research projects have flown or are in the process of being flown. The resultant research has consistently proved successful and an additional 5 projects will be added in 2019.

During this 60th anniversary of NASA, America is preparing to return to the Moon. On December 11, President Trump signed Space Policy Directive 1, a change in national space policy that provides for a U.S.-led, integrated program with private sector partners for a human return to the Moon, followed by missions to Mars and beyond. We foresee the research conducted on the ISS as a major contribution to this effort.

To increase awareness of the above process, the EPSCoR program has dedicated this edition of their annual *Stimuli* document to the EPSCoR ISS Flight Opportunity. In the following pages, we present the researcher's annual reports to demonstrate how the relationship between the ISS University Research Program and the Office of STEM Engagement's EPSCoR program has resulted in research that supports the ISS mandate while also directly supporting NASA mission requirements.

Sincerely,

Marybeth Edeen

Manager, ISS Research Integration Office

Highlighting Our PIMs and RIMs

Payload Integration Manager (PIM)

A Payload Integration Manager (PIM) is assigned to each payload by the ISS Payloads Office. The PIM functions as the primary point of contact between the Payload Developer and the ISS Program. Once a PIM is assigned to a payload, the PIM provides the Payload Developer with guidance during the entire integration process. The PIM is responsible for the successful integration of a payload to ISS and the launch vehicle.

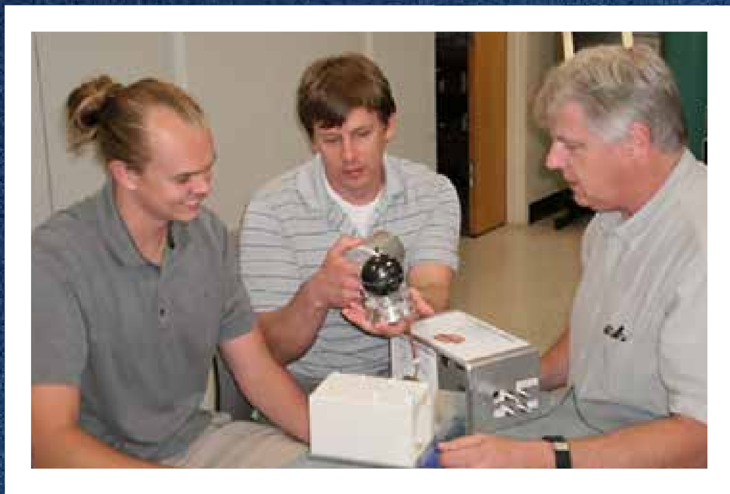
Research Integration Manager (RIM)

A Research Integration Manager (RIM) is responsible for the successful technical integration of experiments/payloads for launch and operation on the International Space Station (ISS). One of NASA's top priorities for research aboard the ISS is the development and testing of new technologies and materials considered for future exploration missions.

Team members from Alpha Space Test & Research Alliance, LLC Kirk Nelson (l), Maria Katzarova (c) and Nathan Hughart (r), Payload Integration Engineer, after completing the MISSE-9 integration of the LEO-STF-treated space suit layups

Steve Huning, Research Integration Manager and Uma Verma, ISS Payload Integration Manager

Will Lutz, Research Technician and Payload Developer, Professor Gloria Borgstahl, PI and Payload Developer and Graduate Student



Dr. Eric Benton (r), The University of Oklahoma examines the Active Tissue Equivalent Dosimeter (ATED) with team members

Dr. Brock LaMeres (left), Montana State University with team members and Willie Williams (right), Johnson Space Center

Dr. Eric Eberly, NanoRacks Technical Monitor talks to class at Montana State University

Holly Mein, ISS Payload Integration Manager, The Boeing Company

University of Louisville team looking at their ACE-T12 samples. From left to right: Chris Lant (ZIN Technologies), Dr. Gerold Willing (UofL), Luke Hawtrey (UofL), J. Ellery Payne (UofL) and Ron Sicker (NASA)

Dr. Ali Abedi with Payload Integration Manager Brandon Wagner at the Johnson Space Center

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Improved EVA Suit MMOD Protection Using STF-Armor™ and Self-Healing Polymers

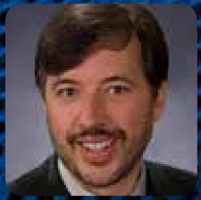
University of Delaware/NASA Johnson Space Center, Human Exploration & Operations, Space Technology Mission Directorates, International Space Station

Industry Collaboration: STF Technologies, LLC and Alpha Space Test and Research Alliance, LLC

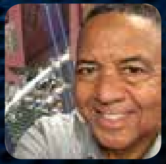
Dr. Katzarova and Alpha Space Test and Research Alliance engineers, post-integration of the LEO-STF-treated spacesuit materials with the MISSE-9 ram, swing side, materials sample carrier deck, June 2017

The low-Earth orbit (LEO) environment exposes astronauts performing extravehicular activity (EVA) to potential threats from micrometeoroid and orbital debris (MMOD). Moreover, impacts of MMOD with the International Space Station (ISS) can cause craters along hand railings which can pose a cutting threat to astronauts during EVA missions. In this research, we are developing advanced nanocomposite textiles based on STF-Armor™ to improve astronaut survivability. The aim of these investigations is the incorporation of the STF technology to improve the protection of astronaut EPGs capable of withstanding extended exposure to the space environment during multiple EVAs. A hypodermic needle puncture test is used to simulate the threat posed by damaged surfaces. LEO-compatible-STF-treated spacesuit layups are two times more resistant to puncture than the current TMG, without sacrificing weight and thickness of the spacesuit.

The longevity and robustness of LEO-STF-treated spacesuit materials, successfully launched with the Materials International Space Station Experiments, MISSE-9, aboard SpaceX-14 resupply mission on April 2, 2018, will be tested over the next year. The samples will be exposed to extreme levels of solar- and charged-particle radiation, atomic oxygen, hard vacuum, and temperature extremes. The gathered data including monthly high-resolution images of the samples, temperature, particulate contamination and UV intensity data can be used to evaluate the proposed LEO-STF spacesuit materials for possible use in planetary exploration beyond Earth such as NASA's mission to Mars.



Prof. Norman J. Wagner
Science PI
University of Delaware

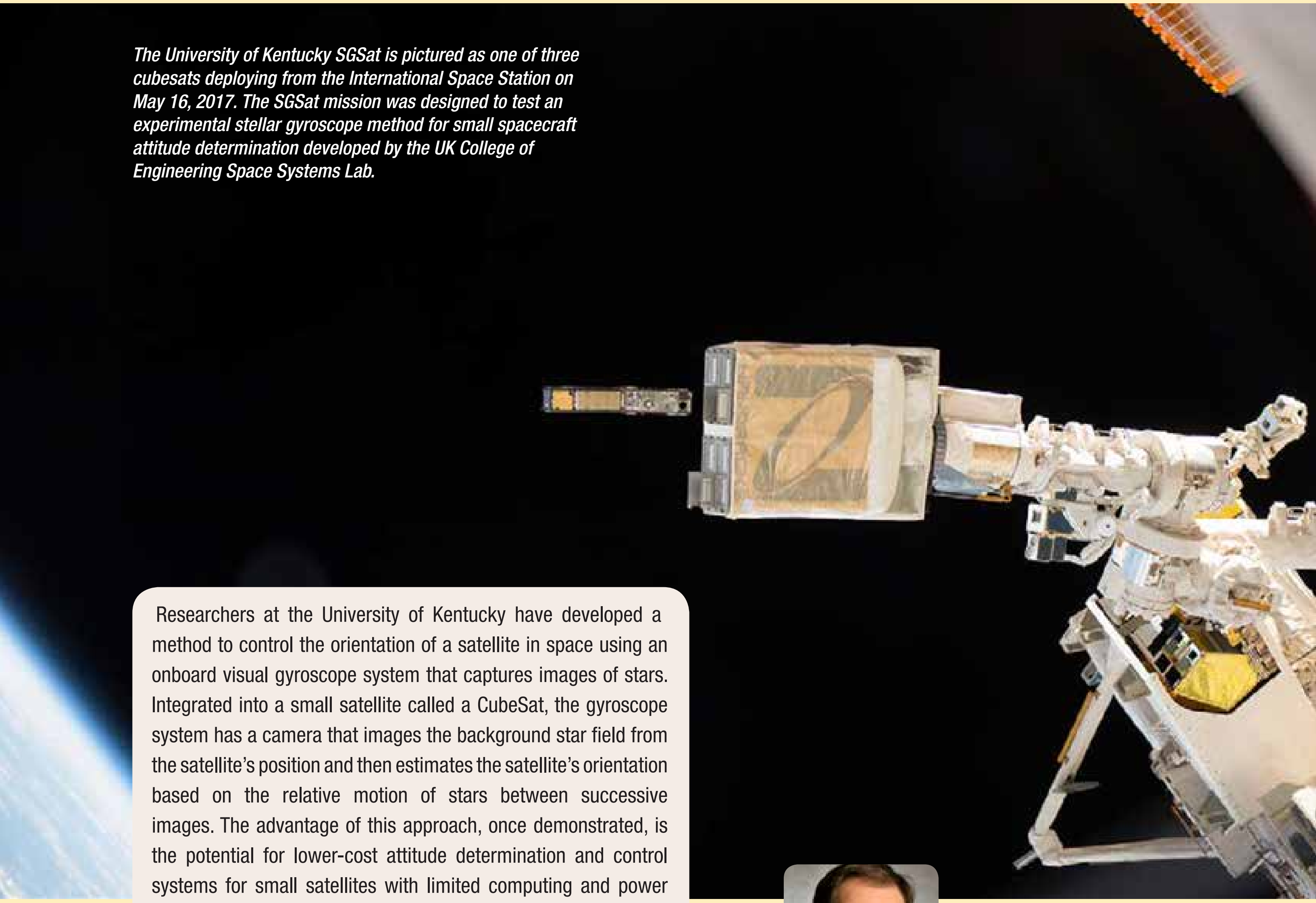


Willie Williams
NASA Technical Monitor
Johnson Space Center

Validation of a Cubesat Stellar Gyroscope System

University of Kentucky/NASA Johnson and Kennedy Space Centers/Human Exploration & Operations and Space Technology Mission Directorates, International Space Station

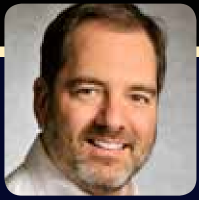
Industry Collaboration: NanoRacks



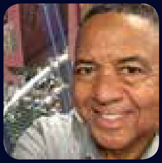
The University of Kentucky SGSat is pictured as one of three cubesats deploying from the International Space Station on May 16, 2017. The SGSat mission was designed to test an experimental stellar gyroscope method for small spacecraft attitude determination developed by the UK College of Engineering Space Systems Lab.

Researchers at the University of Kentucky have developed a method to control the orientation of a satellite in space using an onboard visual gyroscope system that captures images of stars. Integrated into a small satellite called a CubeSat, the gyroscope system has a camera that images the background star field from the satellite's position and then estimates the satellite's orientation based on the relative motion of stars between successive images. The advantage of this approach, once demonstrated, is the potential for lower-cost attitude determination and control systems for small satellites with limited computing and power resources, which may dramatically increase the utility of small satellite missions.

A team of students and faculty at the University of Kentucky Space Systems Lab prepared the CubeSat, called SGSat, for launch into low-Earth orbit from the International Space Station in 2017. This NASA EPSCoR project gives researchers in the UK College of Engineering access to space to test their concepts and hardware, while also providing UK students firsthand experience with spacecraft testing and operations.



Dr. James E. Lumpp, Jr.
Science PI, Professor
University of Kentucky



Willie Williams
NASA Technical Monitor
Johnson Space Center

Joint Leak Detection and Localization Based on Fast Bayesian Inference from Network of Ultrasonic Sensors Arrays in Microgravity Environment

University of Maine/NASA Johnson Space Center, Human Exploration & Operations Mission Directorate

Industry Collaboration: Boeing

Leaks causing air and heat loss are a major safety concern for astronauts. A wireless leak detection system created by University of Maine researchers was launched to space in 2016 aboard a JAXA HTV-6 rocket to the International Space Station. The prototype, which was tested at the Wireless Sensing Laboratory (WiSe-Net Lab), and NASA JSC has led to increased safety of space missions. Electrical engineering graduate students Casey Clark (UMaine MSc student, now at SpaceX) and Lonnie Labonte (UMaine PhD student, now at NASA GSFC) worked on this payload. The project involved the development of a flight-ready wireless sensor system that can quickly detect and localize leaks based on ultrasonic sensor array signals. The device has six sensors that detect the frequency generated by the air as it escapes into space and triangulates the location of the leak using a series of algorithms including stochastic signal processing and estimation theory principles. The device then saves the data on a SD cards that are sent back to Earth. The device is fast, accurate and capable of detecting multiple leaks and localizing them with a lightweight and low-cost system.

MSEE Student, Project Manager and Professor Ali Abedi (Science PI).

Willie Williams
NASA Technical Monitor
Johnson Space Center

Actual payload placement photos from inside ISS.

Space Flight Demonstration of a Radiation Tolerant, FPGA-Based Computer System on the International Space Station

Montana State University, Bozeman/NASA Marshall Space Flight Center, Glenn Research Center, Human Exploration & Operations and Space Technology Mission Directorates
International Space Station

ISS installation of the MSU Computer by ESA astronaut, Thomas Pesquet (bottom = Pesquet taking computer out of storage bag; top = Pesquet plugging the computer into the NanoRacks internal experiment locker).

Researchers at Montana State University are currently testing a new type of radiation tolerant computer technology on the International Space Station. The project is known as RTcMISS (pronounced Artemis), which stands for "Radiation Tolerant computer Mission on the International Space Station". The computer uses a novel approach to mitigating radiation-induced faults using spare processors that are continually reconfigured in real-time. This approach allows processors that are faulted by radiation to be repaired without halting the computer. This increases performance and improves reliability by giving the system backup processors it can rely on. To date, the computer has been running without error for 7 months on the ISS. The NASA EPSCoR program gave this program its initial start in 2010 through a research initiation grant and has now provided an opportunity to reach its highest level of maturation through a demonstration in orbit. The NASA EPSCoR ISS Flight Opportunity has allowed the computer technology to reach a readiness level of 7, which is only two steps away from being a fully adoptable technology for NASA missions.

Dr. Brock J. LaMeres
Science PI
Associate Professor
Montana State University

Willie Williams
NASA Technical Monitor
Johnson Space Center

Investigation of Fatigue Due to Solar Neutron and Other Radiation Absorption in New Materials for Neutron Voltaic Devices

University of Nebraska, Lincoln/NASA Glenn Research Center, Goddard Space Flight Center, Science Mission Directorate, International Space Station

Industry Collaborators: Rhombus, LLC and Trojan Defense, LLC

Detecting neutron radiation: The Adventures of Solar Neutrons

by Peter Dowben, Nicole Benker

Neutron radiation from the sun can damage satellites and harm astronauts in space. But unlike electrons and protons, neutrons don't have any electric charge. Neutrons can pass through many kinds of solid objects without being scattered or absorbed. This makes it difficult to build devices to detect them, so we need special materials that absorb neutrons and leave a measurable signature when they do. To get around this difficulty, researchers at the University of Nebraska-Lincoln are studying the effects of solar neutron radiation on two types of materials on the International Space Station (ISS), using detectors made of very stable compounds that contain boron-10 and lithium-6 that readily absorb neutrons far better than most other elements. Since neutrons from the sun are too energetic to be "caught" by the detectors, we had to reduce their energy first. The neutron moderator "steals" energy from neutrons as they pass through the material. The UNL Detector for the Analysis of Solar Neutrons (DANSON) experiment's lithium tetraborate crystals and boron carbide diodes were encased in a neutron-moderating polycarbonate (Fig. 1). Placing the detectors at different depths allows us to determine the energy of the neutron radiation we capture—we can infer that neutrons captured deeper in the moderator must have had higher starting energy, since they were able to penetrate further into the material.

Now that the DANSON experiment has returned from the ISS, we analyzed the neutron detector elements and found that the steady state neutrons, from the sun, have a mean energy in the region of 1 to 2 MeV with a flux of more than 125 to 188 neutrons cm-2s-1. This is a significant neutron flux. This provides a novel glimpse into the nuclear fusion processes that fuel our sun.

Students assembling part of the detector assembly before handoff to NASA for verification and then launch

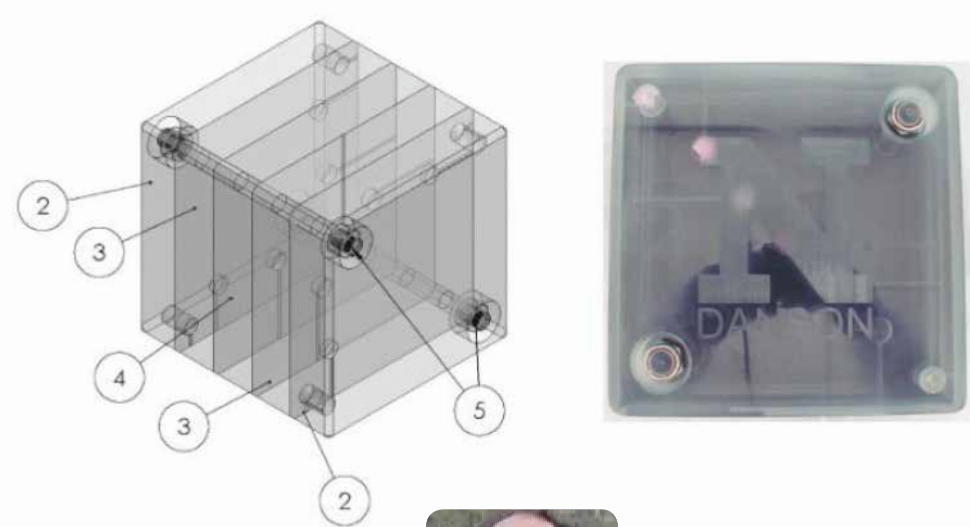
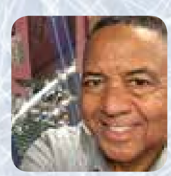


Fig. 1 The DANSON moderator cube diagram and photo. By encasing the detector elements in a neutron-moderating plastic, we can "slow down" the neutrons enough for the detectors to capture them.

Dr. Peter Dowben
Science PI
University of Nebraska, Lincoln



Willie Williams
NASA Technical Monitor
Johnson Space Center

NASA astronauts Scott Kelly and Tim Kopra commanded the Canadarm2 to release Cygnus Feb 19, 2016 at 7:26 a.m. EST when it began gracefully departing the vicinity of the station. Cygnus ultimately burned up during reentry through the Earth's atmosphere on Saturday, Feb 20.

Time Course of Microgravity-Induced Visual Changes

Geisel School of Medicine at Dartmouth/NASA Johnson Space Center, Marshall Space Flight Center, Human Exploration & Operations Mission Directorate, International Space Station

Industry Collaborators: Wyle Labs and Creare, LLC

During the first full protocol run through, Allison Anderson, Ph.D. self-administers the EyeNetra exam while experiencing lower body positive pressure in the prone position. Research assistant Kseniya Masterova monitors her progress.

This research project will allow us to measure the time course of the changes to the length of the eye (axial length) in space. This will help to understand why astronauts are returning home after long duration missions with changes to their vision. The mechanism for the axial length changes in space is unknown, and we are using numerical modeling to develop hypotheses about how these changes could occur. One key missing element in the model, however, is the time course for the changes. It is not known if axial length changes happen right away in space, or develop over time. Different time courses suggest different mechanisms for the changes, and so critical axial length information must be known to build an accurate model. Our project aims to provide a simple, on-orbit way to track changes in axial length. As the length of the eye changes, the location where light focuses in the eye changes. We plan to measure this change where the light focuses using a portable autorefractor (a type of device often used in the eye clinics to determine the prescription strength needed for glasses). Sending this type of device to the International Space Station will enable us to us measure and understand how the length of the eye changes in space and to determine the time course of those changes. Additionally, the autorefractor could be used as a clinical tool by NASA flight medicine to help evaluate astronauts' vision and determine changes to their eyeglass prescriptions.

Dr. Jay C. Buckey, MD
Science PI
Geisel School of Medicine

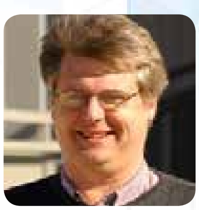
Devin Cowan, Research Programmer, is shown with Willie Williams, NASA Techical Monitor from Johnson Space Center

Demonstration of the OSU Tissue Equivalent Proportional Counter for Space Crew Dosimetry Aboard the International Space Station

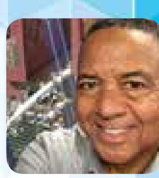
The University of Oklahoma, NASA Johnson Space Center,
Human Exploration & Operations Mission Directorate, International Space Station

The Active Tissue Equivalent Dosimeter (ATED), developed by the Radiation Physics Laboratory at Oklahoma State University, is a compact, portable, low cost ionizing radiation detector designed for use on a range of different platforms including manned spacecraft, unmanned satellites and space probes, high altitude balloon flights and on commercial, civil (business) and military aircraft. We are currently preparing for the first experiment of ATED on the International Space Station scheduled to being in March 2018 with the launch of SpaceX-14. The instrument is based on a gas-filled tissue equivalent proportional counter designed to simulate a ~3 □m3 biological cell such that the sensitivity of the detector to ionizing radiation is similar to that of human tissue.

Exposure of astronauts to elevated levels of ionizing radiation is one of the major hazards of spaceflight—especially long duration space missions such as the human exploration of Mars or the establishment of human habitats on the Moon. Real time monitoring of the radiation levels that space crews are exposed to will be essential on human exploration missions. ATED will measure the radiation dose received by crew during spaceflight as functions of time and the orbital location of the ISS.



Dr. Eric Benton
Science PI
The University of Oklahoma



Willie Williams
NASA Technical Monitor
Johnson Space Center

OSU Graduate Student adjusting the ATED detector head during calibration exposures at the HIMAC heavy ion accelerator in Chiba, Japan

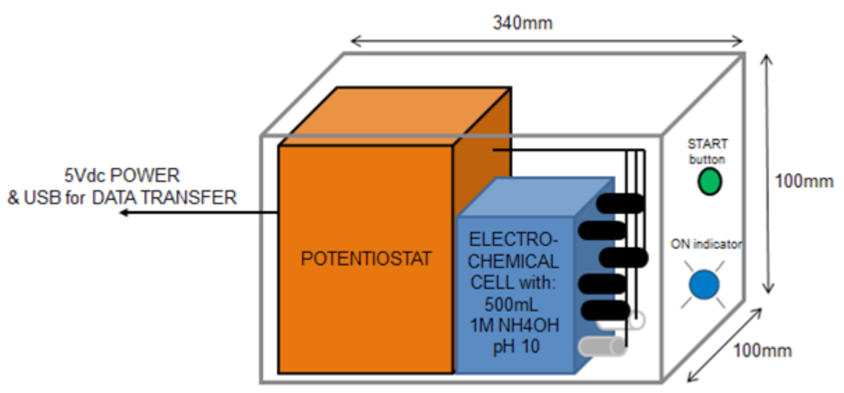
PR

2016

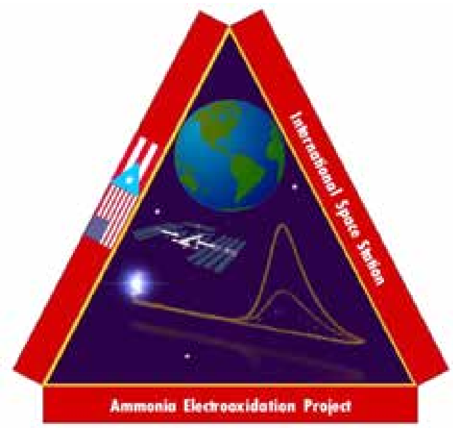
Elucidating the Ammonia Electrochemical Oxidation Mechanism Via Electrochemical Techniques at the International Space Station

University of Puerto Rico, NASA Johnson Space Center,
Human Exploration & Operations Mission Directorate, International Space Station

This project is a collaborative effort in conjunction with NASA Ames Research Center (ARC) to specifically address the Forward Osmosis Secondary Treatment (FOST) technology of urine reclamation. A key subsystem of the FOST is the so called Electrochemical Ammonia Removal (EAR) subsystem. The EAR is an ammonia electrochemical removal system with a setup similar to a fuel cell. In the electrochemical process ammonia molecules are oxidized to gaseous nitrogen (N_2) while reducing oxygen molecules from air at the cathode producing hydroxide molecules (OH^-), which are diffused through an anion exchange membrane to the anode side to produce water. The formation of stagnant nitrogen gas on the catalyst materials occurs under microgravity conditions causing a decrease on the EAR system energy production. The nanostructuring of catalyst materials is necessary to enhance nitrogen gas moving away from the catalysis site responsible for the ammonia oxidation and energy production.



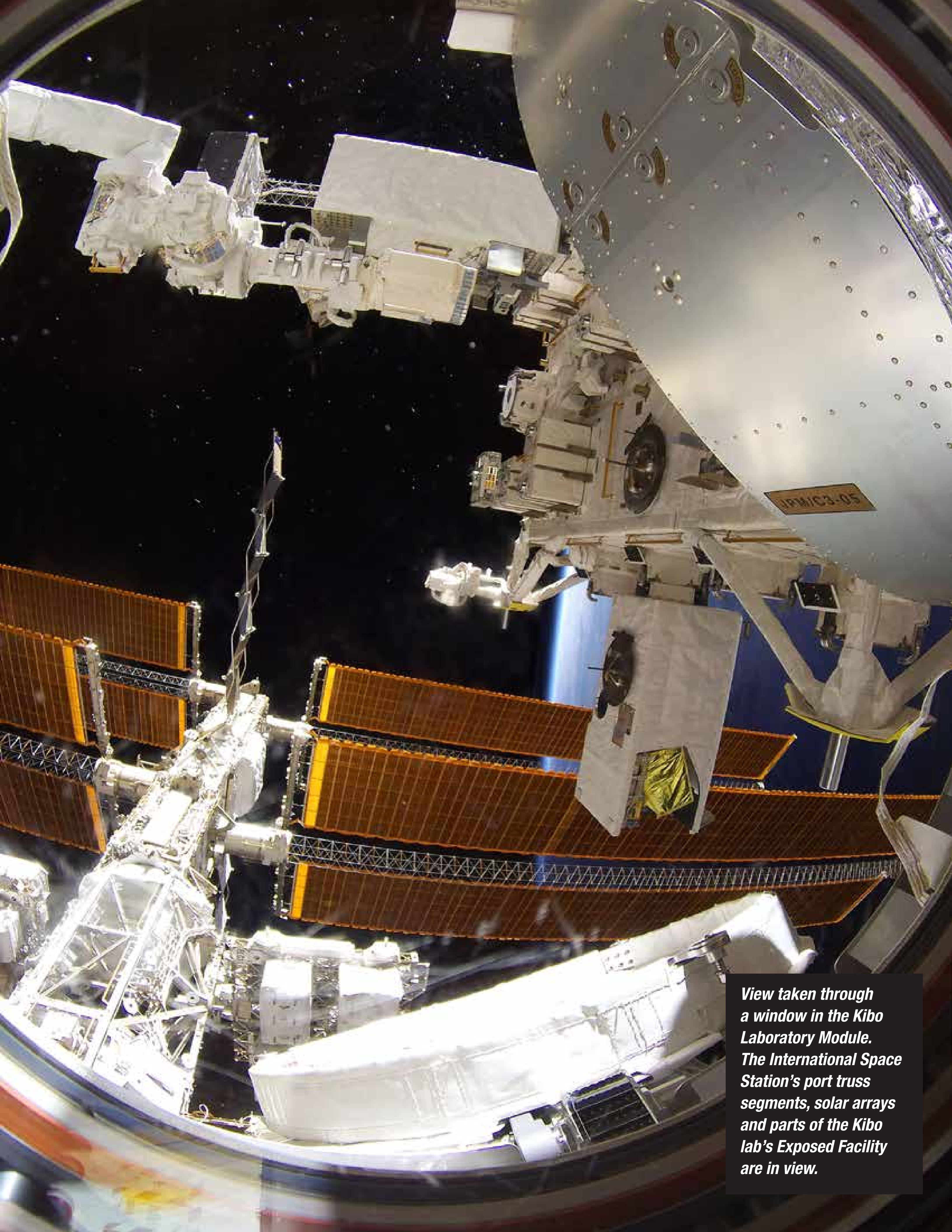
Schematic drawing of the electrochemical experimental setup to be placed at the ISS.



UPR-ISS Logo

Willie Williams
NASA Technical Monitor
Johnson Space Center

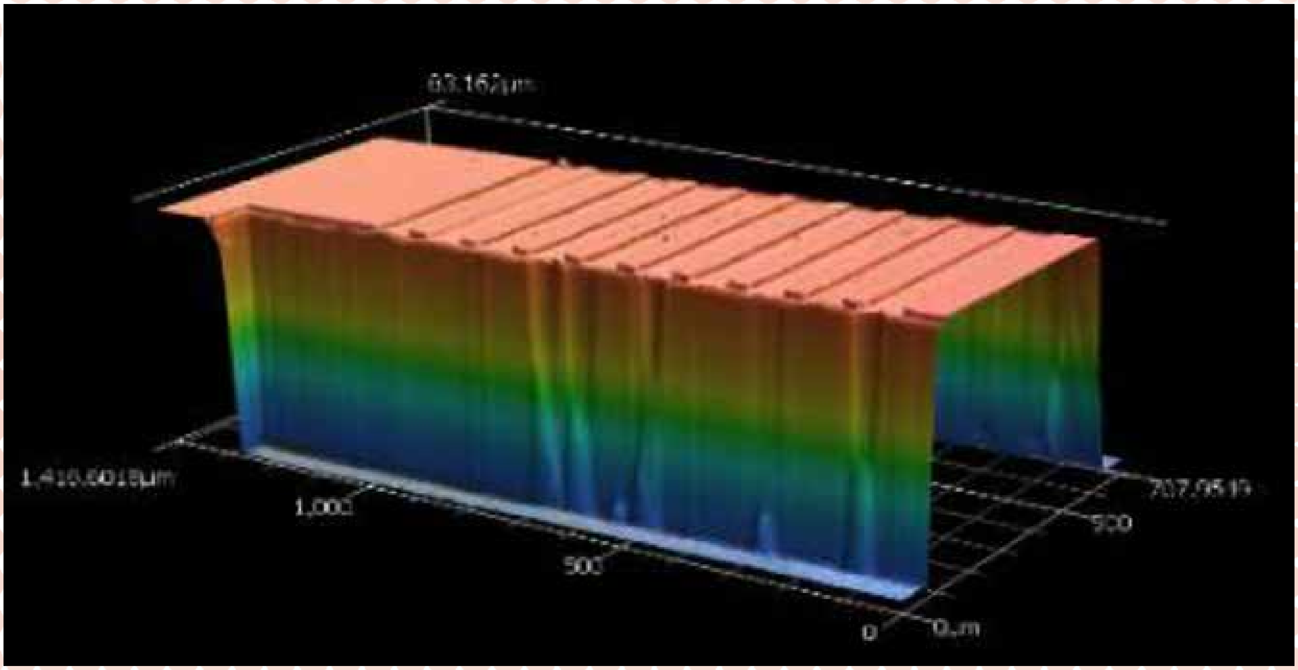
UPR-ISS Team:
Prof. Eduardo Nicolau,
Graduate Students and
Prof. Carlos R. Cabrera,
Science PI.



View taken through a window in the Kibo Laboratory Module. The International Space Station's port truss segments, solar arrays and parts of the Kibo lab's Exposed Facility are in view.

Arkansas CubeSat Agile Propulsion Technology Demonstrator Mission (ARKSAT-2)

University of Arkansas, Fayetteville, NASA Johnson Space Center, Human Exploration & Operations and Space Technology Mission Directorates



A laser scanned image of an array of 10 channels that are 2.2 µm deep and 500 um long that have demonstrated the ability to contain the liquid propellant when one end is exposed to vacuum.

The design of a novel cold-gas (like a duster can) micro-propulsion system, called CubeSat Agile Propulsion System (CSAPS) for small satellites of the nano-satellites class (1-10kg) that is low-cost, non-toxic, non-flammable, and no-pressurized at launch conditions is currently being developed at the University of Arkansas. The propellant is a water-propylene glycol mixture, where the latter is often used as a food additive; not to be confused with the highly toxic ethylene glycol found in common car coolants. Central to the CSAPS is the phase separator technology that uses micro/nano-channels with diameters in the range of 1/100 to 1/10000 millimeters. These tiny channels help contain the liquid propellant mixture and only permits water vapors to be passed and feed the thruster nozzles.

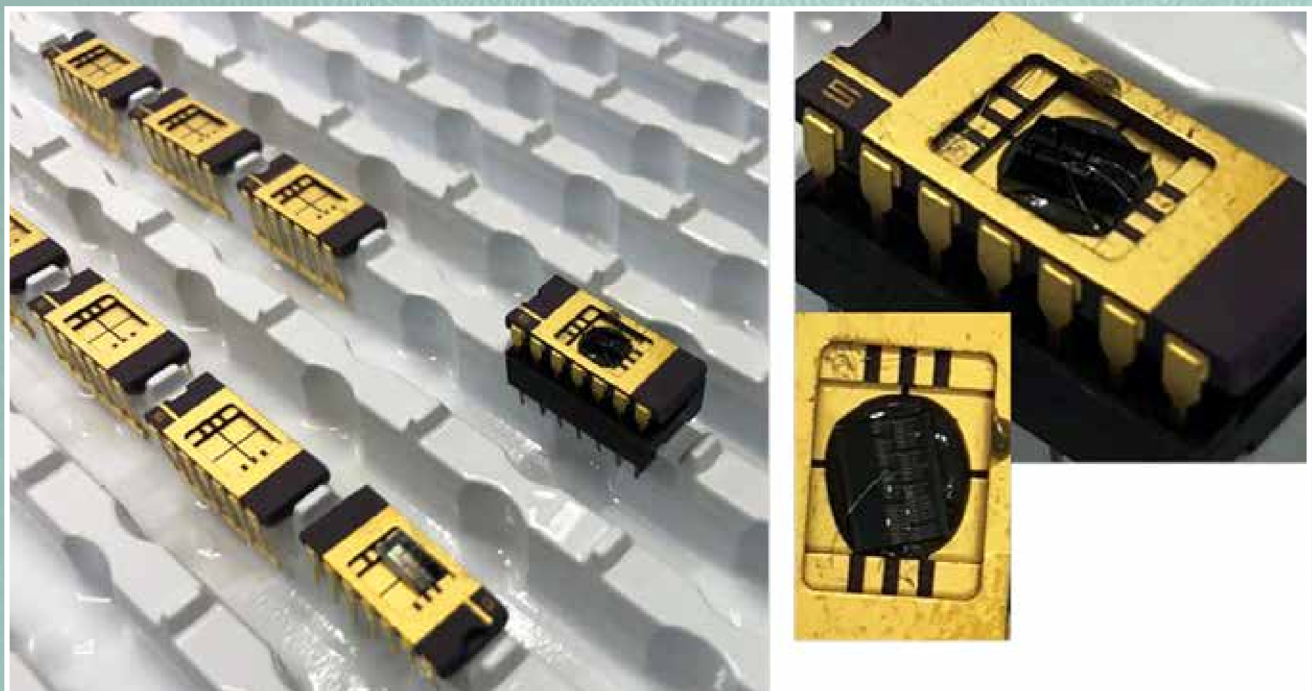
Po-Hao Huang
Science PI
University of Arkansas, Fayetteville

Elwood Agasid
NASA Technical Monitor
Deputy Program Manager
Small Spacecraft Technology Program,
Ames Research Center

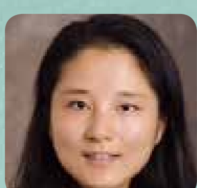
Evaluation of Graphene-Silicon Photonic Integrated Circuits for High-Speed, Light Weight and Radiation Hard Optical Communication In Space

University of Delaware, NASA Johnson Space Center, Human Exploration & Operations Mission Directorate, Space Technology Mission Directorate, International Space Station

Industry Collaboration: Nokia Bell Labs

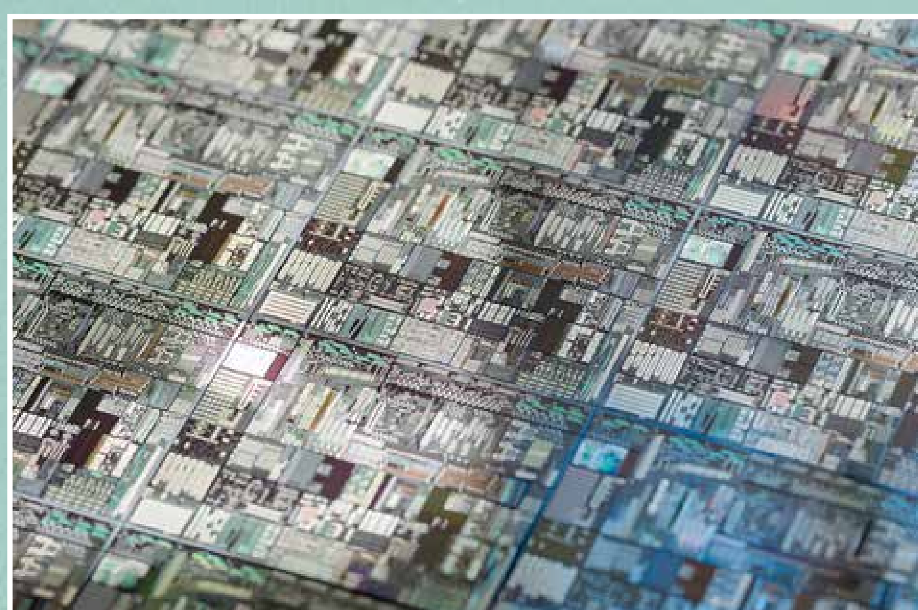


Packaged photonic chips at University of Delaware Nano Fabrication (UDNF). The packaged device will fly on 2018 RockSat-C Program launching on June 22, 2018 from NASA's Wallops Flight Facility of Chincoteague Island, Virginia.



Tingyi Gu, Science PI
Assistant Professor
Electrical & Computer Engineering
University of Delaware

NASA Technical Monitor
Dr. Michael A. Krainak
Goddard Space Flight Center



Optical image of the wafer scale integrated photonic devices made in CMOS foundry.

Enhanced Science on the ISS: Influence of Gravity on Electrokinetic and Electrochemical Assembly in Colloids

University of Louisville, NASA Johnson Space Center, Human Exploration & Operations and Science Mission Directorates, International Space Station

Industry Collaboration: Proctor & Gamble

Dr. Stuart J. Williams
Science PI
Associate Professor
Mechanical Engineering
University of Louisville

Dr. William V. Meyer
NASA Technical Monitor
Glenn Research Center

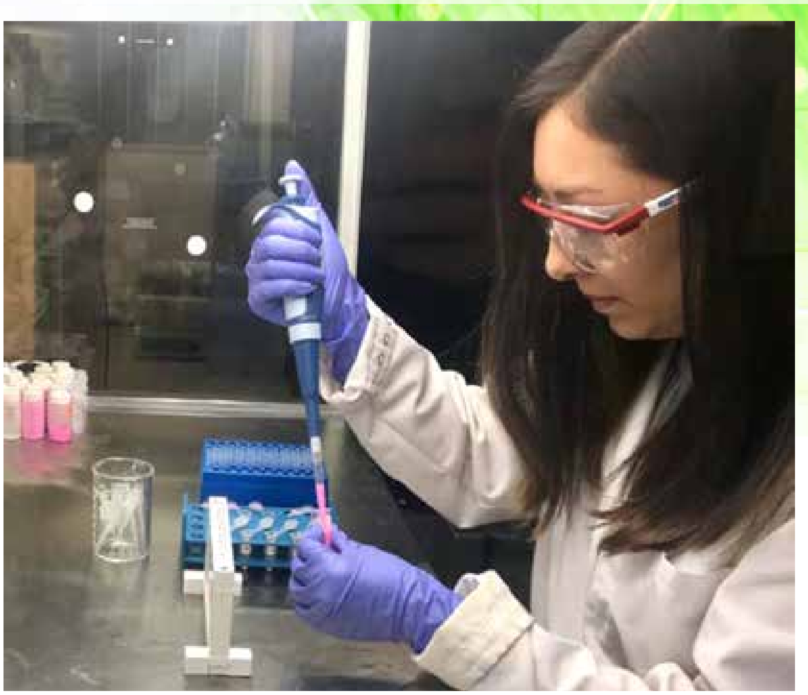
University of Louisville (UofL) faculty and student researchers are working with NASA Glenn Research Center and the NASA International Space Station (ISS) Program to examine behavior of fluids in the microgravity environment of low-Earth orbit.

The project, Enhanced Science on the ISS: Influence of Gravity on Electrokinetic and Electrochemical Assembly in Colloids, investigates how to precisely control colloids and develop potential for new materials with enhanced energy, thermal, optical, chemical, and mechanical properties. Colloids are liquids, like milk, that contain suspended particles. Experimentation will research colloid synthesis and nanoparticle haloing of colloidal samples in terrestrial and microgravity experiments.

This NASA EPSCoR research project utilizes the national laboratory onboard the International Space Station to gain fundamental understanding of colloidal interactions under minimal influence of gravity, enabling insight into the physics that govern colloidal stability and assembly.

UofL researchers were awarded this second launch of an experiment to ISS to conduct additional research improved by results of a previous ISS flight in 2016. Due to this additional flight opportunity, this Kentucky research team will now incorporate insight gained from their previous experiment as well as benefit from the space station's newly upgraded confocal microscope. The team will be working with a research group capturing the first 3D microscopic imaging onboard ISS.

On the ground, additional experimentation and sample characterization are being conducted to properly compare on-earth observations with results acquired from the ISS. UofL professors are incorporating this experience with space-based research into their classes and student research programs and advancing collaboration with industrial and academic partners.



The University of Louisville has prepared flourescent silsequioxane microparticle solutions that also contain a concentration of zirconia nanoparticles for microgravity experimentation. The stability of the microparticle suspension will be visually monitored on the ISS. Credit: Williams Research Group, University of Louisville

Utilizing ISS as a Test Bed to Validate the Performance of Nano-Enhanced Polymers Subjected to Atomic Oxygen and/or Hypervelocity Impact

University of Mississippi, NASA Johnson Space Center, Human Exploration & Operations and Space Technology Mission Directorates and International Space Station

Industry Collaboration: Victory Solutions, Inc.

The current EPSCoR funded research is aimed at developing and testing a new class of ultra-lightweight nano-composite sheet that can provide significant improvement in the shock absorption/attenuation and dispersion of modern debris shields. These new shields could be retrofitted on ISS and also used on spacecraft destined for planetary missions.

The long-term strategic vision of the UM research activities (which has been enriched by the EPSCoR opportunity) is to provide an integrated, interdisciplinary research environment to foster academic and industrial partnership, and to educate a globally competitive science and engineering workforce to advance the engineered systems. Four new graduate courses were developed as part of this initiative and a new graduate degree in nano engineering and science has been proposed to the school of engineering at UM. Various research programs within the University of Mississippi (UM), and partner Universities, are poised to contribute discoveries and innovations in the modeling, synthesis, characterization, and production of advanced materials with new and exciting characteristics applicable to the fields of engineering, physics, chemistry and pharmacy. A number of academic courses and programs are preparing innovative professionals and scientists, knowledgeable leaders, and literate citizens for a "materials" world. By working together, those involved in these programs can pool their talents and resources to amplify their collective impact.

Research Associate Xiaobing Li Testing Graphene Reinforced Polymers for Hypervelocity Impact Application

Marisabel Kelly
NASA Technical Monitor
Glenn Research Center

Dr. Ahmed Al-Ostaz
Science PI
University of Mississippi

Satellite Demonstration of a Radiation Tolerant Computer System Deployed from the International Space Station

Montana State University, Bozeman, NASA Johnson Space Center,
Human Exploration & Operations and Space Technology Mission Directorates, International Space Station

RadSat-g being deployed out of Deployer from International Space Station

The overall goal of this project is to conduct a satellite mission to demonstrate a novel radiation tolerant computer technology. A 3U small satellite will be deployed from the International Space Station (ISS) using the NanoRacks CubeSat Deployer (NRCSD), which will provide 12 months of operation of the computer technology in Low Earth Orbit (LEO). The successful operation of the computer in a full stand-alone mission will increase its technical readiness level (TRL) to TRL-9. This computer technology has been in development for nearly a decade at Montana State University (MSU), with the majority of funding coming from NASA EPSCoR. The computer technology is currently in-orbit on the ISS as an internal experiment through funding from the 2014 NASA EPSCoR ISS Flight Opportunity program. This internal demonstration has allowed our team to verify the operation of the computer in a controlled environment and reach TRL-7. In this proposal, we seek funding to support a different, more advanced experiment in which the computer technology will be integrated into a satellite, deployed from the ISS, and operated for 12 months in LEO. This next critical demonstration is necessary to take the computer technology to its final level of TRL-9. The proposed satellite has been selected by the NASA CubeSat Launch Initiative (CSLI) program for a flight in summer of 2018. As such, we do not require any launch services support from the EPSCoR program. Our team has also been able to design and prototype the satellite through the NASA Undergraduate Student Instrument Program (USIP). These prior NASA programs have enabled our technology to be ready for flight within 12 months of project funding. The funding request in this proposal is for flight unit qualification, integration, and safety coordination (achieving TRL-8) to demonstrate the computer in LEO using the ISS-based NRCSD (achieving TRL-9).

RadSat-g from Montana State University tests a new computer architecture that can recover from faults caused by space

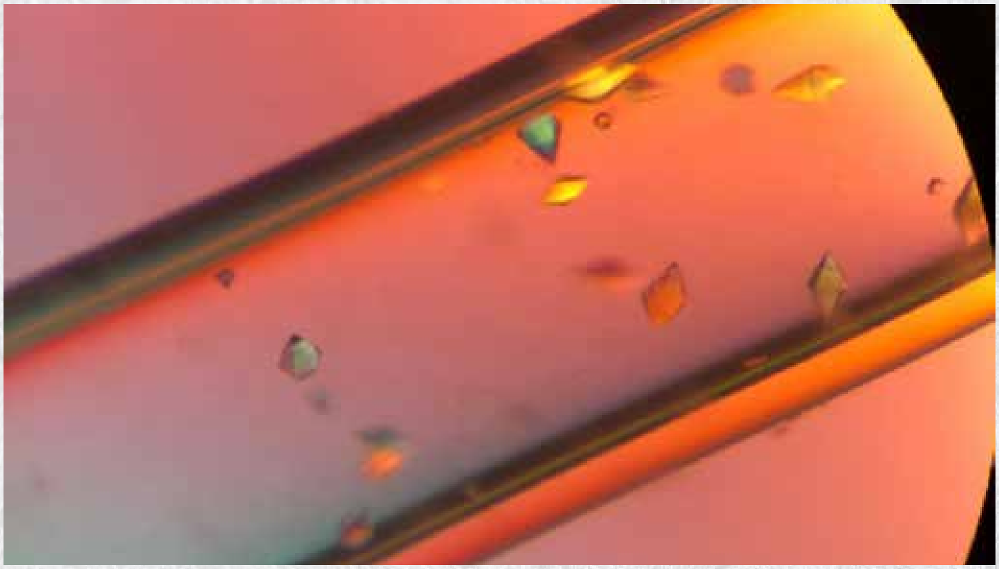
Dr. Eric A. Eberly
NASA Technical Monitor
Marshall Space Flight Center

Dr. Brock J. LaMeres
Scientce PI
Associate Professor
Montana State University

Growth of Large, Perfect Protein Crystals for Neutron Crystallography

University of Nebraska, Omaha, NASA Johnson Space Center, Human Exploration & Operations, and Science Mission Directorates, International Space Station

Industry Collaborators: Protransit Nanotheraphy



Photograph of human MnSOD crystals grown in a GCB. Gravityinduced convection currents prevent the growth of large volume crystals on Earth by this method.

Sridhar Gorti, Ph.D
NASA Technical Monitor
Marshall Space Flight Center

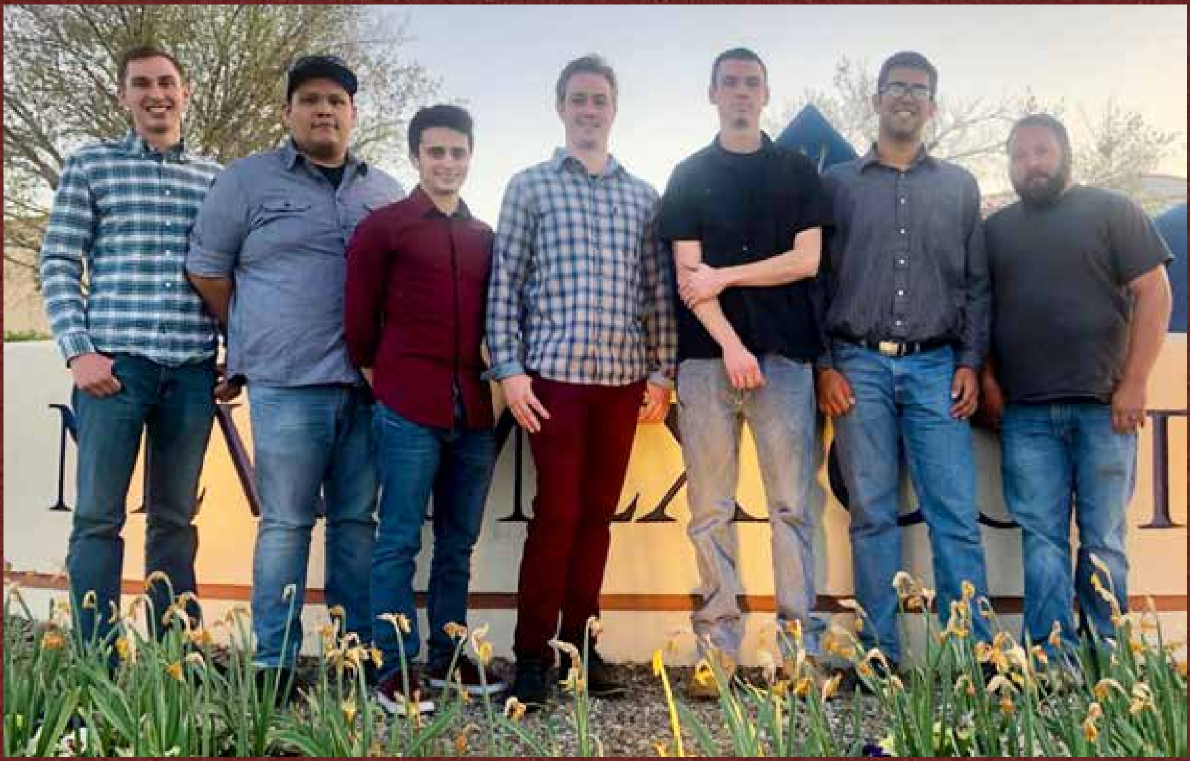
The susceptibility of astronauts to radiation-induced disease has instigated large efforts in biochemical technologies to combat the effects of radiation exposure. The detrimental consequences of radiation are derived from its production of reactive oxygen species (ROS) in cells of the human body. The most significant organic molecule in countering ROS within human cells is manganese superoxide dismutase (MnSOD). While research over five decades has proven that MnSOD is one of the most significant proteins for human health and vitality, how MnSOD works is still unknown. Our research aims to discern the mechanism of MnSOD using recent technological developments in neutron crystallography, where a neutron beam diffracts off crystallized MnSOD molecules. Despite the developments in neutron crystallography, high quality and large crystals are needed to yield the quality data needed to reveal the mechanism. To circumvent this issue, we proposed growing crystals in specialized hardware aboard the International Space Station, which we are now preparing for in collaboration with the Johnson Space Center. Our previous work has demonstrated that protein crystals grown in a microgravity are of significantly higher quality compared to earth grown counterparts. The quiescent environment in space has proved to be paramount in resolving the mysteries of the radio-protective MnSOD and harnessing its working for preventing radiation damage.

Gloria Borgstahl, Ph.D., Science PI, (middle) with two of her doctoral graduate students.

Students preparing human MnSOD samples in the Borgstahl laboratory

In Orbit Structural Health Monitoring of Space Vehicles

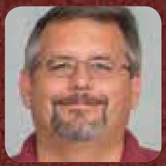
New Mexico State University, NASA Johnson Space Center, Human Exploration & Operations and Space Technology Mission Directorates, International Space Station



Undergraduate design clinic research team.

Would you like to go to space? Would you like to worry less about risks of such a travel? Would you worry less if you know that your spacecraft feels the flight environment and adapts to maximize safety and minimize maintenance cost? This project focuses on development of a structural health monitoring (SHM) approach for space vehicles and testing it in low Earth orbit (LEO) environment aboard of international space station (ISS). It is expected that SHM system will provide real-time data on structural conditions at all stages of the spaceflight and will be used in re-certification for the next flight; or, as a part of a "black box" for event investigations. As the space industry is moving towards smart structures with integrated sensors and actuators; understanding functionality, performance, and longevity of such structures in the space environment is of paramount importance. The team has started research efforts to investigate the effects of the space environment on piezoelectric sensors – active elements of SHM, to explore structural vibrations in microgravity and to demonstrate the feasibility of SHM during long term space missions. It is anticipated that such research will have long lasting significance to the space industry and particularly its commercial branch.

Graduate Student, left, shown with Andrei Zagrai, Science PI, New Mexico Institute of Mining and Technology



John D. Lekki
NASA Technical Monitor
Glenn Research Center

Assessment of Radiation Shielding Properties of Novel and Baseline Materials External to ISS

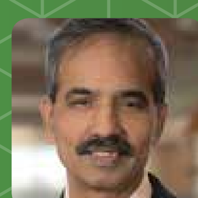
Oklahoma State University, NASA Johnson Space Center, Human Exploration & Operations and Space Technology Mission Directorates, International Space Station

Filament extrusion set up (top and side views).

In 2014, NASA EPSCoR funded the "Radiation Smart Structures with H-rich Nanostructural Multifunctional Materials" project to develop new multifunctional materials to shield space crews from the ionizing radiation environment encountered during space flight. This project also includes a major component to test the radiation shielding properties of these novel materials using ground-based particle accelerators and computer model-based simulations. A number of promising new materials have been developed as a result of this work, in particular a hydrogen-rich carbon fiber composite suitable for use in the fabrication of high-pressure storage tanks for oxygen, water and other consumables needed during space flight and in the pressure vessel of the space craft or planetary habitat.

In response to the NASA EPSCoR ISS Flight Opportunity CAN of 12/5/2016, we propose an experiment to test and measure the radiation shielding and other properties of our multifunctional materials in the actual space environment external to the International Space Station (ISS). The proposed experiment would consist of mounting samples of the multifunctional materials, as well as samples of a number of baseline materials such as aluminum, polyethylene and copper, on the existing Materials for ISS Experiment (MISSE) [1,2] platform. Another possibility would be to use a NanoRacks external platform [3]. Passive radiation detectors in the form of CR-39 plastic nuclear track detector (PNTD) and thermoluminscence detector (TLD) will be placed behind the material samples at varying depths in order to measure the Linear Energy Transfer (LET) spectrum, absorbed dose, and the biologically weighted dose equivalent as a function of depth behind the materials. These types of detectors require no electrical power and have been successfully used by the proposers on several previous experiments to measure ionizing radiation outside spacecraft [4-8].

The proposed experiment is highly feasible, not only in terms of the proposed budget ($90K), but also in terms of the five (5) feasibility criteria listed in Section 1.5 of the CAN. By using existing facilities (MISSE or NanoRacks), hardware costs are minimal and time to flight is less than 1 year, crew time is already allocated as part of the larger MISSE or NanoRacks programs, the experiment does not require power, and the physical space requirements are already allocated, again as part of the larger MISSE or NanoRacks programs. Previous experience with measuring radiation on the exterior of spacecraft indicates a strong likelihood of success.



Ranji Vaidyanathan
Science PI
Oklahoma State University

Laurence Thomsen
NASA Technical Monitor
Langley Research Center

3D Printed Titanium Dioxide Foams Under Extreme Environment Exposure at Low-Earth Orbit

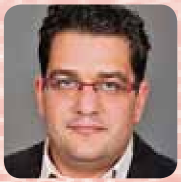
West Virginia University, NASA Johnson Space Center, Human Exploration & Operations and Space Technology Mission Directorates, International Space Station

The proposed project will combine research in materials science and physics of liquid foams with 3-D printing to further advance robotic printing of titanium dioxide (TiO2) foams and understand their degradation behavior upon exposure to the space environment Low Earth Orbit (LEO). These printed foams exhibit great potential for space applications ranging from efficient solar cells to batteries and radiation shielding.

The proposed experimental work will be accomplished by using the MISSE–FF platform at the ISS to expose the Earth-printed foam samples at LEO conditions. Potential degradation mechanisms will be investigated, upon return to Earth, using a suite of characterization methods. These degradation data for the 3-D printed specimens will give significant early insight into the applicability of our TiO2 foam materials for the identified potential space applications before going forward and exploring their printing characteristics under microgravity conditions. During this project, further collaborations with NASA (both locally and Nationwide), and UTV will be fostered. Also, a graduate research student will be trained for years 1 and 3 of this project.

At the end of the proposed work it is expected that an advanced understanding about TiO2 foam degradation mechanisms at LEO will be attained. We expect to attain insights about potential erosion mechanisms of the organic components of the foams due to high atomic oxygen flux. Also, the role of carbon-based materials such as graphene and CNT's will be investigated in terms of strengthening the printed structures.

Renishaw core metal foam. Photo by Michael Petch.



Dr. Konstantinos Sierros
Science PI
West Virginia University

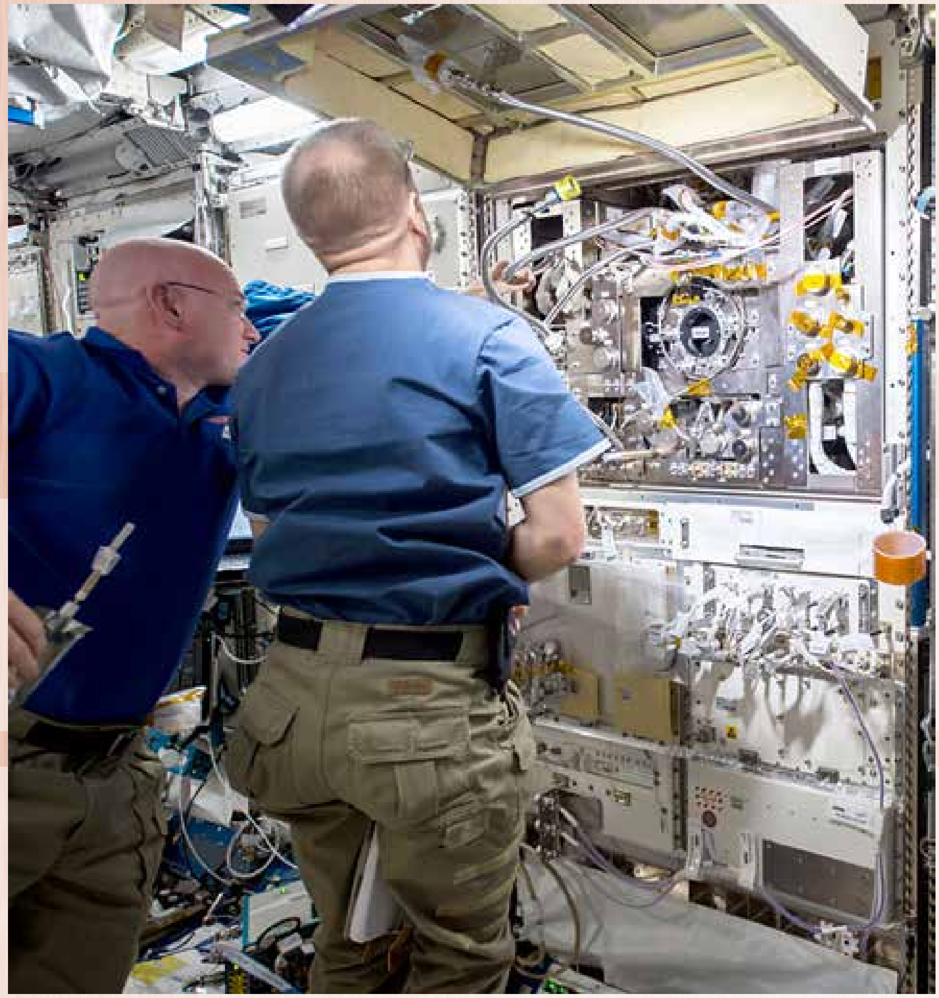
Justin R. Morris
NASA Technical Monitor
NASA Goddard Space
Flight Center / IV&V

This wide view of the seven windows of the International Space Station's Cupola serves to give a paneled look of Earth, in this case, a point in the South Atlantic. The Cupola is used to conduct experiments, dockings and observations of Earth such as this. The observatory was launched aboard STS-130 on Feb. 8 2010 and attached to the Tranquility node.

Silicon-Cobalt Alloy Properties

University of Alabama, Huntsville,
Human Exploration & Operations Mission Directorate

This proposal addresses Research emphasis to enable the eventual production of high-silicon-transition metal alloys. The thermophysical property measurements will use the Japan Aerospace Exploration Agency Electrostatic Levitation Furnace. The casting simulation requires precise and accurate thermophysical and physical properties during the entire solidification process. Among the required thermophysical properties are the viscosity, surface tension, density, and heat capacity, among others. Metals and metallic alloys often have high melting temperatures and highly reactive liquid states. Thus, processing these liquids in containers leads to significant contamination and uncontrolled under-cooling behavior. The above is especially true for molten silicon and its alloys. Density and heat capacity are performed as a separate but paired set of experiments. Silicon-transition metal alloys maintain the lower density, high compressive strength, and mitigate the brittleness of pure silicon. While silicon itself is corrosion resistant, it wets and dissolves all but a few materials; molten silicon is commonly called "the universal solvent". The development of low-density (low-mass), high strength, compression alloys for space missions would enable lower mass components resulting in less vehicle mass and higher durability. Silicon and silicon-transition metal alloys are systems that can take advantage of the benefits of containerless processing, or levitation facilities in a low gravity environment. Silicon is a semiconductor or semi-metal depending on the temperature. The levitation and melting of silicon in terrestrial Electrostatic Levitator systems requires close attention and adjustment of the sample size, heating and levitation parameters. Off-eutectic alloys are particularly difficult to process since during melting there is a mixture of liquid and solid. The determination of thermophysical properties such as viscosity, surface tension, density, and heat capacity of silicon alloys is well-suited to electrostatic levitation in a low gravity environment due to the lower electrostatic forces required for sample.

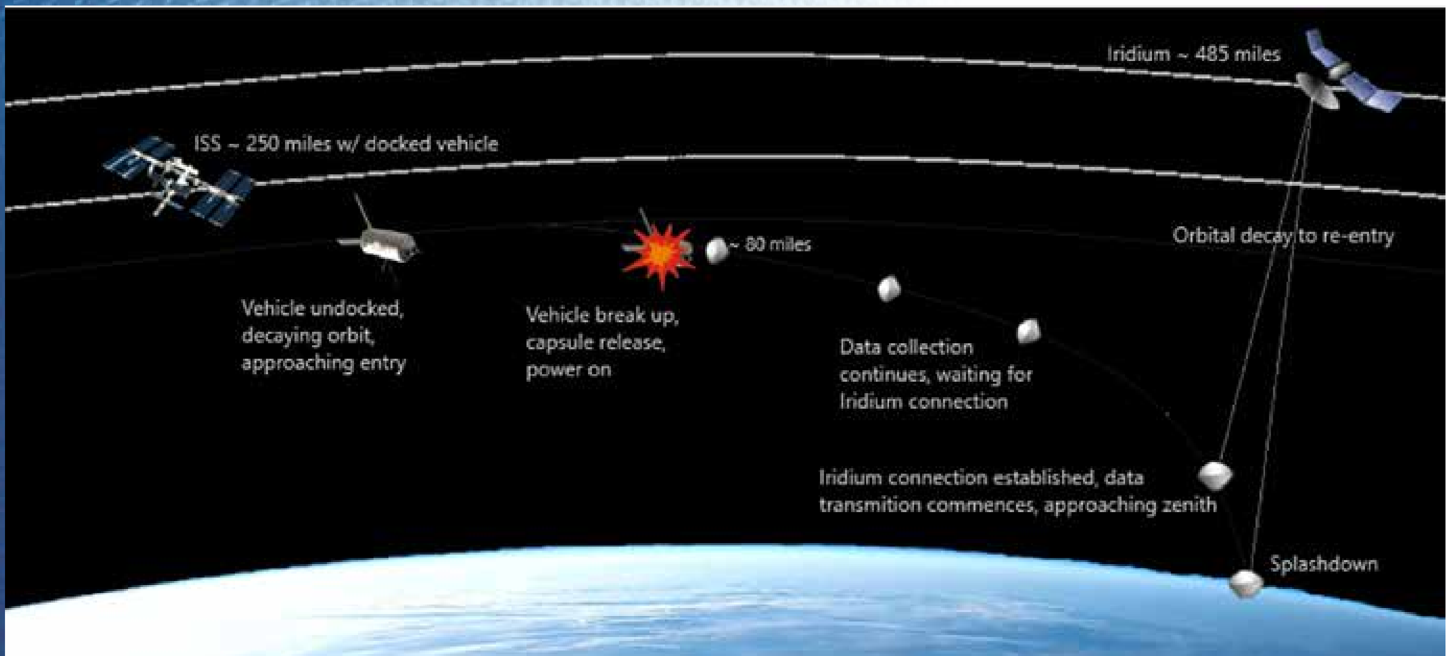


NASA Image: ISS046E018737 - Photographic documentation taken during Multi Purpose Small Payload Rack 2 (MSPR2) Electrostatic Levitation Furnace (ELF) setup by the Expedition 46 crew in the Japanese Experiment Module (JEM) Pressurized Module (JPM). Astronauts Scott Kelly and Tim Kopra are visible are photo during setup

Richard Banish, Science PI

KRUPS: ISS Flight for Heat Shield Testing

University of Kentucky, Lexington,
Human Exploration & Operations and Space Technology Mission Directorates



Concept of Operation for the proposed mission

Thermal protection systems (TPS) are required to mitigate the extreme heating encountered during hypersonic entry into the Martian, Venusian, and outer planet atmospheres as well as for manned and sample-return missions into the terrestrial atmosphere. The design of an efficient TPS remains one of the most challenging tasks of planetary exploration missions. Over the last 50 years, only a handful of high-speed entry experiments have been performed. Not only were these flights part of elaborate and costly exploration programs, but the TPS tested were at the final stage of design. In order to reach that stage, extensive ground test campaigns had to be performed, using arc-jet and hypersonic tunnel facilities, but none were flight proven. There is clearly a need to provide a low-cost testbed to quickly and reliably evaluate TPS materials, and provide orbital flight validation data. The Kentucky Re-entry Universal Payload System (KRUPS) is a small entry capsule designed as a technology test-bed, built at the University of Kentucky. For this first incarnation, KRUPS has been designed to test TPS material and instrumentation. KRUPS recently completed two sounding rocket sub-orbital flights, aimed at testing various sub-systems. After completion of these prior tests, the KRUPS capsule is matured and ready for more extensive tests, this time at orbital velocities. The overall objective of the proposed project is to launch a KRUPS capsule from the International Space Station, and use the capsule to obtain orbital entry data for numerical model validation. The proposed project leverages NASA EPCSoR RA investment by 1) using the modeling codes developed through these investments to design and size the TPS of the capsule and 2) gathering flight data acquired to provide additional validations for these codes.

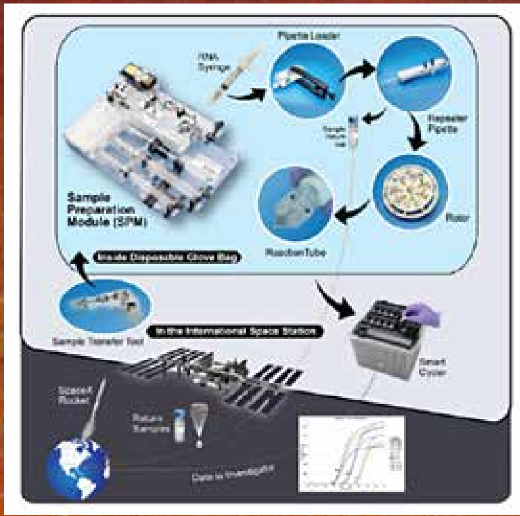
Full-scale KRUPS capsule

Dr. Alexandre Martin, Science PI

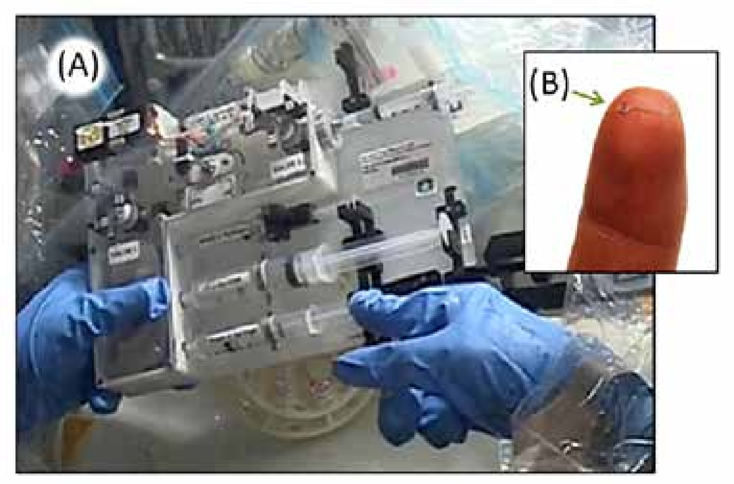
One-Step Gene Sampling Tool to Improve the ISS Bioanalytical Facility

Louisiana Tech University,
Human Exploration & Operations and Science Mission Directorates

This proposal is to request an ISS flight for validation of a solid-phase genetic sampling device that will be a powerful addition to the instruments that are already on-station. This implementation of the technology will reduce crew time for RNA extraction by nearly two orders of magnitude, provide sampling that will be less invasive than existing methods, and provide repeated sampling of specimens. These enhancements represent a significant improvement for space biologists. The small size reduces mass and enhances sampling precision as select tissue volumes can be analyzed. The aim to support extended human presence in space has led to the establishment of NASA's GeneLab, which combines a data base repository dedicated to ISS biological experiments and corresponding ground-based studies. Superior analytical tools such as the proposed technology will enhance genetic analyses at variable intervals without destroying the specimen as is required for traditional technology. The solid-phase extraction avoids transfer of biopsy material is minimally invasive and does not require sacrificing of the specimen. Most valuably, though, the probes need no further processing to separate RNA from the tissue. Based on probe preparation either a sample of all available mRNA or specific mRNA hybridizes to the surface of the probe. In either case no tissue or nuclear contamination occurs. This technology development was funded by a NASA EPSCoR research project entitled, "Genetic Assessment of the Space Environment Using MEMS Technologies".



The current WetLab-2 hardware and workflow (Reproduced from [8]). The SPGE pins described in this proposal can replace the Sample Transfer Tool (STT), the Sample Preparation Module (SPM), the RNA Syringe, and the Pipette Loader in this workflow. Those tools and their associated processes consume the lion share of the crew time that is required to perform gene expression analyses



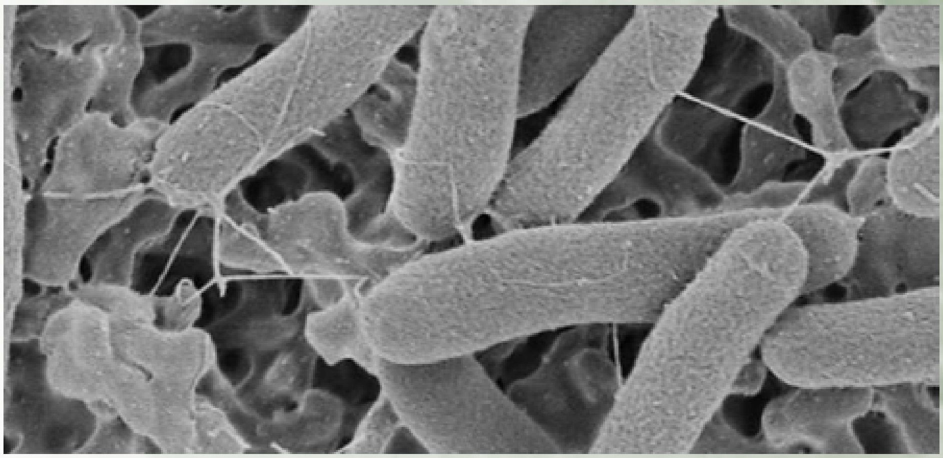
The sample prep module in use on the ISS (A) is manually operated, needing ~15 min of crew time to extract mRNA from a specimen. In contrast, SPGE probes (B) isolate mRNA directly from a living specimen with a brief pin-prick, such that 10 samples could be collected in ~4 min. The yield is ~ 10 ng, which is ideal for immediate RT-qPCR analysis on the WetLab SmartCycler that is in use on the ISS

Dr. Niel Crews, Science PI

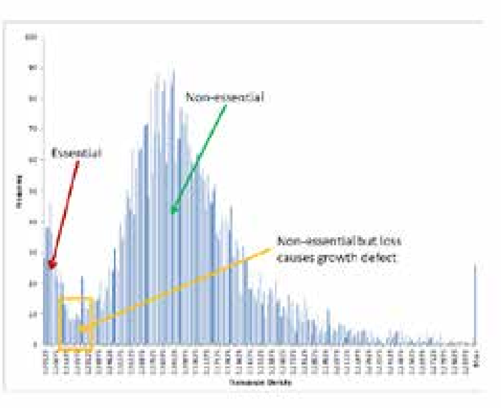
Assessment of Whole Genome Fitness of Bacteria Under Microgravity

University of Mississippi,
Human Exploration & Operations and Science Mission Directorates

The conditions of spaceflight are stressful on living organisms, yet many people believe that bacteria, being so small that they are virtually weightless already, have no particular physiological response to microgravity. However, years of research have shown that bacteria do behave and live differently aboard space-faring vehicles. This is important because bacteria aboard such vessels have been shown to degrade material components and clog critical fluid systems before, as well as potentially pose a disease threat to astronauts. Unfortunately, most studies of bacteria in microgravity either have to use simulated microgravity on Earth which does not match all the various conditions of actual spaceflight, or only focused on one or two specific bacterial characteristics such as attachment to surfaces or stress tolerance. There have been few attempts to assess global bacterial physiological responses to spaceflight. The experiments outlined in this proposal aim to assess every gene in the genome of several bacterial organisms with regard to the fitness they provide for growth during spaceflight. This will be accomplished by using a technique referred to as Comparative TnSeq. In this technique, a target organism is mutagenized to create a library of hundreds of thousands of different mutants. Samples from this library are then grown under two conditions: in this case the first condition is aboard the International Space Station and the second condition is grown in a laboratory on Earth. Genomic DNA is then extracted from each culture and mutations mapped by Next Generation Sequencing. By comparing which mutations become under-represented in the ISS libraries, we can determine which genes are particularly important for growth during spaceflight. This will be done on several bacterial organisms to see how bacteria from different environments and with different physiologies respond to spaceflight, and if there is a gene or process that is universally important to bacterial growth in space-faring vehicles. The more we understand how bacteria respond to spaceflight, the more intelligently we can design mechanisms for their control.



Micro-12 is a life science research mission that will investigate the effects of spaceflight on the physiology of Shewanella oneidensis MR-1, a species of bacteria that has the potential to be a part of the next generation of biologically-based life support systems. The study was launched to the International Space Station (ISS) aboard SpaceX-15 in June 2018.

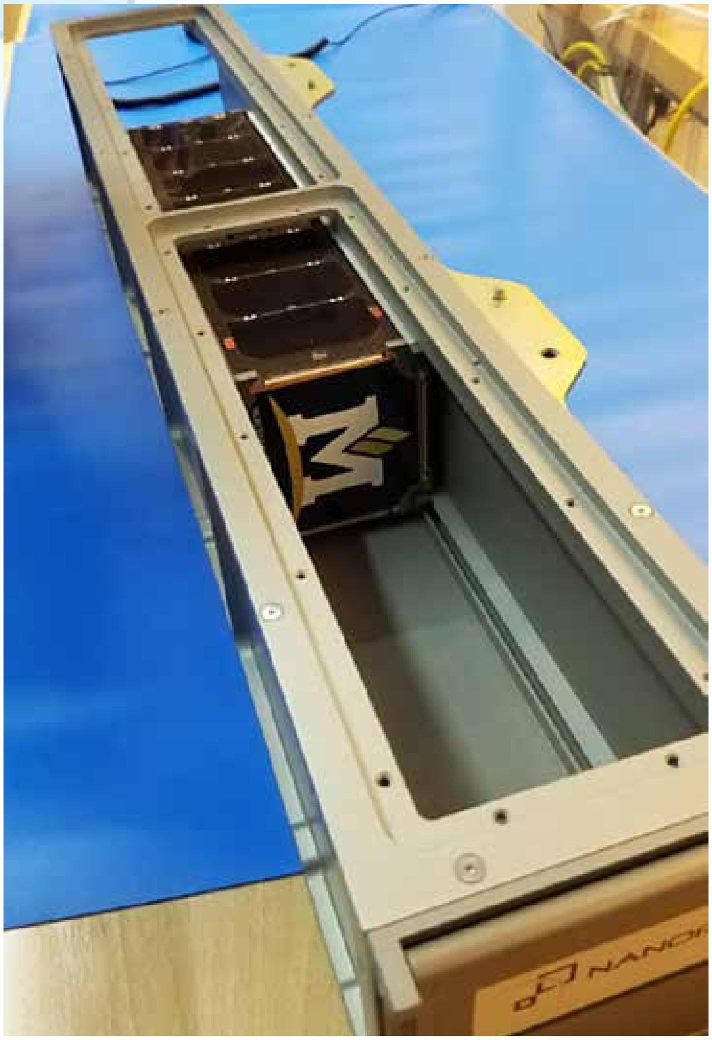


Histogram of transposon densities from A. tumefaciens TnSeq analysis. Densities found in the peak close to the axis are exceptionally low and represent essential genes. Densities in the much larger peak represent non-essential genes. Densities in the trough between the peaks represent genes with high-fitness, where their disruption is non-lethal but does lead to growth defects

Patrick Curtis, Science PI

Demonstration of Radiation Tolerant Memory Synchronization within a Reconfigurable Flight Computer

Montana State University, Bozeman,
Space Technology Mission Directorate



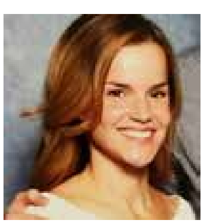
RadSat-g Integration Going Into Cubesat Deployer which was launched on OA9, Orbital ATK in 2018

The overall goal of this project is to conduct a satellite mission to demonstrate the reliability and synchronization of the memory sub-system of a radiation tolerant flight computer. The computer technology employs a novel fault-mitigation strategy that uses redundant processing cores and real-time reconfiguration of the hardware to quickly recover from radiation-induced failures. In 2017, the EPSCoR International Space Station (ISS) Flight Opportunity program funded a 1-year demonstration onboard the ISS to test the real-time reconfiguration of the processing cores of this computer in a space environment. In 2018, the EPSCoR ISS Flight Opportunity program funded a 1-year stand-alone satellite mission deployed from the ISS to test the core recovery procedure in an operational environment. In the proposed project, we will conduct a second ISS-deployed small satellite mission to test the final sub-system required by the computer, the fault tolerant memory system. In this project we will demonstrate the fault tolerant memory system and the core synchronization procedure at the same time. We will leverage the existing 3U satellite design funded by the 2017 EPSCoR ISS Flight Opportunity program to reduce the risk of the mission. The satellite will be carried to the ISS on a commercial resupply mission and then put into orbit using the NanoRacks CubeSat Deployer (NRCSD). This deployment mechanism will provide up to 12 months of satellite operation in Low Earth Orbit (LEO) where telemetry information will be continually downlinked to the MSU ground station in Bozeman, MT

CubeSat Mission Parameters

Mission Name	Mass	Cube Size	Desired Orbit		Acceptable Orbit Range	400 km @ 51.6 degree incl. Acceptable - Yes or No	Readiness Date	Desired Mission Life
RadSat-u	4.0 kg	1 x 3 U	Altitude	400 km	385 - 450 km	Yes	6/1/2019	12-mo
			Inclination	> 40°	40° to 140°			

Dr. Brock J. LaMeres, Associate Professor, Science PI



Our artist for the cover art is Lorraine Charbonneau Hernandez, a Resource Specialist with Logical Innovations, Inc. at the NASA Armstrong Flight Research Center inside the Edwards Air Force Base in California. Lori specializes in comic book and realistic portraits, and her artistic highlight includes having art in a Hurricane Hunter (now retired) plane. Lori primarily works in Copic marker, colored pencil, graphite, and charcoal.

National Aeronautics and Space Administration

John F. Kennedy Space Center
Kennedy Space Center, FL 32899

www.nasa.gov

NP-2018-09-1087-KSC