National Aeronautics and
Space Administration

NASA EPSCoR Stimuli

2018–19

NASA EPSCoR

National Aeronautics and Space Administration

Headquarters
Washington, DC 20546-0001

June 21, 2019

Reply to Attn of: Office of STEM Engagement

Greetings,

NASA has been charged to get American astronauts to the Moon in the next five years with a landing on the lunar South Pole. This will not be flags and footprints, but an American-led investment to establish a sustainable human presence on and around the Moon. We will move forward to the Moon, this time to stay, and then we will use the technologies we develop to make future missions to Mars possible.

This lunar effort involves the whole nation, uniting the brightest minds of academia, businesses and communities of all sizes and types. NASA will have partners from the commercial world contributing our research, scientific instrumentation, payloads, and possibly the launch vehicles and crew capsules. NASA EPSCoR researchers and commercial partners play a major part in this effort, including providing important research into planetary systems, life support systems, new materials, and sensor/platform development.

As you browse through this issue of *Stimuli,* please note the people, the diversity, and the research that is the result of their labor. The research is state-of-the-art and highly technical and is being overseen by NASA researchers to ensure its space application. In addition to advancing space exploration, it 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 our commercial partners and their contributions to our future efforts to place the next man and the first woman on the Moon and then on to Mars.

Sincerely,

Michael A. Kincaid
Associate Administrator
for Office of STEM Engagement

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Alaska Research Infrastructure Development

University of Alaska Fairbanks

Ground-Based Remote Sensing Research Improves Climate and Air Quality Predictions

by Carol Brzozowski

The Artic region – a beacon of global climate change – has undergone dramatic temperature and ecological changes over the past century, with the rate accelerating in recent decades, notes Jingqiu Mao, assistant professor, University of Alaska Fairbanks Geophysical Institute, Department of Chemistry and Biochemistry.

In a research project initiated in 2017 – Mao, along with a graduate student, Professor William Simpson and the Goddard Space Flight Center Pandora project team – use Pandora and MAXDOAS ground instruments to evaluate satellite observations of formaldehyde (HCHO) columns in boreal forests and tundra regions.

A PhD student in the Department of Chemistry is working on the NASA Pandora instrument for remote sensing of atmospheric composition.

Satellite observations of HCHO – an oxidation product of biogenic volatile organic compounds – "serve as a powerful tool to improve our understanding on biosphere-atmosphere exchange on regional and global scales," notes Mao.

Satellite sensor observations tend to have large uncertainties on reactive carbon in the Arctic region due to factors such as instrument sensitivities and retrieval algorithms.

"Ground-based remote sensing significantly narrows down the uncertainties," says Mao, adding that research findings "will improve understanding on biosphere-atmosphere exchange at northern high latitudes and their impact on climate and air quality. Such information will help to better predict future climate and air quality in the Arctic region and how we can adapt to those changes."

Denise Thorsen, PhD
Alaska EPSCoR Director
University of Alaska Fairbanks

Research Helps Understanding of Global Solar Wind – Magnetosphere Interaction

by Carol Brzozowski

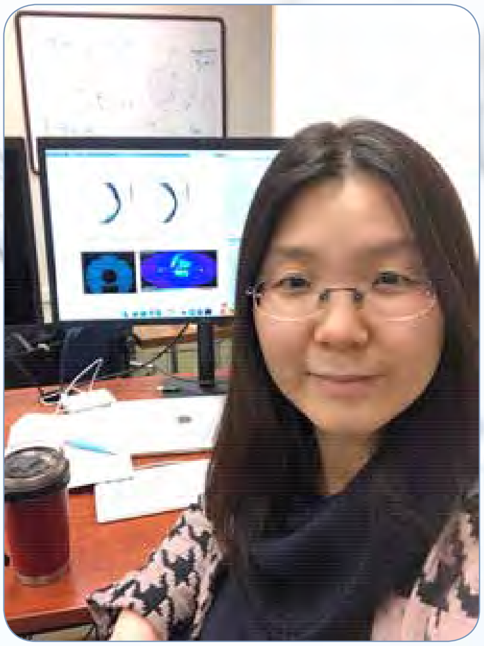
SMILE (Solar wind – Magnetosphere – Ionosphere Link Explorer) – a soft X-ray imaging spacecraft funded by NASA, ESA and China scheduled for a 2023 launch – provides wide fieldof-view soft X-ray images of Earth's dayside magnetosphere to help understand global solar wind – magnetosphere interaction.

Research estimating exospheric neutral hydrogen densities near the subsolar magnetopause by UAF Physics assistant professor Hyunju Connor advances knowledge of Earth's dayside exosphere and its response to the solar cycle.

Estimated densities help predict the strength of near-Earth soft X-ray signals to optimize the SMILE mission.

Soft X-ray is emitted when solar wind plasma steals an electron from the Earth's exospheric neutral hydrogen. Its density is a key parameter of the near-Earth soft X-ray signals, Solar Wind Charge Exchange (SWCX).

High neutral hydrogen density produces strong SWCX signals. Those strong SWCX events observed from the XMM-Newton astrophysics mission dataset and the magneto-hydrodynamics model help estimate dayside neutral densities from solar maximum to solar minimum for more realistic magnetospheric conditions.



Dr. Connor extracts a density of the Earth's outer atmosphere by using the noise of astrophysics data.

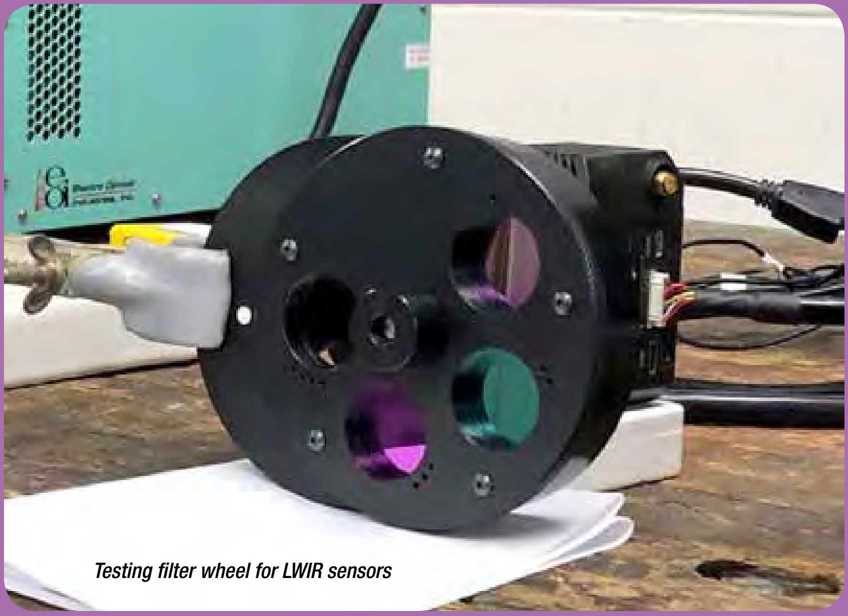
"Our exosphere is composed of mostly a hydrogen atom, the most abundant particle species in our universe," says Connor. "Studying the earth's exosphere is more cost-effective than sending spacecraft to a planet and can help to understand other planets' exosphere."

UAS Infrared Payload Research Reduces Emergency Response Risk

by Carol Brzozowski

VOLCANIC ERUPTIONS AND FOREST FIRES POSE LIFE AND PROPERTY RISKS.

NASA EPSCoR research by Dr. Peter Webley, associate director, UAF Alaska Center for Unmanned Aircraft Systems Integration, has focused on developing an Unmanned Aircraft Systems (UAS) payload with adapted filters to extend current sensors' range and analyze the critical properties first responders and hazard assessment experts need for optimal decision-making and validating modeling approaches in near real-time without personal risk.



Testing filter wheel for LWIR sensors

Current small UAS have broadband long wave infrared (LWIR) cameras onboard that have limits in the measurable temperatures possible from the air and ability to classify the plume or cloud content.

"Ground-based and space-borne remote sensing have developed narrow band approaches to use LWIR sensors to determine gas and/or ash content in volcanic clouds and extend the camera's capability to measure higher temperatures," says Webley.

Research focused on the capability of current small form factor LWIR sensors designed for UAS as well as the impact of narrow band and neutral density filters on the signal-to-noise of the cameras.

The aim: to develop a larger project with NASA collaborators to fully integrate and transition the new system to UAS operations and with UAS manufacturers seeking to adopt the technology for broader utilization.

Stereo-Derived Topography for the Last Frontier and the Final Frontier

University of Alaska Fairbanks

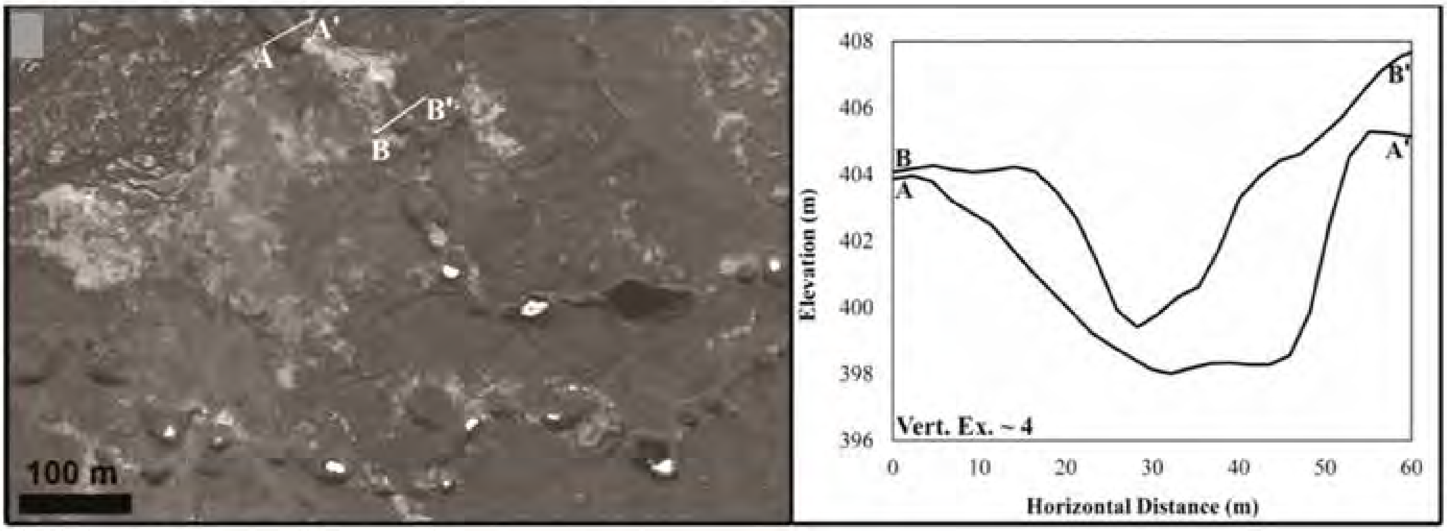


Image of a portion of Lost Jim Lava Flow, Alaska, with profiles across a collapsed lava tube using topography derived from WorldView satellite stereo images

Martian Mapping Helps Scientists Understand Earth's Topography

While it's easier to see the contours of geographic features on Earth, it's not easy seeing similar features on other planets. Using an imaging technique called structure from motion (SfM), Robert Herrick has spent decades mapping celestial bodies.

The SfM process estimates the size and shape of 3D objects using 2D images. The idea is that if you take enough photos from enough angles, you can more accurately determine the topographical makeup of a given area.

Most recently, Herrick – a geophysicist at the University of Alaska Fairbanks – has studied lava flows on Mars. His studies into the behavior of lava and its impact on geography provide clues to Mars' past.

During his project, Herrick worked with volcanologists at the Goddard Space Flight Center and also created the UAF Photogrammetry Lab. The lab provides needed infrastructure to more effectively create and share these complex topographic images on a local, national and international scale.

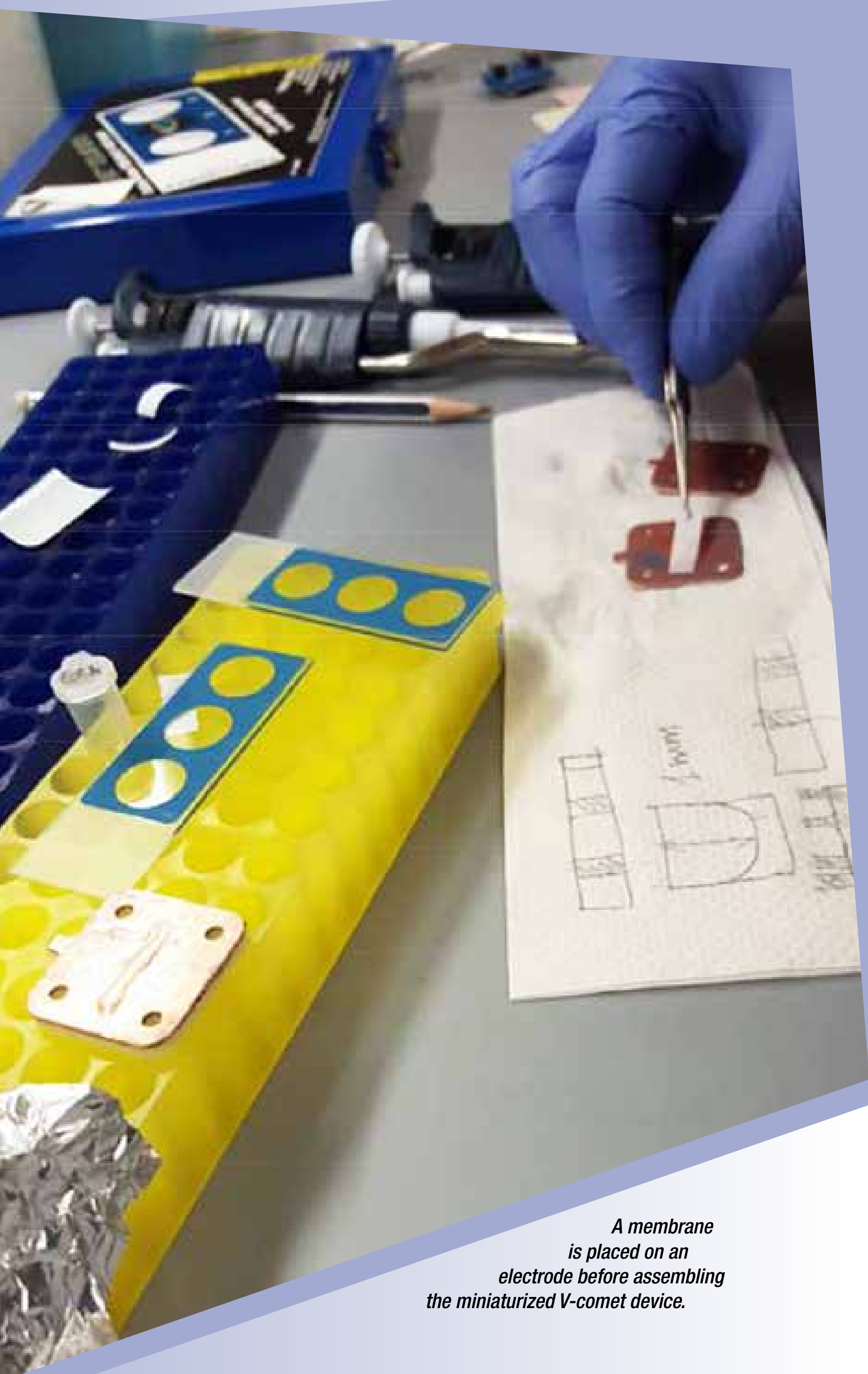
With this infrastructure, scientists can better study geological morphology, engineers will have enhanced visualization for new projects, and exploration firms will have a clearer picture of where to drill or dig. Herrick's research on Mars has real-world impact on Earth, as our planet still has much to reveal.

Science PI
Robert Herrick, PhD
University of Alaska Fairbanks

NASA Technical Monitor
Lori Glaze, PhD
Goddard Space Flight Center

Vertical Comet Assay for Measuring DNA Damage to Radiation

University of Alaska Fairbanks

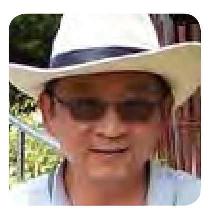


A membrane is placed on an electrode before assembling the miniaturized V-comet device.

Vertical Comet Assay: The Prospect for Measuring DNA Damage from Space Radiation

by Richard Carr

Among NASA's goals is a space mission to Mars. This journey of at least nine months will expose astronauts and crew to strong space radiation, and any larger human effort there—e.g. colonization—will face potentially deadly exposure. Prof. Cheng-fu Chen and Andrej Podlutsky are in the final year of a three-year project dedicated to developing a miniaturized electrophoresis technique that can measure in situ DNA damage caused by radiation. Previously, such damage has been quantified through the comet assay, a technique dependent on live-cell analysis in a laboratory. Their device—portable, lightweight—will allow detection and measurement of DNA damage in the field. Voyagers to Mars, for instance, can be screened in flight through the vertical comet assay, the new technique proposed for measuring the extent of DNA damage from space radiation. Their interdisciplinary team of engineers and biologists are now quantifying the relations between the broken DNA and radiation strength. They have addressed technical hurdles endemic to realizing the vertical comet assay technique and, in bringing the project to completion, will formulate protocols for subsequent researchers. The portable device will permit researchers to monitor health from distant locales and will thus benefit NASA missions or other projects in which DNA damage from radiation may affect human effort.



Science PI Cheng-fu Chen, PhD University of Alaska Fairbanks

NASA Technical Monitor Yuri Griko, PhD Ames Research Center

Development and Characterization of a New Hybrid Polymer-Nanoparticle Composite Coating for Corrosion Protection in Aerospace Applications

University of Alaska Fairbanks

PNCCs (Polymer Nanocomposite Coatings): A Safe Technique for Reducing Corrosion

by Richard Carr

Corrosion control continues to challenge the aerospace industry. New environmental regulations and health considerations have rendered current control methods illegal and obsolete, depending as they do on toxic materials. PIs Lei Zhang and Cheng-fu Chen are addressing the need for "an environmentally friendly and functional coating technique" based on polymer nanocomposite coatings (PNCCs). Now in the second year of their three-year timeline, they are testing the corrosion behaviors of PNCCs in a saline environment.

They will next measure susceptibility indices and model failure mechanisms of stress corrosion cracking of PNCC. The PNCC-based coating technique, once approved, would protect ground/launch systems and spacecraft from degradation. Other systems under development promise partial corrosion protection at best. NASA spacecraft must perform an array of missions, from resupplying space stations to making lunar landings. To meet the demands of this and the next generation of crew and cargo vehicles, scientists will subject facilities and structures to appropriate redesign and testing; anti-corrosion features are critical to new design.

This project has already reaped local benefits through expanding the aerospace workforce and employing dedicated graduate students. Developing and marketing the PNCCs technique promises to boost Alaska economic development and forge a stronger relationship between UAF and NASA.

NASA Technical Monitor
Luz M. Calle, PhD
Kennedy Space Center

Science PI
Lei Zhang, PhD
University of Alaska Fairbanks

Alabama Research Infrastructure Development

University of Alabama

Dr. Lin Li, University of Alabama, "Investigation of microstructure and mechanical property relationship of Inconel 718 fabricated by selective laser melting using coupled phase field and crystal plasticity simulations"

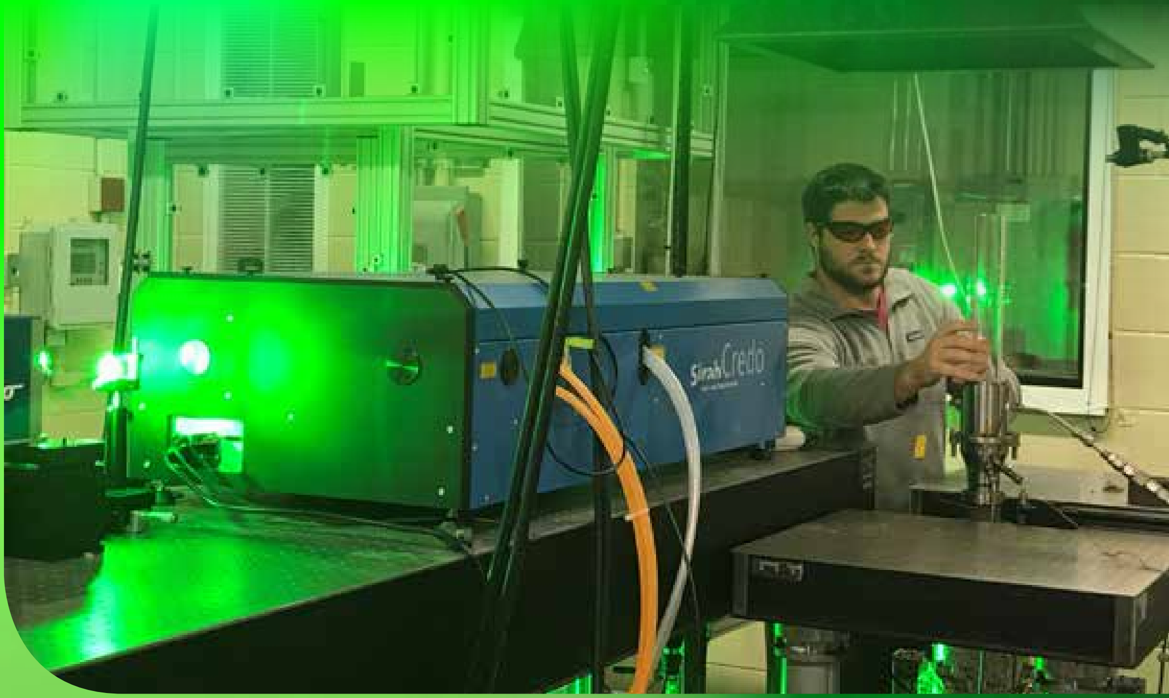
Top: the EBSD results of as-fabricated sample parallel to the build direction of the top, middle, and bottom sections of the sample. Images display the spatial heterogeneity of the as-built SLM parts. Above right: Dr. Lin Li and a student analyze EBSD data of SLM Inconel 718.

Completion of the proposed project will aid in establishing the connection of selective laser melting processing, Inconel 718 material microstructure, and its mechanical responses. The extreme processing conditions create a unique microstructure as the material is built, creating large spatial and mechanical property heterogeneities. Results will be published in peer-reviewed scientific journals and the codes developed will be available as a relevant open source toolbox. Thus the scientific community will have access to the methodology and results. This work has stimulated the development of a course module and will have a lasting impact in educating the students to use the computational tools in their research and future work. This project has also impacted the community beyond the classroom. The work has created research and mentorship opportunities for undergraduate and graduate students, particularly students who are women and under-represented minorities. This work also reaches to encourage students from under-represented universities to attend graduate school with the cutting-edge research, professional development, and funding opportunities.

Dale Thomas, PhD
Alabama EPSCoR Director
University of Alabama

Experimental Investigation of Noise and Thermo-Acoustic Instabilities in Low-Emission, High-Efficiency Combustion Systems for Aviation

University of Alabama

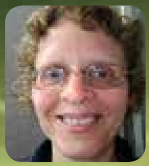


Combustion setup in engine and combustion laboratory at the University of Alabama

This research in the Department of Mechanical Engineering (ME) at the University of Alabama is producing innovative concepts, supplemented with experimental data, to enable lean direction injection or LDI combustion for next generation aviation gas turbines to meet stringent emissions, noise, and efficiency goals established by NASA and regulation agencies. We developed a LDI combustor using a fuel injector with air-assist atomization. Experiments have shown that, under certain conditions, the system can produce high-levels of noise and thermoacoustic instabilities or large-amplitude pressure oscillation that can severely damage the engine. We have identified that that vortical structures in the combustor flow field are responsible for these undesirable effects. To mitigate this problem, we have developed porous insert designs, and have utilized advanced 3D additive manufacturing methods to help create such inserts. We are working with NASA Glenn Research Center (GRC) where LDI combustion research has been extensively investigated.

The project is housed in UA's state-of-the-art Engine and Combustion Laboratory (ECL). Key accomplishments of the project are: (1) one of the students supported by this project is working full-time with a NASA contractor in Huntsville on issue related to rocket propulsion, (2) the project led to winning two major external research grants on related topics; (a) laser diagnostics to improve understanding of rotating detonation engines, and (b) optical diagnostics to understand supercritical combustion at diesel condition. Both of these projects are underway and have resulted in significant increase in PhD, MS, and BS students working in our laboratories, (3) STEP course "Combustion II" was revised and led to record enrollment (twice the normal) of MS and PhD students interested in fuels, energy, and environment, (4) we are able to develop working relationship with at least two major companies in the field, and (5) we have built strong research strength, with the hiring of two new faculty members in combustion/engines area.

Science PI
Ajay K. Agrawal, PhD
University of Alabama

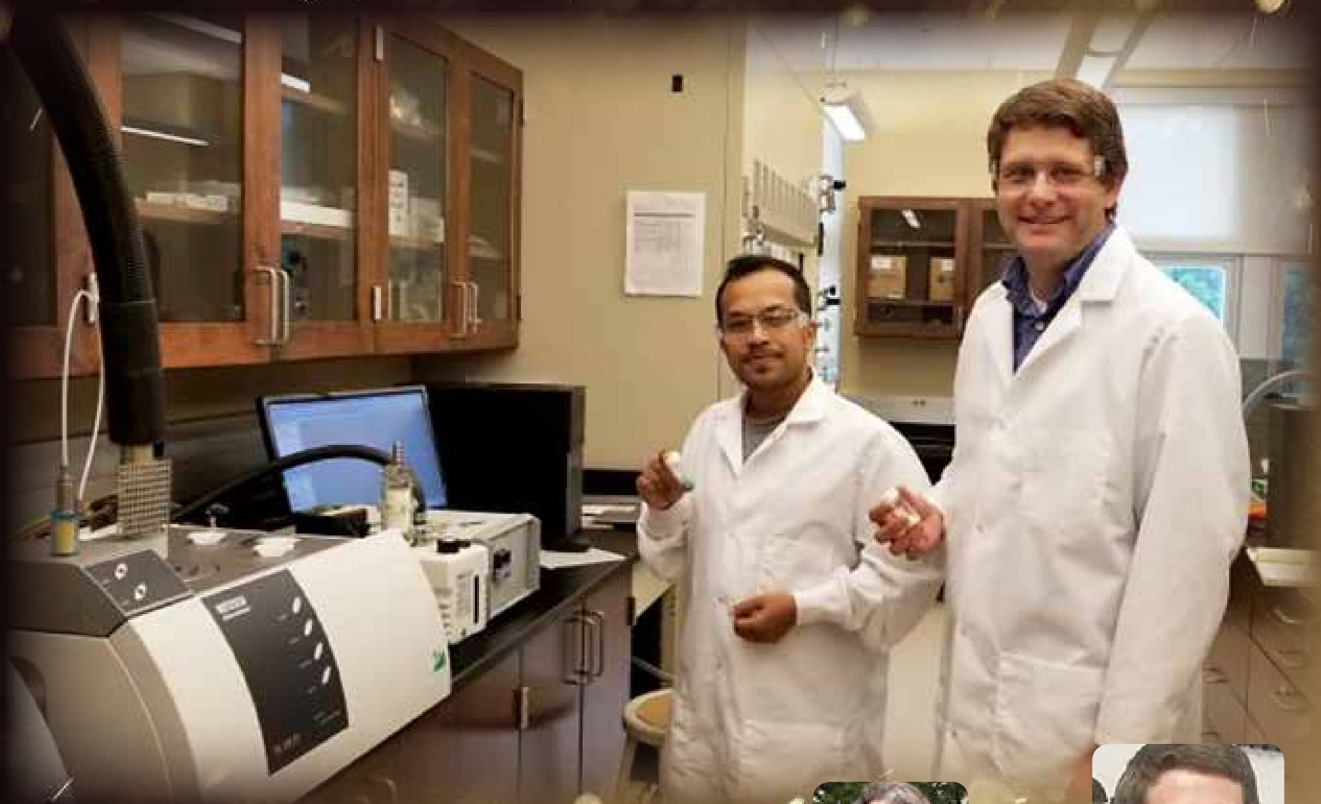


NASA Technical Monitor
Kathy Tacina, PhD
Glenn Research Center

Development of Dust Free Binders for Spacecraft Air Revitalization Systems

University of South Alabama

From a scientific perspective, the research has developed a novel means of reducing the dust formed when using an adsorbent material. The method of reducing dust is broadly applicable to NASA, the DOD, and industrial companies that utilize adsorbents to separate gases. Beyond specific technical details associated with this project, the funding of this NASA EPSCoR grant has provided technical training for 1 post-doctoral fellow, 4 graduate students, and 2 undergraduate students. One graduate student was recently employed as an engineer at AM/NS Calvert (a steel production facility) and another is currently interviewing with Agilent and Shimadzu. The student interviewing was able to secure interviews for these positions as a result of the skills he acquired operating gas analysis instrumentation for this project. The student now employed by AM/NS Calvertis contributing to the growth of minority groups in engineering in the State of Alabama. The 2 undergraduate interns, both of which are from underrepresented groups, have learned how to conduct molecular simulations. One of these students was offered a competitive U.S. Defense Department Fellowship (DOD SMART Fellowship) and a Ph.D. fellowship from the University of Ohio. This program has contributed to the development of research at the University of South Alabama through research infrastructure. The infrastructure purchased by this grant has been utilized by other departments at the University. This is important to note because the University of South Alabama serves a diverse population of students including students with backgrounds in agricultural and heavy industrial, and by providing research infrastructure, the grant has allowed students to consider professional careers that they may not have considered otherwise.



Dr. Glover and Post-Doctoral Fellow Mohammad Hossain discussing the characterization of an adsorbent sample. The samples developed by Dr. Hossain produce 95% less dust than conventionally pressed pellets.

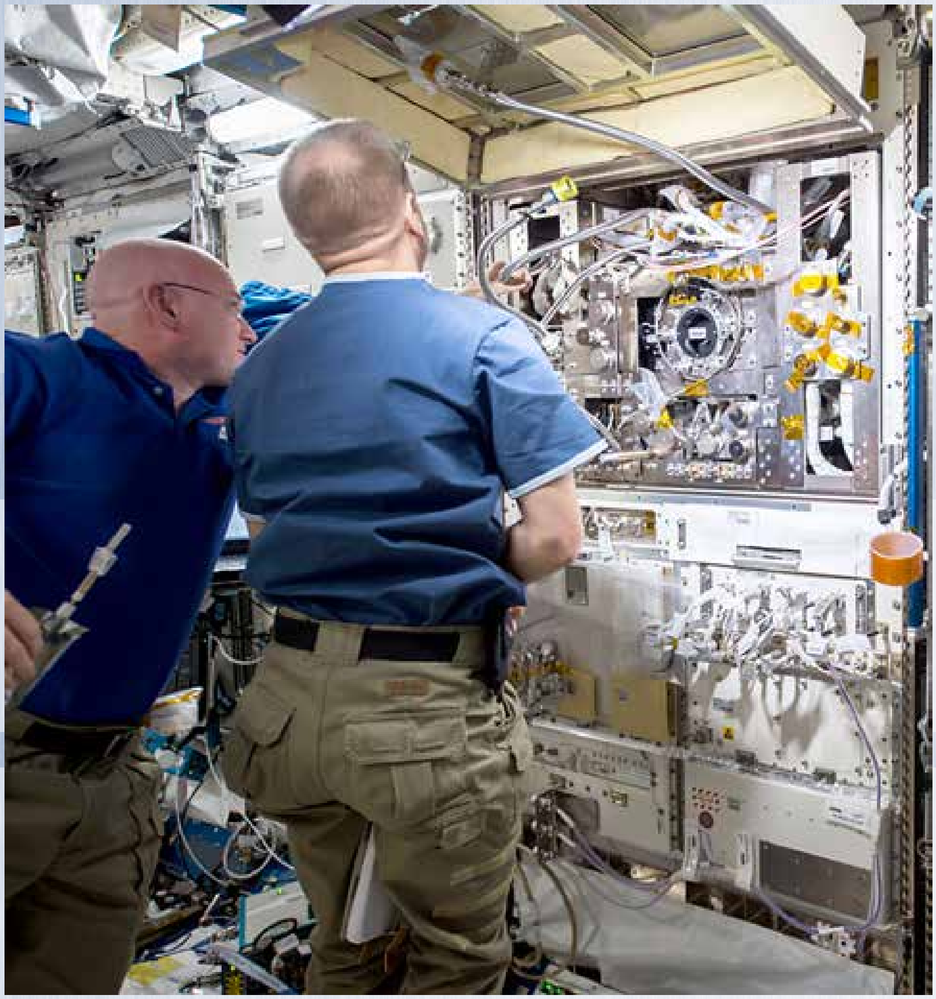
NASA Technical Monitor
John C. Graf, PhD
Johnson Space Center

Science PI
T. Grant Glover, PhD
University of South Alabama

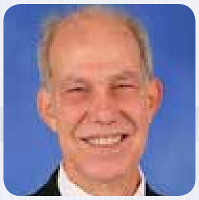
Silicon-Cobalt Alloy Properties

University of Alabama

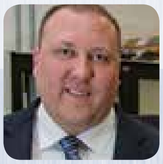
This proposal addresses Research emphasis to enable the eventual production of high-silicon-transition metal alloys. The thermophysical property measurements will use the Japan Aerospace Exploration Agency Electrostatic Levitation Furnace. The casting simulation requires precise and accurate thermophysical 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 in photo during setup.



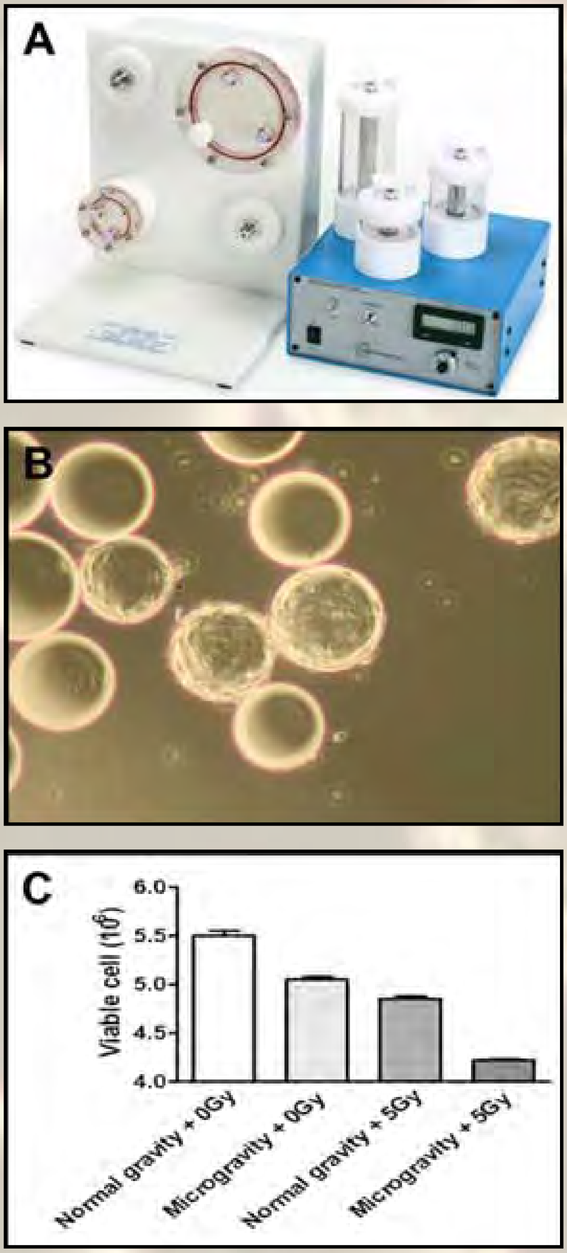
Science PI
R. Michael Banish, PhD
University of Alabama



NASA Technical Monitor
Michael SanSoucie
Marshall Space Flight Center

Arkansas Research Infrastructure Development

University of Arkansas at Little Rock



Exposure to ionizing radiation (IR) under microgravity is inevitable during manned space missions. Both IR and microgravity impose numerous adverse effects on endothelial cells. Endothelial dysfunction is associated with serious disease states, such as cancer and cardiovascular disease. However, no systematic study has been undertaken to investigate whether microgravity enhances damage to irradiated endothelial cells. We subjected human endothelial cells to simulated microgravity and/or IR. Molecular and cytogenetic markers of endothelial dysfunction, as well as functional activity and viability of endothelial cells were measured. In un-irradiated endothelial cells, microgravity alone did not affect cell viability, cytogenetic alterations, or functional activities. In contrast, all endpoints were significantly altered after IR exposure. Moreover, microgravity further enhanced cell death, cytogenetic alterations, and endothelial dysfunction in irradiated cells. Finally, the vitamin E analog gamma tocotrienol (GT3) suppressed micro-gravity- and/or IR-induced endothelial cell damage. These results suggest that microgravity exacerbates IR-induced endothelial cell injury and that GT3 should be explored as a countermeasure against the health risks for astronauts from space missions.

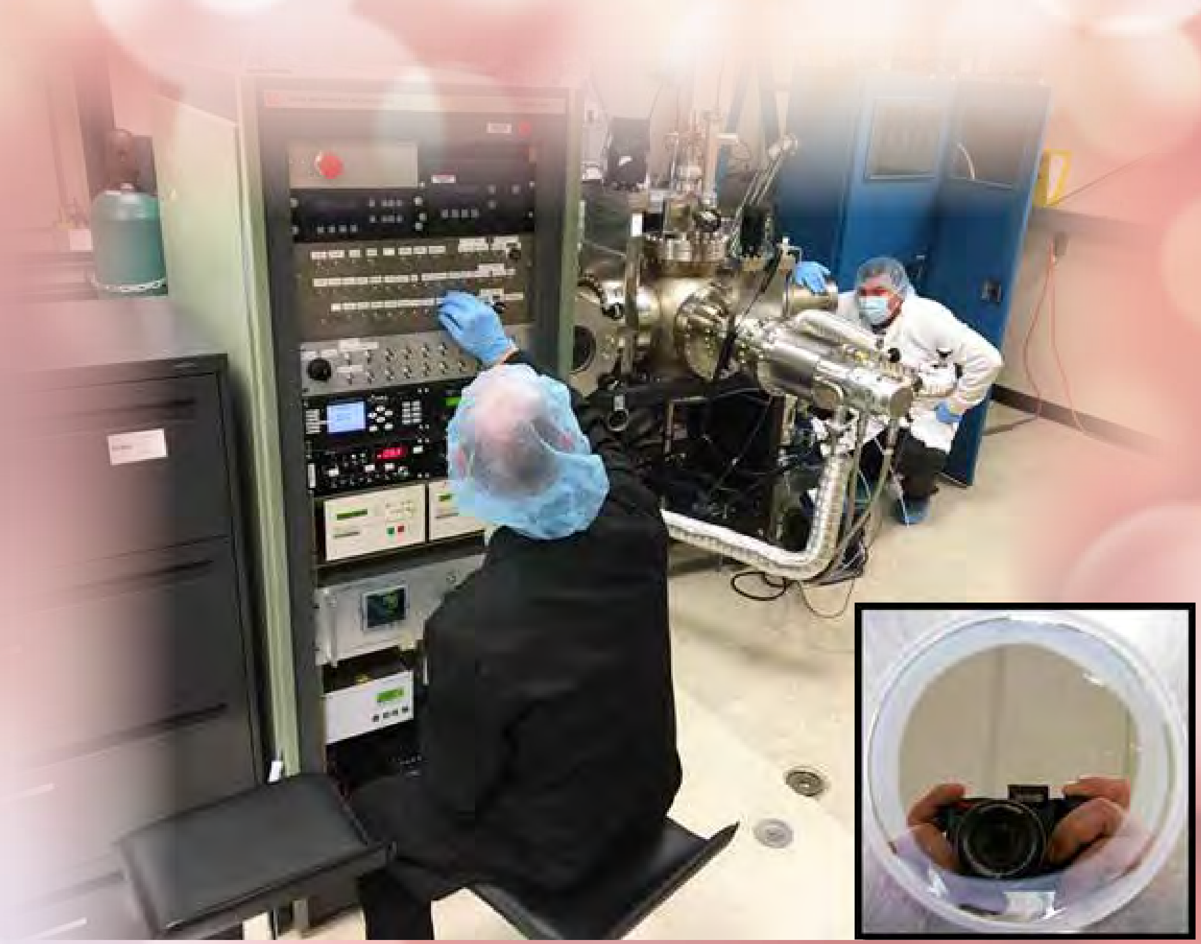
Photographs showing HARV instrument (A), photomicrograph showing HUVECs on beads (B), and Trypan blue assay showing microgravity enhances radiation-induced cell killing (C)

AR

Mitchell Keith Hudson, PhD
Arkansas EPSCoR Director
University of Arkansas
at Little Rock

SiGeSn Based Photovoltaic Devices for Space Applications

University of Arkansas



Graduate student researchers working in lab for GeSn film deposition (Inset: a four inch GeSn wafer produced in the lab)

The next generation of high efficiency photovoltaic (PV) devices requires multi-junction solar cells that can utilize the full range of solar spectrum as well as being compatible with low-cost manufacture route. In order to achieve that goal, researchers at the University of Arkansas Fayetteville are developing a material structure based on silicon, germanium, and tin called SiGeSn-based PV devices. Preliminary results indicated that SiGeSn is able to provide low cost and high-efficiency PV devices. The University of Arkansas Fayetteville has invested a lot of effort on the growth of high quality Ge and GeSn as a benchmark for the growth of high quality SiGeSn structures. Ge and GeSn epitaxial layers were grown using an ultra-high vacuum chemical vapor deposition (UHV-CVD) system. Different techniques including plasma-enhanced growth and epitaxial growth using diluted precursor gases were employed. Systematic characterization techniques were conducted after each growth process to provide sufficient feedback to the growth team. Adjusting the growth parameters based on the feedback resulted in an improvement in the material quality. Results of the material and optical characterization confirmed that the quality of the epitaxial films were appropriate for the fabrication of PV devices.

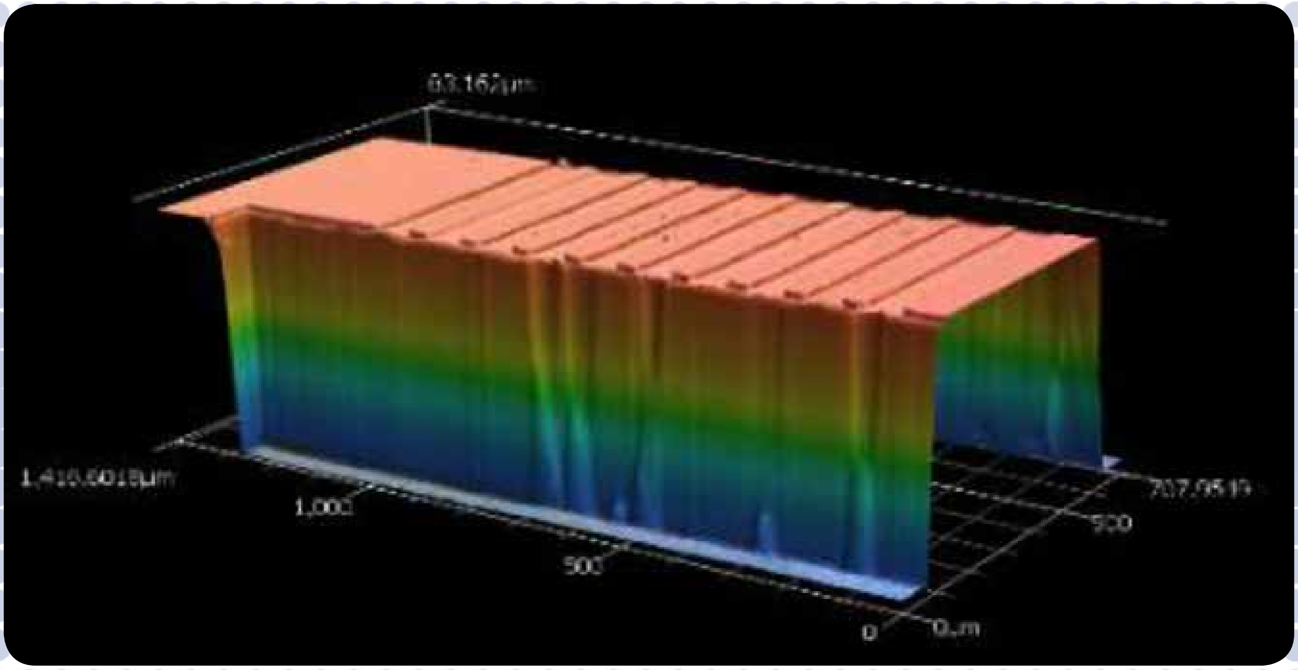
Science PI
Shui-Qing (Fisher) Yu, PhD
University of Arkansas

NASA Co-Technical Monitor
Sang H. Choi, PhD
Langley Research Center

NASA Co-Technical Monitor
Geoffrey A. Landis, PhD
Glenn Research Center

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

University of Arkansas



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

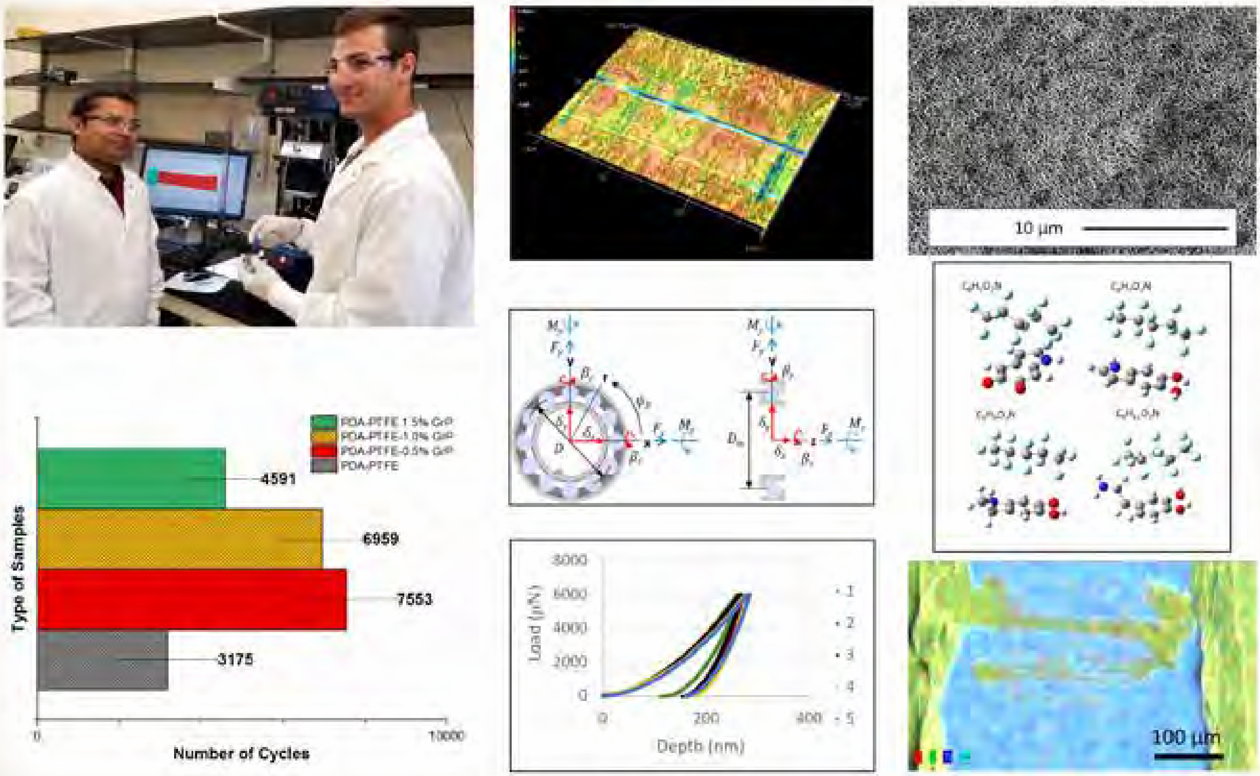
The design of a novel cold-gas (like a duster can) micro-propulsion system, called CubeSat Agile Propulsion System (CSAPS) for small satellites of the nano-satellites class (1-10kg) that is low-cost, non-toxic, non-flammable, and no-pressurized at launch conditions is currently being developed at the 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.

Science PI
Po-Hao Huang, PhD
University of Arkansas

NASA Technical Monitor
Elwood Agasid
Ames Research Center

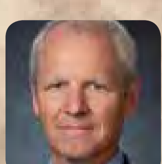
Bio-Inspired PTFE-Based Solid Lubricant Coatings on Nickel-Titanium for Space Mechanisms and Aerospace Applications

University of Arkansas



Arkansas researchers are developing low friction and long-lasting bio-Inspired PTFE-based solid lubricant coatings on nickel-titanium substrate for space mechanisms.

Science PI
Min Zou, PhD
University of Arkansas



NASA Technical Monitor
Samuel A. Howard, PhD
Glenn Research Center

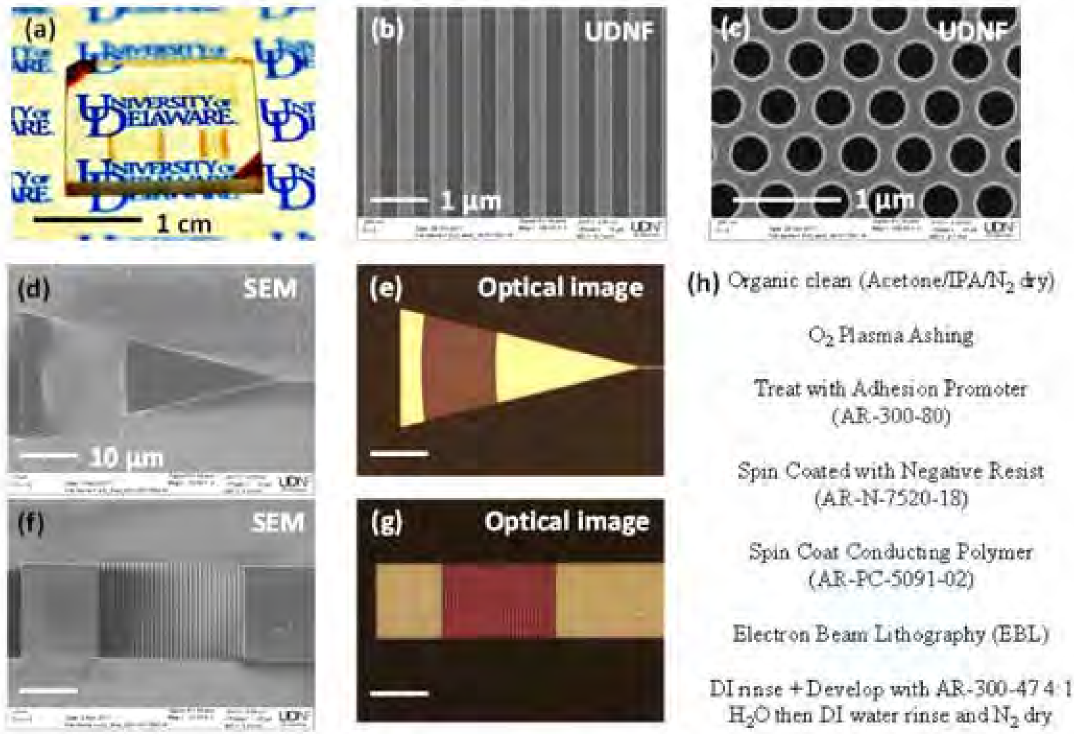
The Distillation Assembly (DA) of the Water Recovery System is a critical part of the International Space Station (ISS). The ball bearings and timing gears in the ISS DA operate in a warm, humid, and strongly acidic environment. The highly corrosive environment causes the stainless steel ball bearings to corrode, and the warm moisture causes the polyimide timing gear to deform, affecting the timing accuracy. NASA is currently evaluating NITINOL 60 to replace the problematic stainless steel ball bearing and the polyimide timing gear. Although NITINOL 60 has demonstrated many desirable properties, its dry lubrication performance is very poor. However, dry lubrication is required for bearings and gears operate inside the DA.

Through the NASA EPSCoR support, the Arkansas team is developing novel bio-Inspired poly tetrafluoroethylene (PTFE)-based solid lubricant coatings for NITINOL 60 material. Preliminary results showed our coatings reduced the friction of the NITINOL 60 by 80 % and significantly improved its wear resistance during dry contact conditions. This project enabled the formation of a multi-campus, interdisciplinary team and the training of 1 postdoc, 3 graduate students, and 2 undergraduate students in an interdisciplinary research environment. Strong collaborations have been established with the NASA technical contacts at the Glenn Research Center.

Delaware Research Infrastructure Development

University of Delaware

The harsh environment of space necessitates the careful engineering of all devices for use on spacecraft. Without the protection of Earth's atmosphere, devices in space are subjected to significantly higher levels of ionizing radiation. Photonic devices are currently used on Earth in communication, sensing and energy harvesting systems. Unfortunately, the durability of nanoscale phonic components to intense radiation has undergone relatively little study. Strategies must be developed to effectively shield photonic components from radiation and to make them less susceptible to the radiation to which they would be exposed (e.g., in high-speed laser communications systems in space). We developed a protocol for evaluating the performance of photonic components exposed to radiation. We first explored the use of various methods of non-invasive optical spectroscopy for probing radiation induced defects/color centers in commonly used in photonic materials. With this evaluation protocol in place, we designed and fabricated "test devices" that incorporates a variety of photonic elements that will be suitable for ground testing in a radiation facility. By developing this protocol and test device, we are better prepared for applying to funding opportunities to conduct radiation testing of photonic components.



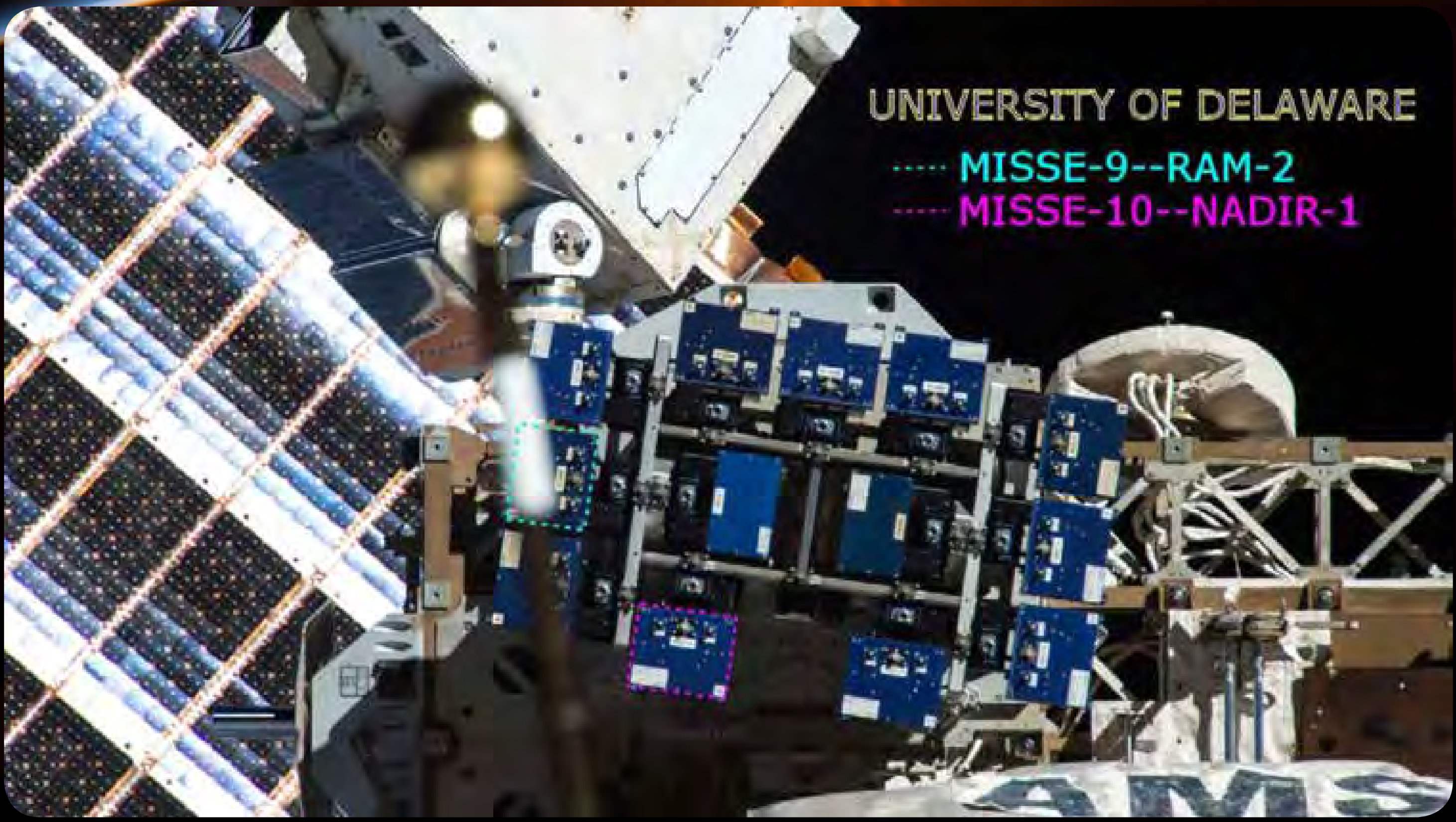
(a) A thin film of nanophotonic structures defined on a transparent glass substrate (b) Scanning electron microscope (SEM) image of 1D Photonic crystal structure (PhC) (c) 2D PhC (d,f) SEM and correspondent (e,g) Optical microscopic image of optical resonance structure (h) Anish Soman (PI's group) developed recipe in UDNF

DE

Prof. William H. Matthaeus
Delaware EPSCoR Director
University of Delaware

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

University of Delaware



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 2nd, 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. Pictured above are the whereabouts (dashed outlines) of two of the MISSE experiments for the University of Delaware led by Dr. Katzarova and supported by Alpha Space Test and Research Alliance, January 2019.

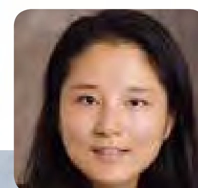
Science PI
Norman J. Wagner, PhD
University of Delaware

NASA Technical Monitor
Willie Williams
Johnson Space Center

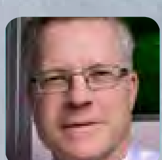
Evaluation of Graphene-Silicon Photonic Integrated Circuits for High-Speed, Light Weight and Radiation Hard Optical Communication in Space

University of Delaware


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.

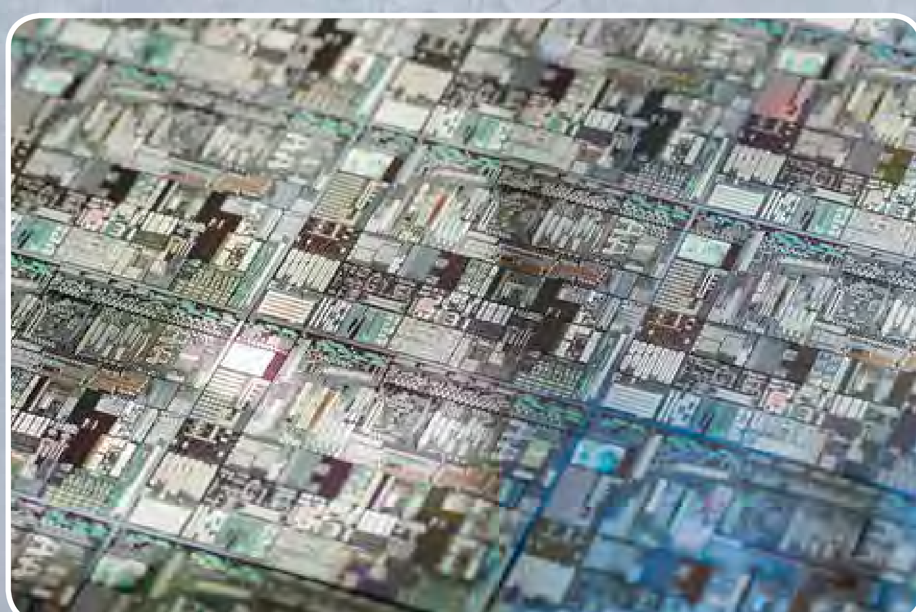


Science PI
Tingyi Gu, PhD
University of Delaware



NASA Co-Technical Monitor
Michael A. Krainak, PhD
Goddard Space Flight Center

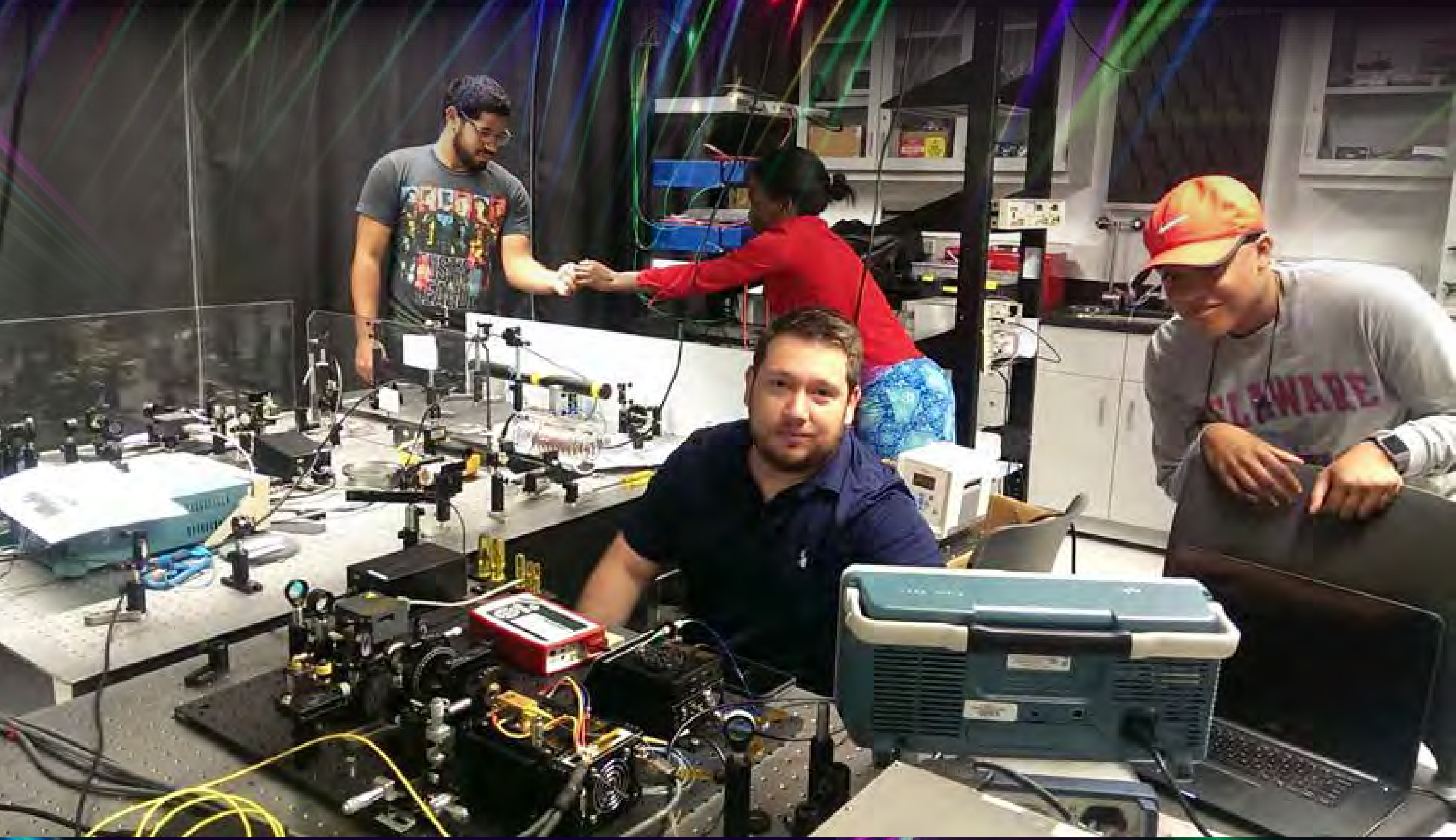
NASA Co-Technical Monitor
Anthony Yu, PhD
Goddard Space Flight Center



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

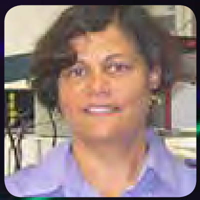
Laser-Based Remote Magnetometry with Mesospheric Sodium Atoms for Geomagnetic Field Measurements

Delaware State University

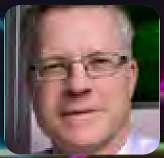


Students working on the development of low power continuous wave sodium laser for spectroscopic studies

The proposed research will create a unique technological advancement capability for remote magnetic field measurement which is of significant relevance to NASA Science Mission Directorate (SMD) and Science Technology Mission Directorate (STMD). DSU Science team of this project will collaborate with three prominent NASA GSFC scientists who are experts involved in many technology missions at NASA. The Sc-I will be able to expand her technology development research in remote sensing, thereby enhancing the State's research capacity in NASA related technology areas. The Sc-I will create a host of education and research opportunities for prevalently underrepresented minority and women students at DSU. Students involved in the project will acquire special skills in magnetometer design, development, and testing experiments. The students will have opportunities to gain hands-on knowledge on all aspects of the proposed research, and interact with NASA scientists via meetings, discussions, and internship opportunities at NASA GSFC. The Sc-I will also conduct outreach activities in local high schools and middle schools in Delaware encouraging them for active participation in NASA related research and STEM education.



Science PI
Renu Tripathi, PhD
Delaware State University



NASA Co-Technical Monitor
Michael A. Krainak, PhD
Goddard Space Flight Center

NASA Co-Technical Monitor
Anthony Yu, PhD
Goddard Space Flight Center

Guam Research Infrastructure Development

University of Guam

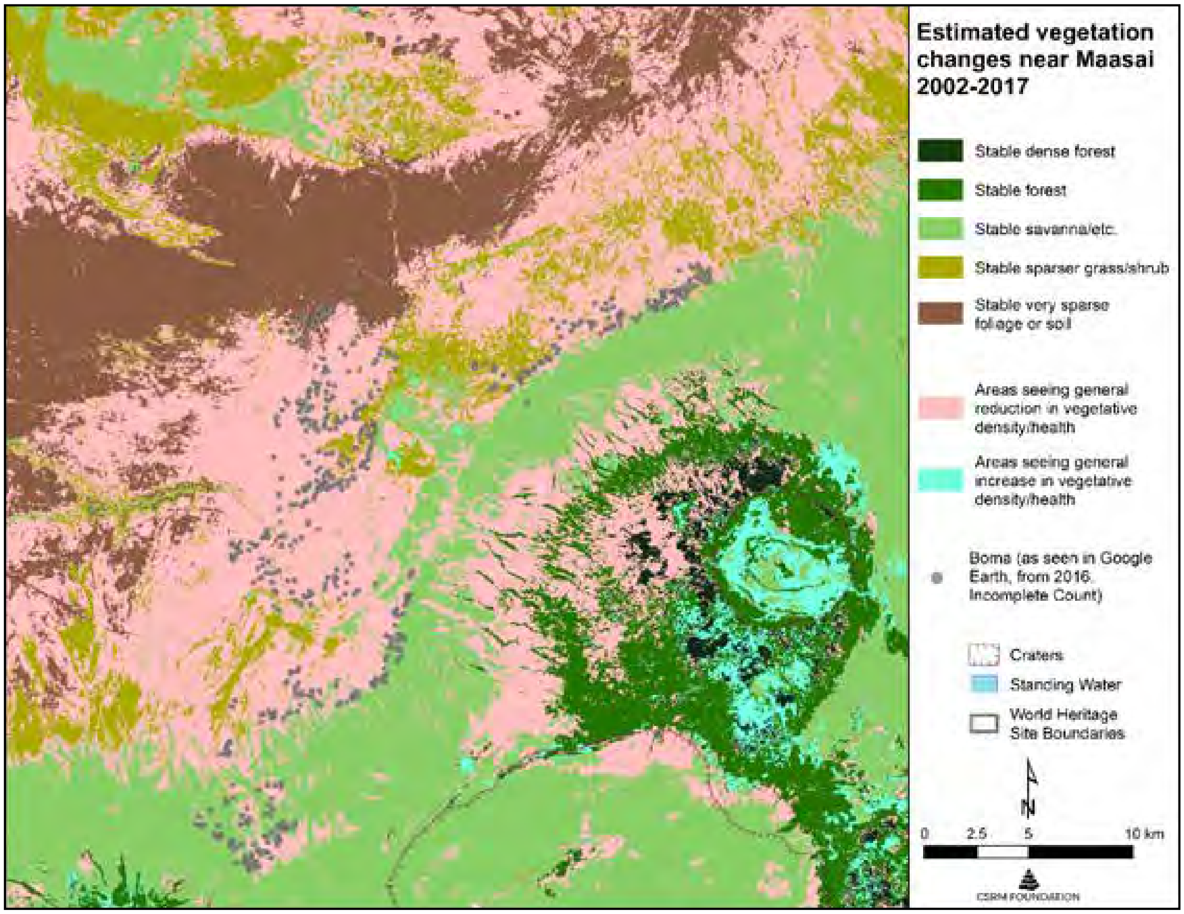


Figure 1: Changes in vegetative health over the Ngorongoro Conservation area

Combined efforts to concurrently manage and conserve natural and cultural heritage using geospatial technology increasingly interest policy makers throughout the world. Jointly inscribed as a biosphere reserve and a cultural heritage site, Tanzania's Ngorongoro Conservation Area World Heritage Site demonstrates the realization of these policy concerns. In recent years, site managers at Ngorongoro have reported developments that are contributing to disconcerting landscape changes. These include: a local Maasai population boom, an expansion of the urban environment onto protected lands, overgrazing leading to a reduction in the productivity and biodiversity of grasslands, and the encroachment of invasive plant species onto the site. To identify and track these deleterious landscape changes, we undertook a pilot study to monitor the vegetative health of the park. To this effect, we analyzed fifteen years of

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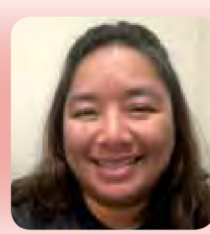


Leslie J. Aquino, PhD
Guam EPSCoR Director
University of Guam

available Landsat 7 and Landsat 8 Level 2 Surface Reflectance data, using a Normalized Difference Vegetation Index (NDVI), which determines the density and health of green vegetation per pixel. Following this initial step, images for the years 2002, 2007, 2012, and 2017 were stacked and the average per year

NDVI values were calculated for each pixel. Subsequently , a change detection algorithm, applied to images between 2002 and 2017, revealed the declining health of the local vegetation (Figure 1). In addition to providing information regarding vegetative health, the NDVI also became a useful tool for classifying the different vegetation types within the region, as different classes of vegetation tend to fall within certain NDVI thresholds. Maps showing these classifications maybe useful in identifying the types of vegetation most at risk and, possibly, in identifying invasive species. Using Google Earth, we have also begun mapping the locations of Maasai boma (livestock enclosures surrounded by habitation areas). Using this location data in combination with the NDVI maps, a Geographic Information System (GIS) was assembled. Overlaying the settlement locations onto NDVI change detection maps indicated a positive correlation between reduced vegetative cover and Maasai settlements (Figure 2). This finding provides potential evidence linking Maasai population expansion, and attendant livestock-driven overgrazing, with the observed declining vegetative health of the grasslands of Ngorongoro. At present, this is merely a hypothesis. Indeed, considering that certain areas located outside of Maasai lands, have also been exhibiting reduced vegetative health, it is likely that other factors (such as climate change) are affecting the local environment. Further analysis will be conducted using an interdisciplinary and international suite of sources, including multispectral data and synthetic aperture radar (SAR) data . Hypotheses based on the analysis of remotely sensed data will be verified in cooperation with local experts.

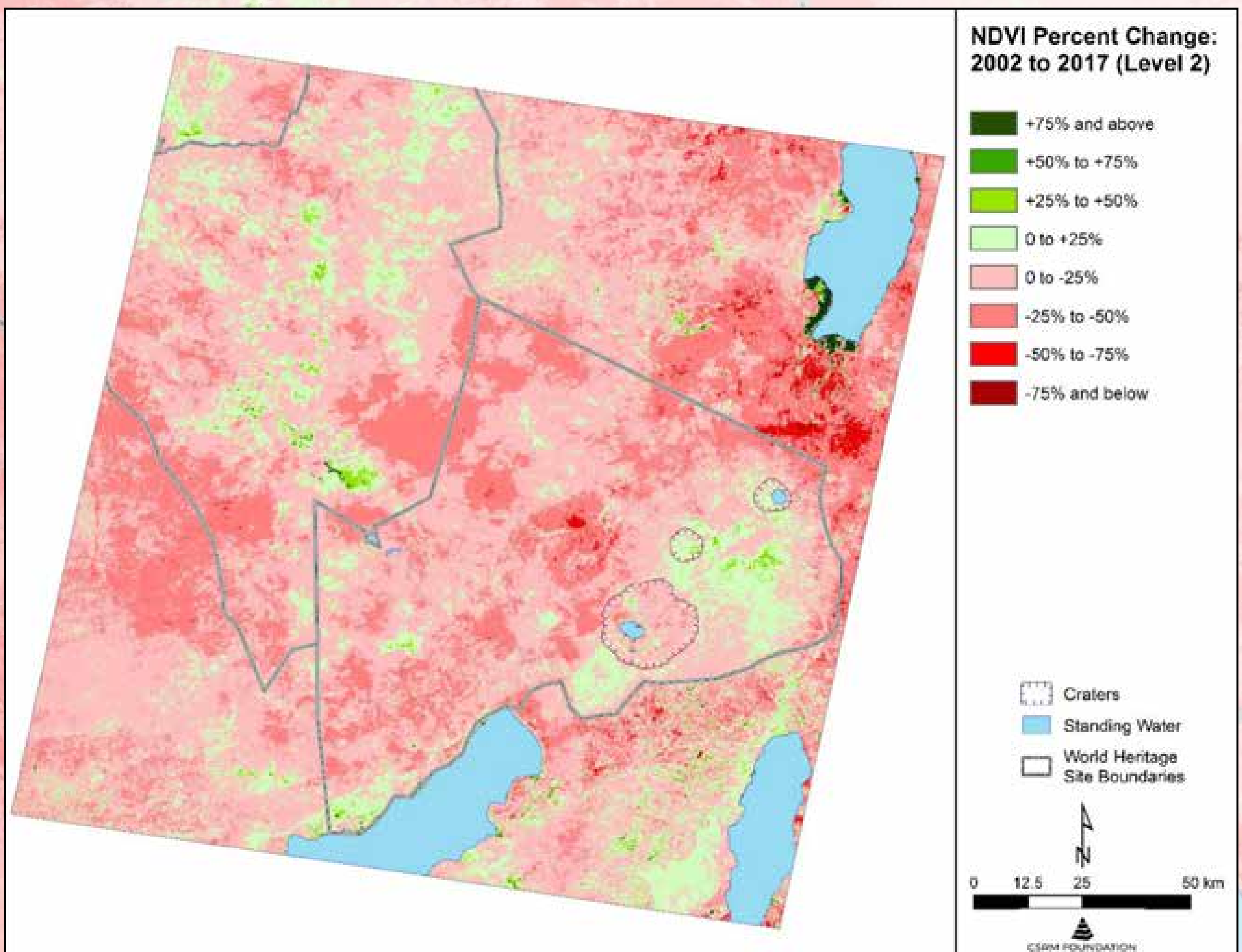
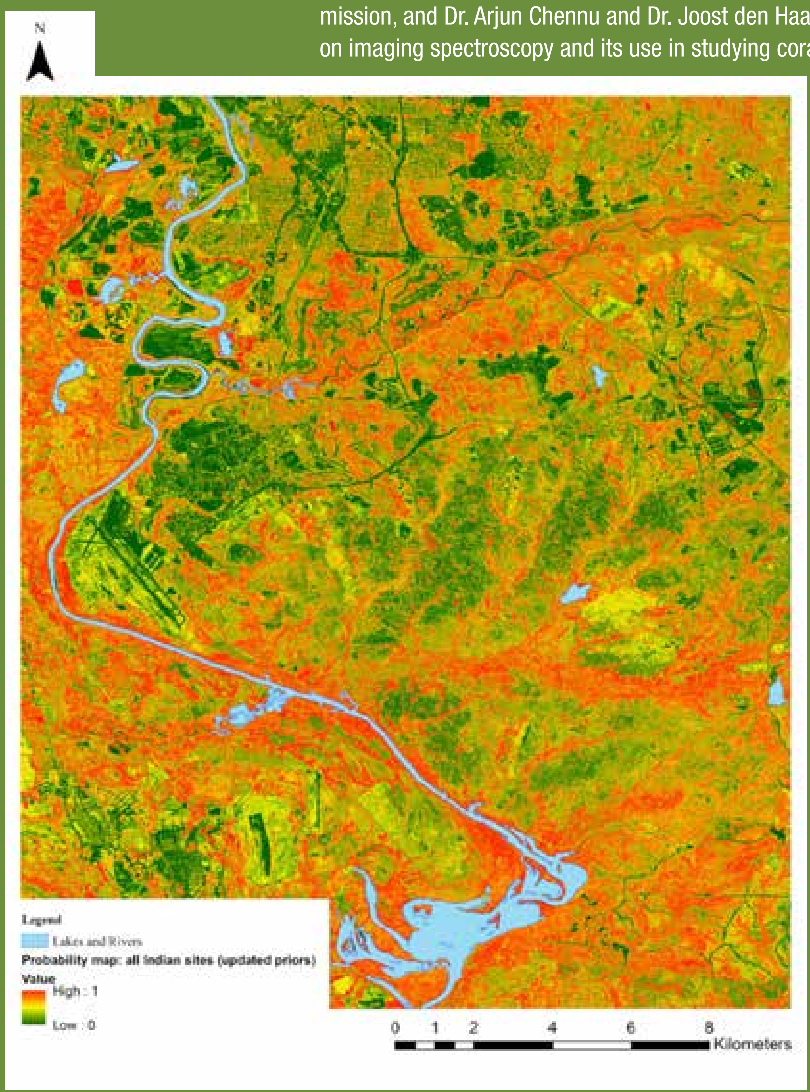


Figure 2: Maasai settlements in relation to different types of vegetation classified by their NDVI values

GEOCORE: Geospatial Studies of Coral Reef Ecology and Health Using Satellite and Airborne Data

University of Guam

The University of Guam is at the cusp of a rapid expansion of capacity for scientific research, especially in the areas of marine and geospatial studies. The recent award of a National Science Foundation EPSCoR program and a NASA EPSCoR Research Infrastructure Development grant provide the focus and the resources to build cyberinfrastructure, STEM education capabilities, workforce development, and coral reef genomic research. For the proposed project, UOG will collaborate with JPL scientists and associates with expertise on NASA science technologies and missions. Dr. Bruce Chapman, of the Radar Science and Engineering Section, and Dr. Ben Holt, of the Ocean Circulation and AirSea Interaction group, will guide the application and analysis of SAR data for understanding landscape change, erosion, and oceanic dynamics. Leo Cheng, a Physicist and JPL Systems Engineer raised on Guam, will perform technical management and educational outreach. Dr. Eric Hochberg and Dr. Michelle Gierach, of the NASA CORAL mission, and Dr. Arjun Chennu and Dr. Joost den Haan, of the Max Planck Institute, will provide expertise on imaging spectroscopy and its use in studying coral reefs and coastal ecosystems. Dr. Douglas Comer, University of Guam Adjunct Professor and Director of CSRM Foundation, will coordinate the engagement of UOG scientists with NASA JPL scientists and oversee the development of a reef fish spawning aggregation site predictive model. Dr. Tom Schils and Dr. Atsushi Fujimora, of UOG, will contribute to the Ocean Science proposed here, and Dr. Terry Donaldson, a UOG Marine Biologist, will serve as Sc-I.



A probability map, which is among the data product types output by CSRM Foundation's predictive models for forecasting and finding areas of archaeological interest. Similar data products and visuals generated by the spawning site predictive model will be made publicly available by GEOCORE.

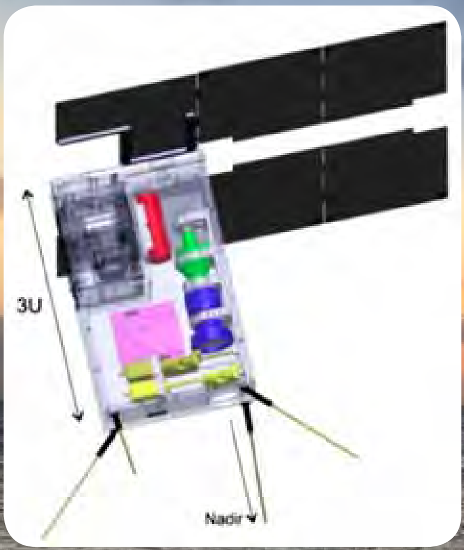
Science PI
Terry Donaldson, PhD
University of Guam

NASA Technical Monitor
Leo Y. Cheng
Jet Propulsion Laboratory

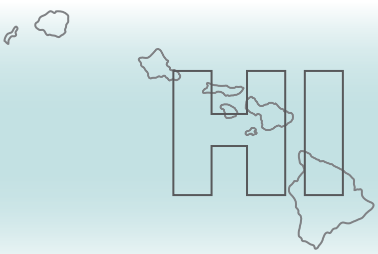
Hawai'i Research Infrastructure Development

University of Hawai'i at Manoa

The Hawai'i Space Flight Laboratory (HSFL) partnered with Jet Propulsion Laboratory, the Hawai'i Institute of Geophysics and Planetology (HIGP), SaraniaSat, Inc. and other small businesses to develop the Hyperspectral Thermal Imager (HyTI). HyTI was funded at over $5M as a 2018 NASA InVEST project with delivery for launch expected in 2020. HyTI will be designed to investigate global food and water security issues: (1) Mapping both irrigated and rainfed cropland areas; (2) Determining crop water use (actual evapotranspiration (ET)) of major world crops; (3) Establishing crop water productivity ("crop per drop") of major world crops. HyTI represents a culmination of a number of HIGP instrument development advances partially funded by NASA EPSCoR CAN awards with EPSCoR RID providing funding for the HSFL engineering team for proposal development. The highly sensitive, 60K-cooled JPL BIRD detectors are standard on larger NASA missions, but this is the first time the technology will use a cryocooler housed in a 6-U CubeSat. The cooled thermal instrument will provide 60 m data in 50 spectral bands at 8.0–10.7 microns. HSFL Facilities allow for in-house testing and modifications in order to deliver the satellite in 24 months.



The Hyperspectral Thermal Imager is a 6-U CubeSat containing a JPL BIRD detector and HIGP instrument package partially developed under previous NASA EPSCoR CAN awards.

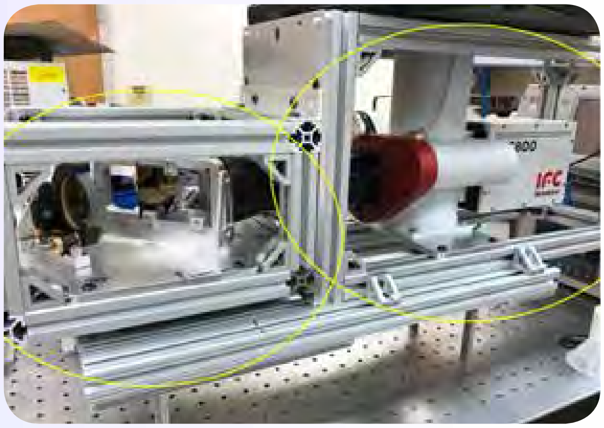


Luke Flynn, PhD
Hawai'i EPSCoR Director
University of Hawai'i at Manoa

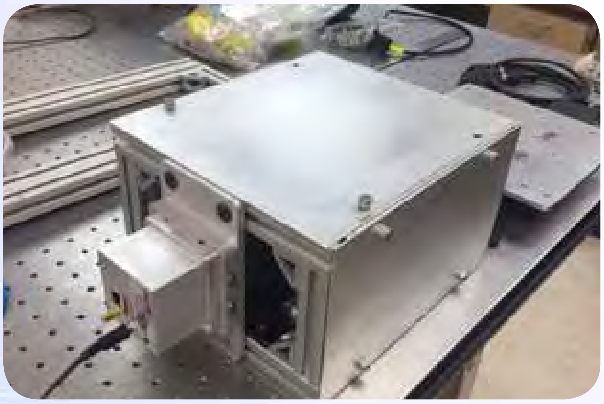
Development of the Miniaturized Infrared Detector for Atmospheric Species (Midas) Instrument

University of Hawai'i

The first instrument (using the cooled InSb detector) is below:



The yellow ellipse on the left shows the interferometer (beam-splitter and two mirrors) and the ellipse on the right shows the InSb camera and imaging lens.



Rear view, with microbolometer visible on left. This photograph shows the uncooled implementation. Here, the interferometer is the same, the only difference being the detector (an uncooled INO mXCam MWIR microbolometer) and imaging lens.

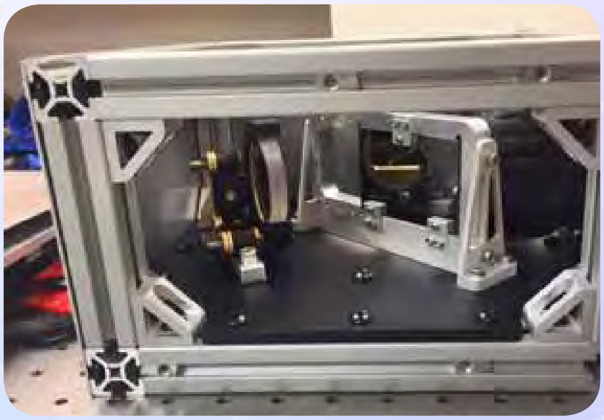
The purpose of the project was to develop a miniaturized instrument for the detection of gases (primarily methane and carbon dioxide), using a Sagnac interferometer and a mid-wave infrared (i.e. 3-5 µm) detector array. An uncooled (MIDAS) and a cooled MWIR detector (CIDAS) was compared to establish whether the extra sensitivity afforded by the cooled detector was necessary to detect and quantify atmospheric gas absorption/emission features. The instruments were tested in i) the laboratory using gas cells filled with calibration gases of known concentrations, and ii) in the field over sites of known CH4 emission.

Year 4 progress included computing the spectral response of the MIDAS uncooled microbolometer and the CIDAS InSb photon detector, fully characterized the MIDAS instrument, and deployed the instrument at Kilauea volcano to make gas measurements in support of NASA's HyspIRI Preparatory Campaign in January 2018.

Science PI
Brendan Hermalyn, PhD
University of Hawai'i

NASA Technical Monitor
Ali Shaykhian, PhD
Kennedy Space Center

Top view (cover removed) showing the mirrors and beam-splitter and imaging lens



Side view. The aperture is on this side of the instrument.

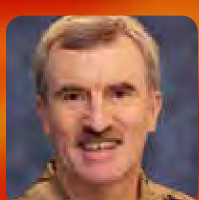
Developing a Capability at the University of Hawai'i for Multiple UAV Observations of Active Volcanism

Hawai'i Institute of Geophysics and Planetology

Testing the integration of our FLYSPEC sensor with the Matrice 100, in collaboration with one of our ARL colleagues. Our FAA certified pilots are in the bright jackets. Right: Close-up view of the FLYSPEC mounted on the Matrice 100

In early May 2018, Kilauea volcano started a new phase of activity, with numerous fissures producing large lava flows within a subdivision called Leilani Estates. This fine view of Fissure 8 was taken on July 15th, 2018, and shows the massive amount of volcanic sulfur dioxide gas (the discolored white cloud above the active lava channel at right) being released. Our goal is to utilize drones to determine the total mass of this gas being released.

U.S. Geological Survey Photo



Science PI
Pete Mouginis-Mark, PhD
Hawai'i Institute of Geophysics and Planetology

NASA Technical Monitor
Matthew Fladeland, PhD
Ames Research Center

The Pu'u O'o and Halemaumau vents of Kilauea volcano, Hawai'i, have produced copious amounts of sulfur dioxide gas (up to ~2,000 tonnes per day) during eruptions that extend back to 1983. This project will use drones to study gases within the volcanic plume, which have an impact on atmospheric chemistry and pose a health hazard to visitors to the Hawai'i National Park. We are exploring ways that commercially produced drones with innovative science instruments might provide high-temporal resolution (seconds to minutes) observations of volcanic sulfur dioxide and aerosols, and then correlate these data with ground measurements. The project has already allowed us to establish greater contact with the FAA UAV Test Site in Hawai'i, incorporate drone studies into undergraduate courses, and collaborate with other scientists at the Hawai'ian Volcano Observatory.

Autonomous Control Technology for Unmanned Aerial Systems with Agricultural and Environmental Applications in Central Pacific Islands

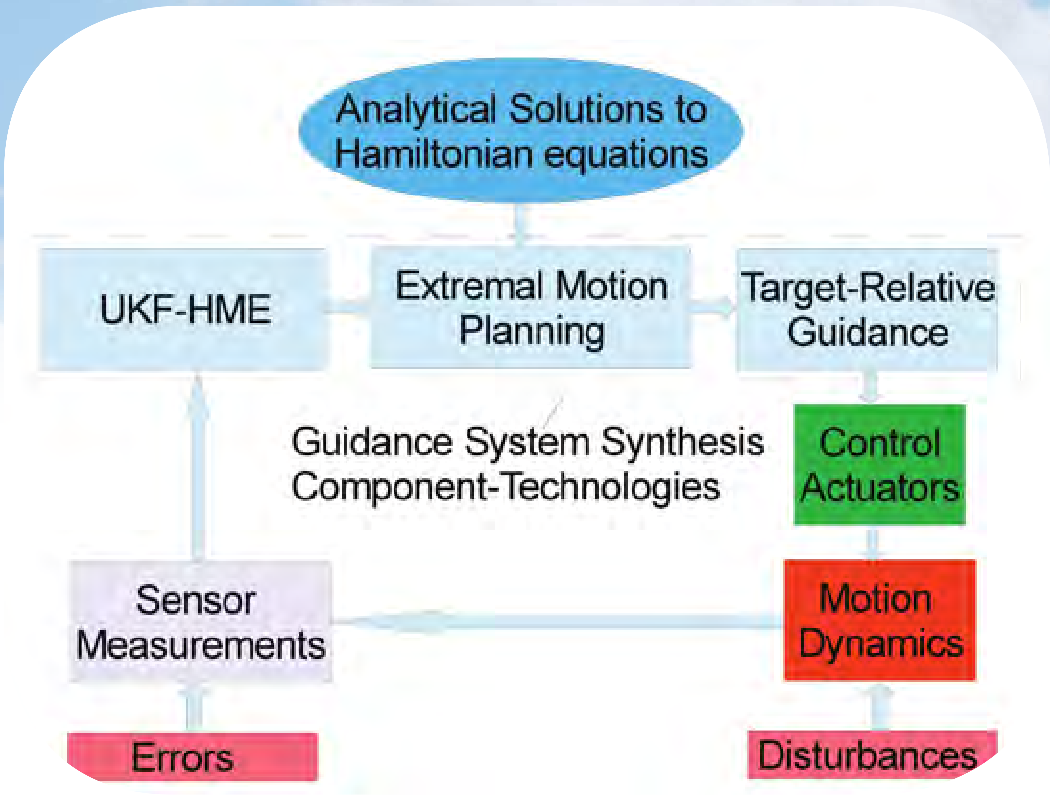
University of Hawai'i at Manoa

The goal of the proposed research is to develop and integrate target-relative guidance, navigation and control (GNC) functions and software algorithms for an autonomous and real-time implementation onboard of unmanned aerial systems (UAVs) for agricultural and environmental applications in Hawaiian Islands. The objectives to accomplishing this goal of the proposed research are 1) development and formulation of new nonlinear analytical and/or numerical and optimal control laws for UAV platforms, including fixed-wing aircraft and multi-rotor platforms, and 2) design and execution of target-relative guidance schemes based on these control laws for an onboard execution to autonomously perform various UAV maneuvers. As proposed in the EPSCoR project, the GNC functions and framework that can accommodate the implementation of these functions for UAVs have been developed (Fig.1). The studies have shown that INAV flight control software is the default and most convenient program that can accommodate this GNC framework.

The proposed research paves the way for numerous opportunities for the UAV development and applications also in Central Pacific and Micronesian Islands, and will contribute to the fulfillment of the NASA strategic plans as well as the NASA Earth Science missions.

Science PI
Dilmurat M. Azimov, PhD
University of Hawai'i at Manoa

NASA Technical Monitor
Corey A. Ippolito, PhD
Ames Research Center



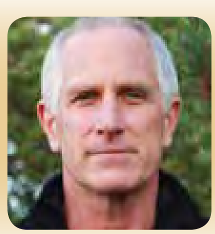
The GNC functions and framework for various UAV platforms as part of the proposed guidance system synthesis

Idaho Research Infrastructure Development

University of Idaho

Dr. David Estrada is proof that the efforts of Idaho NASA EPSCoR and the Idaho Space Grant Consortium are bearing fruit. Originally from Nampa, Idaho, Dr. David Estrada served in the United States Navy as an Electronics Warfare Technician/ Cryptologic Technician-Technical from 1998 to 2004. After leaving the Navy, Dr. Estrada returned to Idaho for his undergraduate education where he was awarded an Idaho Space Grant Consortium scholarship. Since becoming a faculty member at Boise State University, Dr. Estrada has won multiple awards from both the Idaho NASA EPSCoR and Idaho Space Grant Consortium programs including research seed grants and collaboration grants. Idaho NASA EPSCoR's investment and Dr. Estrada's hard work and dedication have paid off. NASA awarded Dr. Estrada a grant titled "Space Grade Flexible Electronics" in 2017 under the National NASA Established Program to Stimulate Competitive Research (EPSCoR) program. The three-year grant aims to use nanotechnology to develop space-grade flexible sensors capable of monitoring and transmitting real-time data for crew and vehicle health such as gas vapors and radiation. Dr. Estrada and his colleagues at Boise State University will collaborate on this grant with the University of Idaho, American Semiconductor, NASA Ames Research Center, Johnson Space Center, Marshall Space Flight Center, and Air Force Research Laboratories. As part of the project researchers will work to design highly sensitive and mission-specific sensors using a number of technologies including, but not limited to, printed carbon nanotubes, thermoelectric nanomaterials with flexible silicon-integrated circuits, wireless communications hardware, and additive manufacturing. In addition to the benefits for the aerospace industry, the team plans to convert the new sensor technology developed during this project into defense applications and consumer electronics.

David Estrada, PhD (left) and a student review the properties of graphene in the Advanced Nanomaterials and Manufacturing Laboratory at Boise State University.



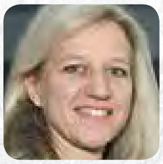
Joseph D. Law, PhD
Idaho EPSCoR Director
University of Idaho

Monitoring Earth's Hydrosphere: Integrating Remote Sensing, Modeling, and Verification

Boise State University

Both Co-PIs Marshall and Glenn were integral parts of the NASA SnowEx field campaign effort, a multi-year experiment to advance the science and engineering of characterizing spatiotemporal variability in snow from remote sensing platforms. Students and lab technicians associated with this EPSCoR award travelled to the Grand Mesa outside of Grand Junction, Colorado. They collected Terrestrial Laser Scanning data as part of the ground truth field campaign. These measurements will be used by snow researches to study the effects of vegetation and vegetation structure on snow accumulation and snow water equivalent.

Science PI
Alejandro N. Flores, PhD
Boise State University

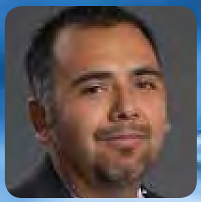


NASA Technical Monitor
Gail M. Skofronick-Jackson, PhD
Goddard Space Flight Center

The spatial domains of the land-atmosphere simulator. The outer domain encompasses the entirety of the Snake River Basin (subbasins shown outlined in white) and is associated with a spatial resolution of 3 km. The inner domain, outlined in black, is associated with a spatial resolution of 1 km.

Space-Grade Flexible Hybrid Electronics

Boise State University



Science PI
David Estrada, PhD
Boise State University

NASA Technical Monitor
Jessica Koehne, PhD
Ames Research Center

Working on an aerosol jet printer in the Idaho Microfabrication Laboratory at Boise State University

A team of researchers in the State of Idaho have established an additive manufacturing facility at Boise State University to investigate the possibility of manufacturing specialized sensors in space, using a flexible hybrid electronics approach. The team is led by Dr. David Estrada – an Assistant Professor in the Micron School of Materials Science and Engineering – and includes partnerships with the University of Idaho, American Semiconductor, Emerson, Air Force Research Laboratory at Wright Patterson Air Force Base, and three NASA Centers.

Preparing a solution of carbon nanotubes in the Advanced Nanomaterials and Manufacturing Laboratory at Boise State University

Flexible hybrid electronics is an innovative approach to combining flexible silicon integrated circuits with printed nanomaterials in order to develop a completely flexible electronic system. Estrada has led the development of an additive manufacturing laboratory and a nanoparticle ink synthesis laboratory to develop a unique research capability within the Idaho EPSCoR jurisdiction. Using these new facilities his team is investigating the practical use of atomically thin materials for environmental and human monitoring in space. By integrating these highly sensitive materials with the computing power of silicon, his team hopes to show that additive manufacturing techniques may be a potential route for fabrication of mission specific sensors on station.

Kansas Research Infrastructure Development

Wichita State University

The projects completed by Kansas researchers in the past year cover a wide range of topics. One project supported the design, fabrication, and testing of a new, miniaturized radar system, which will be used to seek new opportunities in environmental remote sensing. For this research, the proposed application of the radar system was for soil moisture measurements. However, the researchers feel the system could also be used for snow measurements and possibly crop health measurements. This technology should not only potentially benefit Kansas farmers, but the nation's agricultural industry as a whole. This project led to a collaboration with a local Unmanned Aircraft System (UAS) company, Pulse Aerospace, which will continue after the end of this project. Another project led to the development of a new post-tornado damage assessment system, which was based on small UAS. The significance of the project lies in a seamless integration of low-cost UAS platforms into traditional earth observing networks comprising of ground probe stations, manned aircraft, and satellites. This project can also benefit many other post disaster scenarios such as hurricanes, earthquakes, and severe thunderstorms. Kansas researchers formed partnerships with NASA scientists to study drought conditions in agricultural areas such as Kansas. The researchers attempted to determine a drought index which would include soil moisture, evapotranspiration, and other climate variables in an attempt to predict short-and mid-term drought. In addition, the researchers were interested in determining a relation between the duration of the drought event and the impact it would have on the soil moisture and evapotranspiration. The long-term goal is to help the stakeholders such as farmers and water managers to better understand the water availability situation and determine the best way to plan consumption. Aviation and aeronautical research is one of the strategic goals of both NASA and Kansas State University. A study done by collaborators at that university provides a new perspective on vision-based UAS sense and avoid, and the proposed solution is much faster and more robust than any available system of its kind. One primary outcome of this effort is a novel framework for simultaneous and real-time intruder detection, tracking, and depth recovery. The project fulfills NASA's strategic goal to advance aeronautics research and provide the technology innovations to integrate UAV systems into the National Airspace System. In addition, the work will also have significant impact to the economic development of Kansas, especially in aerospace industry, as well as involving students who were able to gain valuable research experience. Overall, the projects in this past year have led to an increase of technical abilities in Kansas, as well as many new collaborations between researchers at Kansas universities and NASA, and with industry. The Kansas Board of Regents (KBOR) has also continued to support the RID program. The expectations are that the RID program will have a positive economic impact leading to self-sustaining research infrastructure, in addition to workforce development.

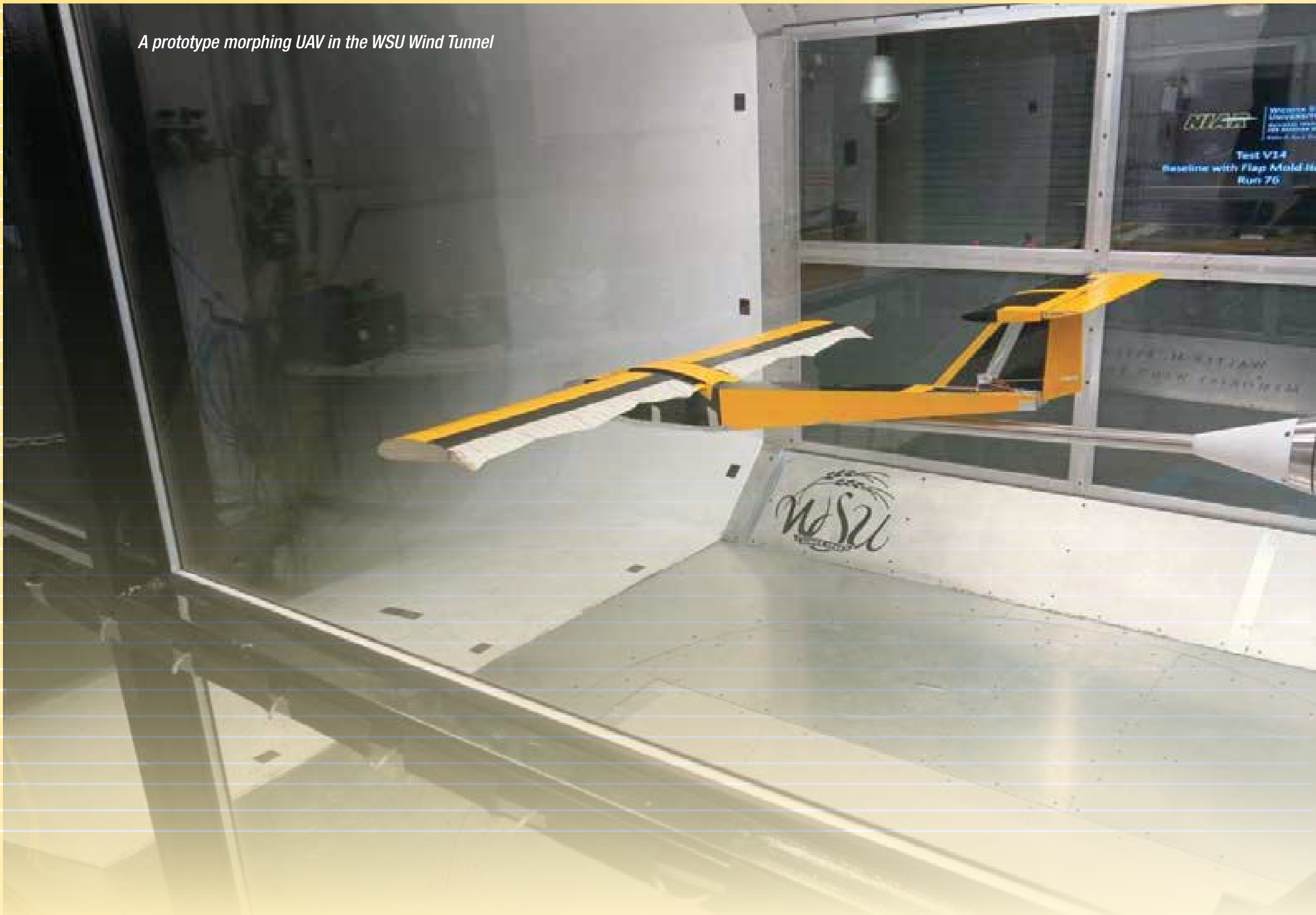
Project collaborators installing the radar antenna on a UAS

KS

L. Scott Miller, PhD
Kansas EPSCoR Director
Wichita State University

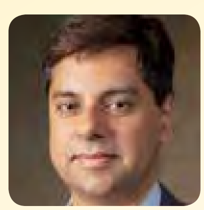
Active Wing Shaping Control for Morphing Aircraft

Wichita State University



A prototype morphing UAV in the WSU Wind Tunnel

This project is developing certifiable active wing shaping control laws for NASA's conceptualized Variable Camber Continuous Trailing Edge and Flaps (VCCTEF) aircraft. Use of active wing shaping control is required in order to achieve the enhanced aerodynamic performance (in terms of higher lift-to-drag ratio) that the VCCTEF is capable of generating. The wing shaping control laws make use of active feedback to continuously modulate the camber across multiple sections of the wings so as to ensure that the local flow distribution over the wing is optimal for every flight condition. This project is developing novel wing shape sensing and control techniques towards meeting these objectives.

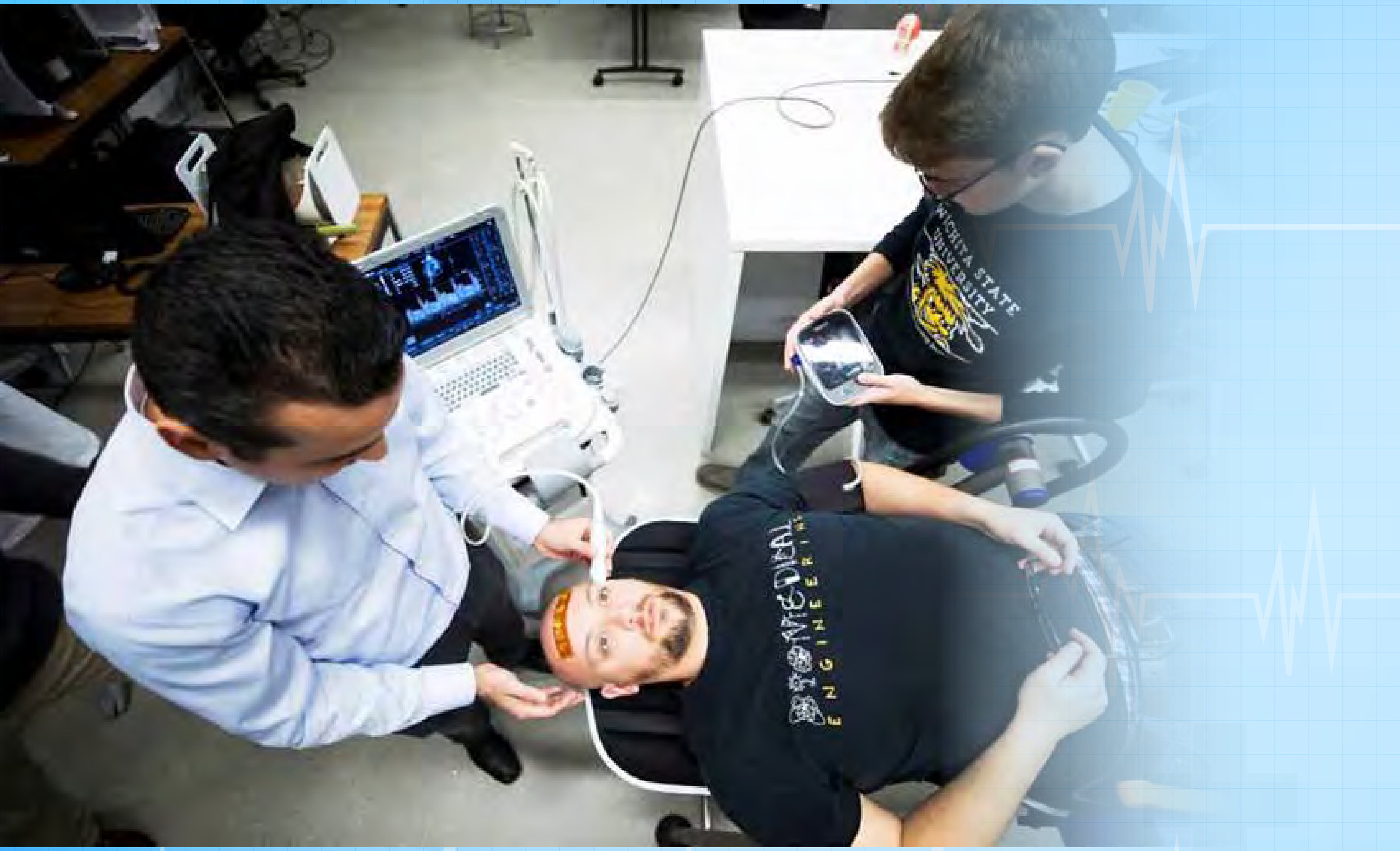


Science PI
Animesh Chakravarthy, PhD
Wichita State University

NASA Technical Monitor
Nhan T. Nguyen, PhD
Ames Research Center

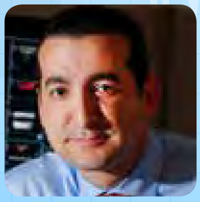
Novel Smart Skin Biomedical Sensor for Monitoring Crew Health Parameters in a Wireless, Passive, Lightweight, Robust, and Non-Invasive Fashion

Wichita State University



NASA research to develop a new wearable sensor to detect multiple physiological parameters. Science PI Dr. Cluff (Left) with students

Our work addresses NASA research interests in wearable health monitoring systems to address the gaps and risks that are critical to crew health and performance during long duration space missions. Specifically, our research fits well with the directives of the National Space Biomedical Research Institute to develop Smart Medical Systems and Technology. We are developing a wearable skin patch to measure multiple physiological parameters in a single sensor which may provide a foundation for a novel strategy for monitoring mission critical crew health parameters in point-of-care fashion. Funding for this research has helped bring visibility to the high quality research being done in the Midwest at our University in Kansas.

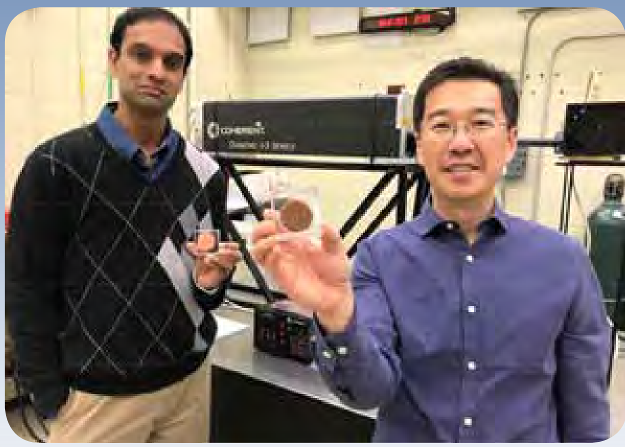


Science PI
Kim Cluff, PhD
Wichita State University

NASA Technical Monitor
Ali Shaykhian, PhD
Kennedy Space Center

Efficient and Compact Thermal and Water Management Systems Using Novel Capillary Structure for Space Technology

Wichita State University



Rajeev Nair, PhD (left) and Dr. Gisuk Hwang, Science PI (right), show the developed wick structures while standing in front of CO2 laser.

Melanie Derby, PhD (left) and graduate students examine the steam flow condensation experimental apparatus.

A Kansas-based research team, led by Wichita State University (WSU) in partnership with Kansas State University (KSU) and the University of Kansas (KU), is researching novel wicking structures. Wicking, or the movement of liquid via surface tension, is a critical mechanism in space due to the lack of gravity. These wick structures are designed to improve heat transfer in NASA temperature control, water recovery, and humidity control systems. The team synergetically combines strengths in manufacturing (WSU), modeling (KU), and energy systems (KSU). This research project features many multi-institutional efforts. The wick structures are manufactured at WSU using a new laser-based additive manufacturing method. The wick structures are modeled at KU, while KSU will provide data for experiment validations. Researchers at WSU and KSU are conducting experiments to understand the performance of these structures in energy and water systems, including boiling and condensation. In the first six months of the project, five faculty members, eight graduate students, and three undergraduate students have begun research and the team includes two female faculty members, four female students, and two students who are members of underrepresented groups. The project has already impacted two graduate and one undergraduate courses.

Science PI
Gisuk Hwang, PhD
Wichita State University

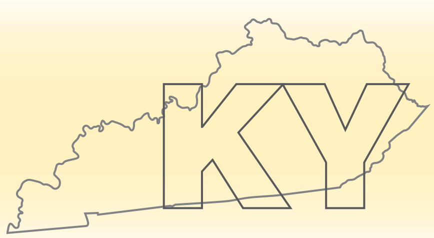
NASA Technical Monitor
Mohammad M. Hasan, PhD
Glenn Research Center

Kentucky Research Infrastructure Development

University of Kentucky

The NASA Kentucky EPSCoR Research Infrastructure Development (RID) program supports research development of Kentucky's higher education faculty with a focus on those in early stages of their careers. NASA KY RID offers complementary opportunities that fund research grants, workshops and conferences, and travel to NASA Centers, all of which develop collaboration with NASA missions and personnel. This in turn benefits the growing aerospace sector of the state economy by helping Kentucky faculty with support they need to build aerospace-related research capability in-state and undertake projects that train students and contribute to industry. Since 2010, 24 RID grants along with 30 Faculty Travel awards to pursue collaboration with NASA researchers have focused on initiating NASA relationships and maturing collaborative research potential. In that time, 23 researchers across Kentucky supported by NASA KY EPSCoR awards have been successfully promoted and tenured, including five who received follow-on NSF or ONR Career Awards. Altogether, NASA KY programs are designed to address economic and workforce development needs of Kentucky and the interests of NASA through strategically targeted expanded research capabilities.

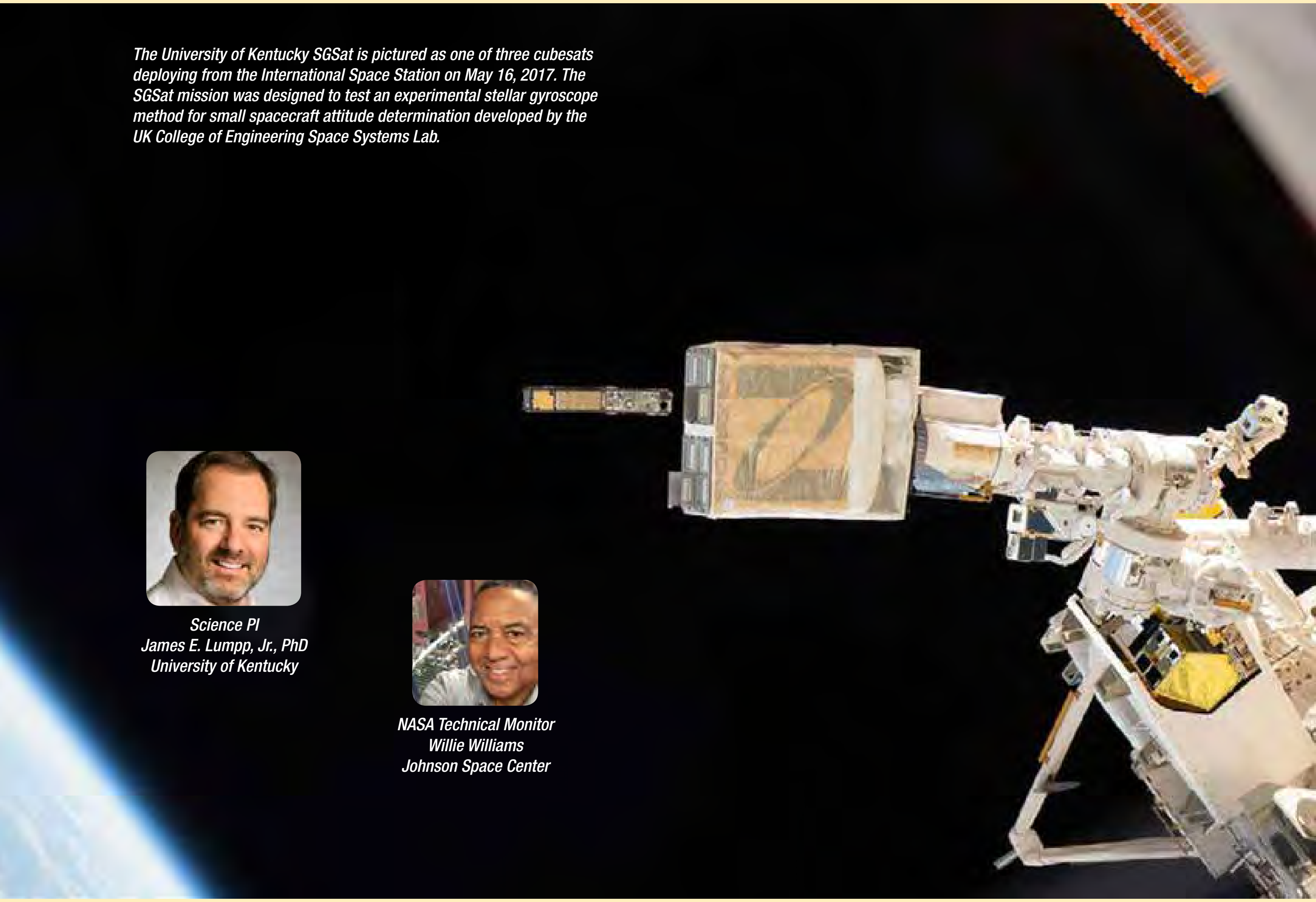
Comparative cut-bar apparatus for thermal conductivity measurements of fibrous insulation materials used in thermal protection systems (TPS) for re-entry vehicles. A molybdenum cut-bar is used as a heat flux gauge to determine the total thermal resistance of a sample. Credit: John F. Maddox, PhD, University of Kentucky.



Suzanne Weaver Smith, PhD
Kentucky EPSCoR Director
University of Kentucky

Validation of a Cubesat Stellar Gyroscope System

University of Kentucky



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.

Science PI
James E. Lumpp, Jr., PhD
University of Kentucky

NASA Technical Monitor
Willie Williams
Johnson Space Center

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.

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

University of Louisville

Science PI
Stuart J. Williams, PhD
University of Louisville

NASA Technical Monitor
William V. Meyer, PhD
Glenn Research Center

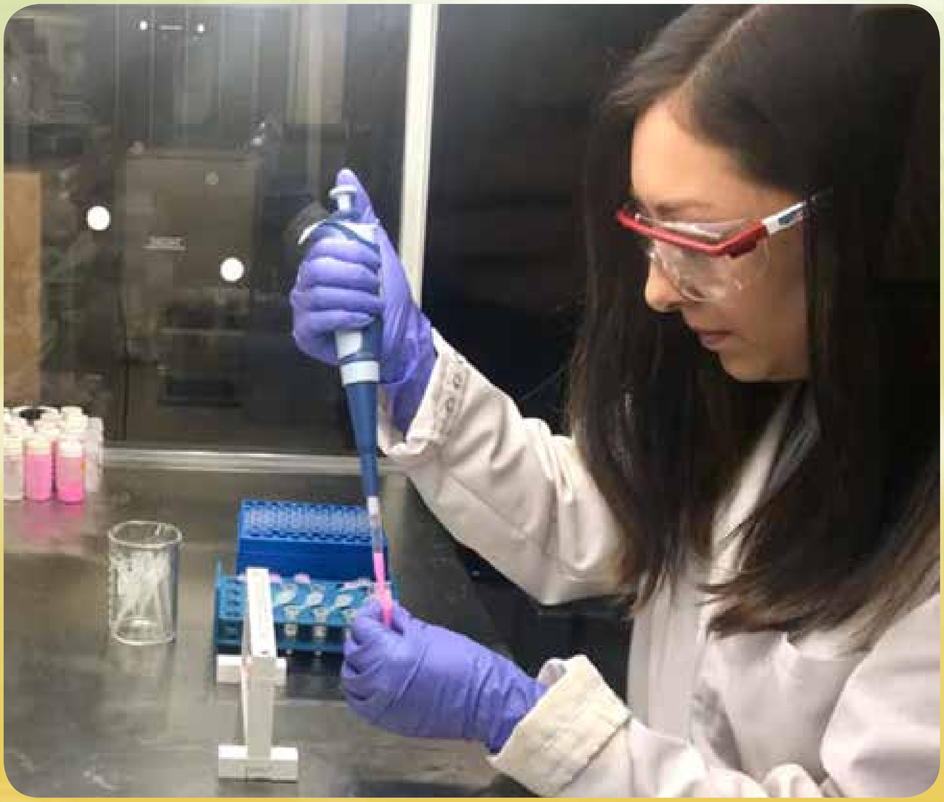
University of Louisville (UofL) faculty and student researchers are working with NASA Glenn Research Center and the NASA International Space Station (ISS) Program to examine behavior of fluids in the microgravity environment of low-Earth orbit.

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.

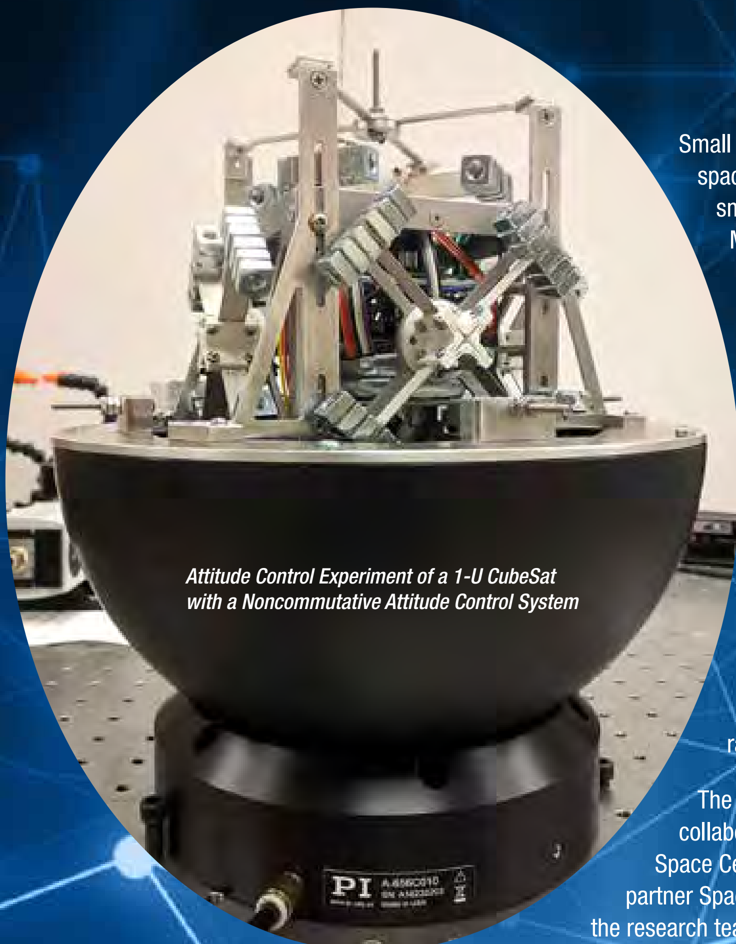
On the ground, additional experimentation and sample characterization are being conducted to properly compare on-earth observations with results acquired from the ISS. UofL professors are incorporating this experience with space-based research into their classes and student research programs and advancing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

Coordinated Position and Attitude Control for Formations of Small Satellites

University of Kentucky



Attitude Control Experiment of a 1-U CubeSat with a Noncommutative Attitude Control System

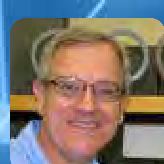
Small satellites are expected to play a significant role in future space missions. Compared to conventional large satellites, small satellites are much less expensive to build and launch. Moreover, for many applications, multiple small satellites working cooperatively can exceed the operational capability of a single conventional satellite and support a broad range of space missions, including space exploration, surveillance, comet detection, cosmological and biological studies, and space-weather monitoring.

University of Kentucky researchers Dr. Michael Seigler and Dr. Jesse Hoagg lead scientific and technical development for the NASA EPSCoR research project, “Coordinated Position and Attitude Control for Formations of Small Satellites.” This project addresses development and integration of new actuation and control technologies for small satellite swarms. These new technologies support next-generation designs of various space systems, such as interferometers, large-aperture telescopes, antennas, radiometers, and gravity-wave detectors

The research plan for Kentucky’s small sat project includes collaborations with NASA Ames Research Center, NASA Kennedy Space Center, NASA Marshall Space Flight Center, and industry partner Space Tango, Inc., headquartered in Lexington, KY. It leverages the research team’s recent developments in small-satellite attitude control, discrete-time formation control, and electromagnetic formation-flying technology, as well as expertise on video guidance sensors and small-satellite design and testing

Major milestones of the project include a 5-satellite cooperative-control experiment using the NASA Marshall flat-floor facility and a 2-satellite formation-flying experiment using Space Tango’s TangoLab-1 facility on the International Space Station (ISS). After successful completion of this project, the research roadmap envisions follow-on projects including satellite formation-flying experiments in orbit.

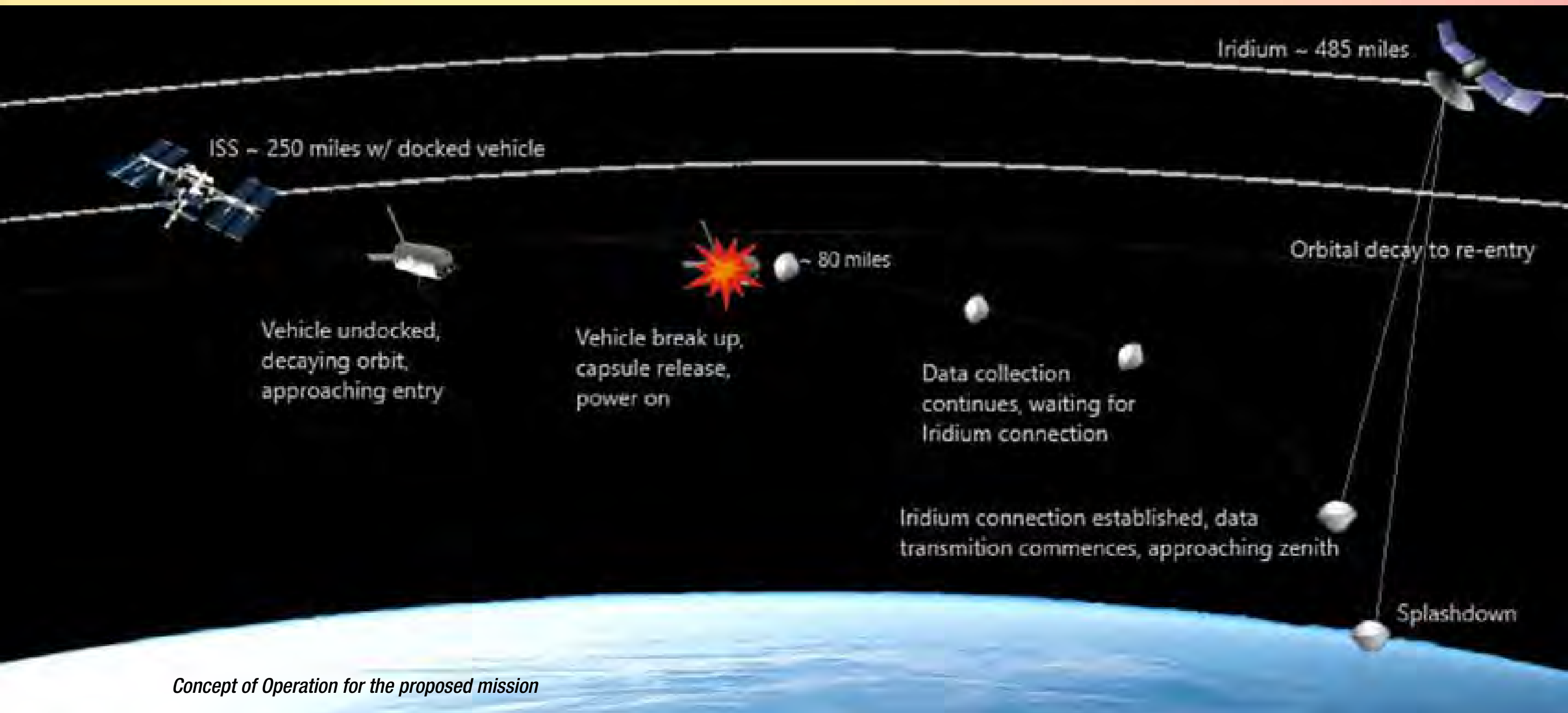
Science PI
T. Michael Seigler, PhD
University of Kentucky



NASA Technical Monitor
Robert C. Youngquist, PhD
Kennedy Space Center

KRUPS: ISS Flight for Heat Shield Testing

University of Kentucky



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.

Science PI
Alexandre Martin, PhD
University of Kentucky

NASA Technical Monitor
Michael Wright, PhD
Glenn Research Center

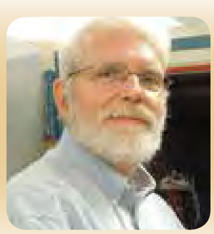
Full-scale KRUPS capsule

Louisiana Research Infrastructure Development

Louisiana State University

LSU Master's student presenting during his early days on the project at the LaSPACE 2017 Council Meeting at LSU in November 2017.

The NASA EPSCoR RID Award provides financial support and a framework to improve the research infrastructure in Louisiana while supporting the mission goals at NASA. During this current 4-year cycle alone – through several small-scale, but targeted programs – we have been able to support 13 different faculty researchers, representing 7 different Louisiana Universities (Dillard, LaTech, LSU, Southern-BR, Southern-NO, ULL, UNO, and Xavier) for research projects in collaboration with 16 NASA researchers from 5 NASA Centers (Ames, Glenn, Johnson, Marshall, and Stennis). We are also supporting STEM engagement and workforce development in the state, by funding 25 graduate and undergraduate student researchers, including the 7 funded with this year's funds. One such supported MS student, Hansen Jones, who was funded under several Louisiana Space Grant programs, as well as Shyam Menon's EPSCoR funded RAP project at LSU to develop a distributed airblast-atomized liquid fuel injection system for low-emission aircraft gas turbine engines, was the first LSU graduate to be hired by SpaceX! Jones is currently employed as a propulsion engineer working on propellant management for the company's Falcon 9 launch vehicle.

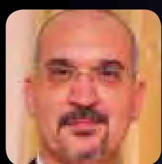


T. Gregory Guzik, PhD
Louisiana EPSCoR Director
Louisiana State University

Investigating Terrestrial Gamma Flash Production from Energetic Particle Acceleration in Lightning Using TETRA-II

Louisiana State University

Science PI
Michael L. Cherry, PhD
Louisiana State University



NASA Technical Monitor
Nasser Barghouty, PhD
Marshall Space Flight Center

Lightning is of great interest to NASA, in part because of the potential damage due to strikes to space vehicles at launch. Terrestrial Gamma Flashes (TGFs) are intense millisecond-long bursts of gamma rays associated with lightning. TGFs are detected by satellite detectors, and a recent ground-based measurement has suggested that there may be a close connection between the particle acceleration that leads to the TGFs and the basic structure of the thunderstorm. The TETRA-II (TGF and Energetic Thunderstorm Rooftop Array) array of gamma ray detectors recently installed at ground level in four locations -- at Utuado in the mountains of central Puerto Rico, at the National Metrology Centre of Panama (CENAMEP) in Panama City; on the roof of the Severe Weather Institute and Radar & Lightning Laboratories (SWIRLL) of the University of Alabama – Huntsville, and at Louisiana State University in Baton Rouge -- is designed to provide detailed and close-up information about nearby (< 5 km) thunderstorms producing TGFs. Better understanding the connection between thunderstorm structure and TGF lightning strikes will allow scientists to assist policy managers in better protecting citizens from lightning-related injuries or deaths.

Google Earth satellite view of ten white TETRA-II detector boxes on the roof of Building B of the University of Puerto Rico – Utuado. The location of the detectors are marked by the yellow arrow.

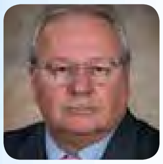
Damage Healing of Polymer Composite Structures Under Service Conditions

Louisiana State University

This project targets several programs in the NASA Aeronautics Research Mission Directorate (ARMD) and Human Exploration & Operations Mission Directorate (HEOMD), and responds to State and Institution research priorities. The research objective of this project is to develop new polymer composite panels for in-service damage healing through (1) design, synthesis, characterization, and manufacturing of two-way shape memory polymers (2W-SMPs), which expand when temperature drops, even without external tensile load; (2) multiscale modeling of the smart composite structures; and (3) additive manufacturing using 3D printing and experimental evaluation of the smart composite panels for impact mitigation and in-service crack healing. In the second year of this project, we synthesized a new thermoset polymer which has mechanical properties comparable to those of conventional thermoset polymers such as epoxy, but is self-healable and recyclable. We also synthesized a new two-way shape memory polymer based syntactic foam, which shows expansion upon cooling and contraction upon heating, has potential to be used in sandwich core, for lightweight structure applications. Finally, a bottleneck for existing entropy driven thermoset shape memory polymers is their low recovery stress and low energy output. We developed a new enthalpy storage thermoset shape memory polymer. As compared to entropy driven counterparts, which usually have a stable recovery stress from tenths to several MPa and energy output of several tenths MJ/m3, our rubbery network achieved a recovery stress of 17.0 MPa and energy output of 2.12 MJ/m3 in bulk form.

Fourth Annual Group Meeting on March 2, 2018 (first row from left to right are the Science PI and Co-Is of this project: Dr. Samuel Ibekwe, Dr. Isiah Warner, Dr. Guoqiang Li, and Dr. Lu Lu)

Science PI
Isiah Warner, PhD
Louisiana State University



NASA Technical Monitor
John H. Vickers, PhD
Marshall Space Flight Center

Understanding and Quantifying Carbon Export to Coastal Oceans through Deltaic Systems

Louisiana State University

LSU gradate student prepares Niskin bottle for coastal water sampling

When soil from a delta submerges into the coastal ocean—due to sea level rise induced land loss—carbon is released from the soil organic matter. The transformation of soil carbon to inorganic carbon will make the coastal water over-saturated with CO2, which is a green house gas. The efflux of CO2 from the coastal ocean to the atmosphere will exacerbate climate change. Collaborating with scientists at Southern University, which is the one of nation's historically black universities, Louisiana State University's oceanographer Dr. Z. George Xue is leading a multidisciplinary team to investigate the "fate" of the carbon exported from the Mississippi Delta system. This project will combine state-of- the-art in situ sampling, remote sensing, and numerical modeling technique to quantify carbon export from two contrasting environment: Barataria Bay, which has a coastline that is experiencing significant subsidence and land loss, and Wax Lake Delta, a fast-growing delta that is expanding. Dr. Xue anticipate to achieve a carbon budget of the Mississippi Delta using his coupled physical- biogeochemical model with support from in-situ and remote sensing data. The knowledge gained from this project will be applicable to other major deltas in the world, the majority of which is under the threats of a rising sea level.

Science PI
Zuo (George) Xue, PhD
Louisiana State University

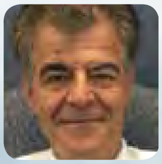
NASA Technical Monitor
Marc Simard, PhD
Jet Propulsion Laboratory

Production of Fuels and Other Life Support Products Using Wastewaters as a Feed into a Space-Based Biochemical Conversion System (BIOSYS)

University of Louisiana

A University of Louisiana PhD student is studying a digestion system for conversion of human-derived wastewaters into biogas (composed of methane, carbon dioxide, and hydrogen via the bioconversion by anaerobic microorganisms) to evaluate the energetic content of the gaseous product.

Science PI
Mark Zappi, PhD
University of Louisiana



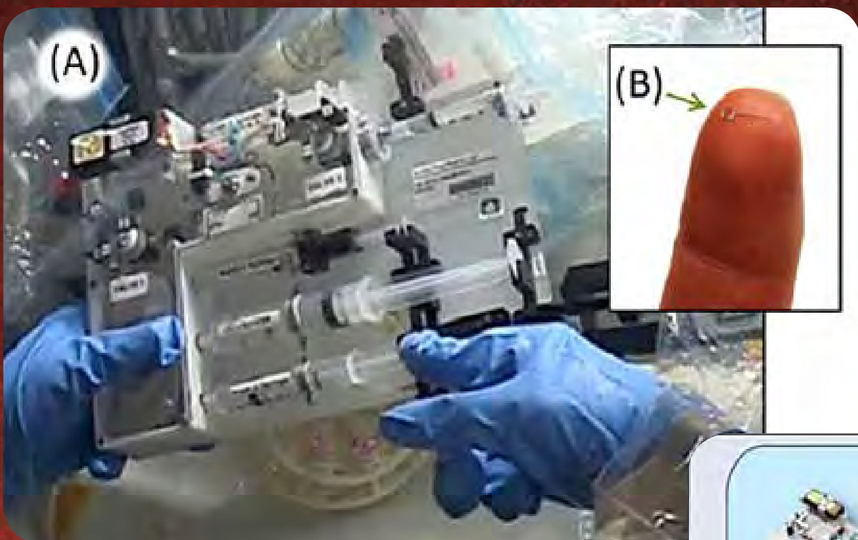
NASA Technical Monitor
Ali Shaykhian, PhD
Kennedy Space Center

Human activities within future residence stations on celestial bodies, such as the Moon and Mars, will produce wastes and consume both water and oxygen. Key waste streams include (1) Black Water (toilet-derived: feces, urine, wipe paper, and water); (2) Food Wastes (kitchen and cafeteria derived with some water generation); and, (3) Grey Water (aka. hygiene water - primarily water, with some soap and solids, generated from sinks and showers). Water and oxygen, at this time, are not produced on-site based on current scientific knowledge of both Moon and Mars geochemical and atmospheric systems; hence, these two key resources need to be recycled as much as possible. Therefore, to sustain future human life support activity at these celestial bodies, recovery of the carbon, oxygen, and hydrogen along with the microchemicals making up the food, water, and air provided to the astronauts is needed to reduce the frequency of expensive make-up deliveries of these life support chemicals to the station.

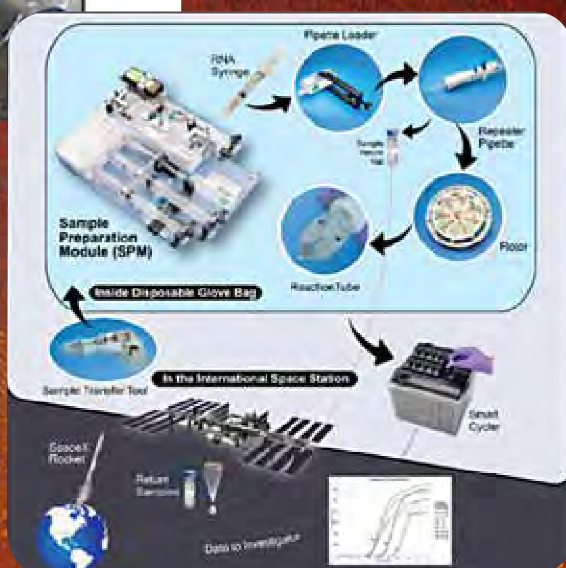
A Biorefinery System (BIOSYS) has been designed, based on a series of R&D projects performed at UL Lafayette over the past 10 years, that will effectively treat all human activity-based waste (black water, grey water, and food waste streams) using biological systems that will produce process by-products, recovered potable water, liberated free oxygen, edible protein cake (with and without lipids), soil amendments, and lube oils. Additionally, the system will capture and chemically bind carbon dioxide into microbial cells and associated by-products thus producing recovered cabin air. This system design will result in the treatment of the COD (chemical oxygen demand) within the water influent to essentially zero concentrations. A key R&D objective will be the optimization of the overall system for maximum performance which is defined as no waste residuals remaining (complete recycle of all waste stream constituents) and the entire system operated at a near-neutral energy footprint. The complete system will be designed using low payload weight and volume while also providing the capability of being operated using minimal labor, mission team member training level, and required energy input. The key benefit will be almost complete recycle of key life support chemicals – water and oxygen – while also producing by-products of great value for long-term life sustainment.

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

Louisiana Tech University



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.



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.

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".

Science PI
Niel Crews, PhD
Louisiana Tech University

NASA Technical Monitor
Matt Romeyn
Kennedy Space Center

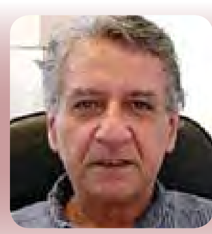
Maine Research Infrastructure Development

Maine Space Grant Consortium

Maine's economy depends heavily on its forest resource base, which faces increasing pressure from environmental and societal changes. There is a strong need to better assess and monitor this valuable resource in order to best prepare managers and policy makers for various possible futures. The primary goal of this Research Infrastructure Development (RID) project is to build a foundation supporting a sustained research program to assess, monitor, and project the value of Maine's forest resources. To address such a foundational goal, this RID project laid out three specific objectives for research and infrastructure development in the near-term: (1) identify potential study sites to create a strong and integrated observational network in Maine; (2) collect baseline in situ and remote sensing data; and (3) process and summarize collected data for future research efforts. Furthermore, this project would involve forming new, key partnerships between the University of Maine, NASA and other stakeholders in order to lay the groundwork for a sustained, long-term and highly collaborative research program to benefit the state of Maine while also advancing NASA's science mission.

Infrared aerial image of the NASA G-LiHT acquisition over the Schoodic Peninsula, Maine, on August 9th, 2017

ME



Terry Shehata, PhD
Maine EPSCoR Director
Maine Space Grant Consortium

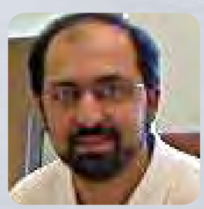
Joint Leak Detection and Localization Based on Fast Bayesian Inference from Network of Ultrasonic Sensors Arrays in Microgravity Environment

University of Maine

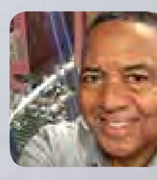
Actual payload placement photos from inside the ISS

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 Dr. Ali Abedi



Science PI
Ali Abedi, PhD
University of Maine



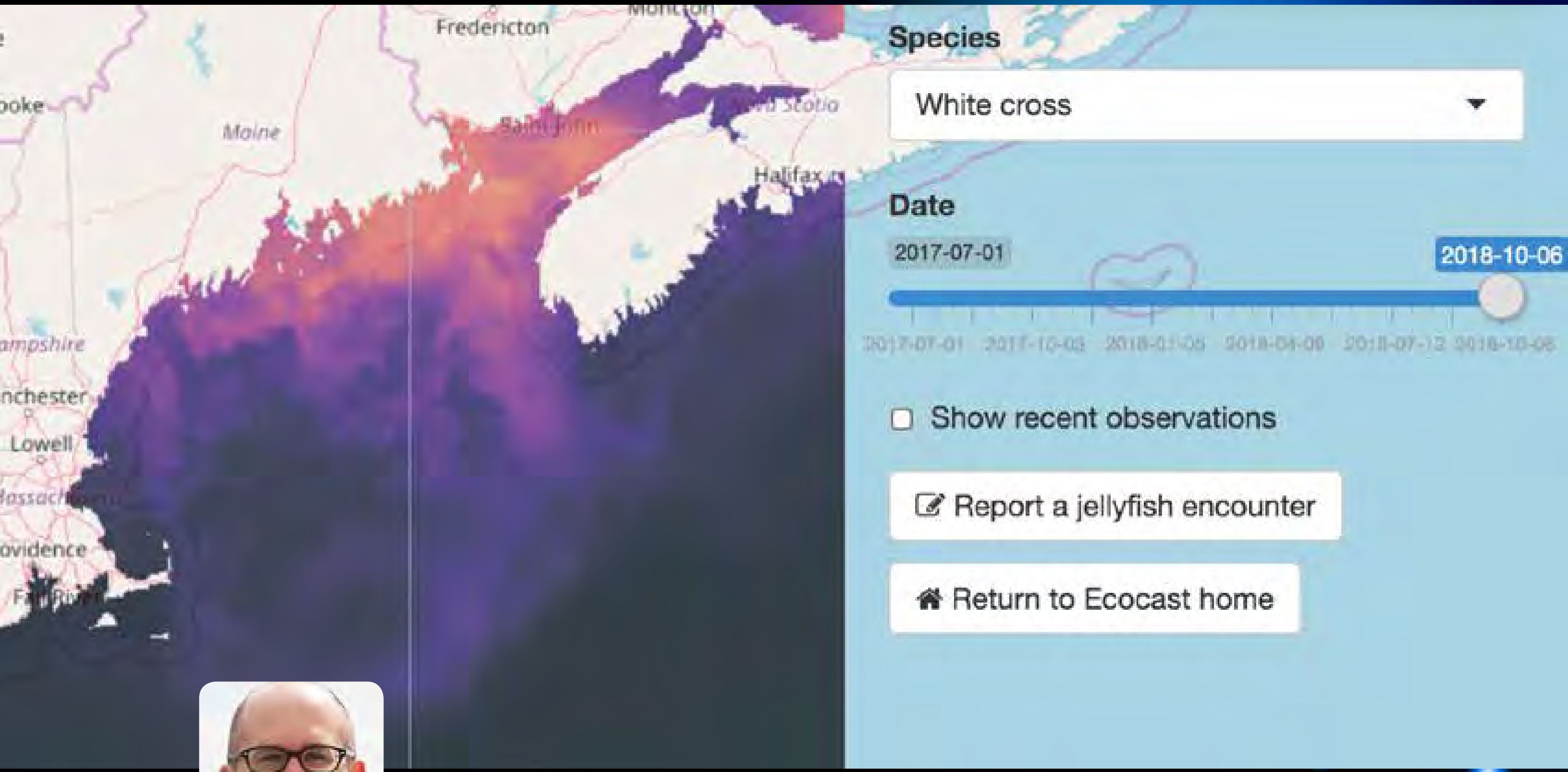
NASA Technical Monitor
Willie Williams
Johnson Space Center

Earth System Data Solutions for Detecting and Adapting to Climate Change in the Gulf of Maine

Gulf of Maine Research Institute

Linking NASA data with crowds to forecast ecosystems. We all like to be able to glance into the future when we can. When people plan their weekends, they often check the weather forecast. Imagine if that weather forecast could also tell you the chances of encountering jellyfish, ticks, mosquitos, or toxic red tides. This is the essence of "ecosystem forecasting".

Ecosystem forecasting has great potential to benefit human health, recreation, and the economy. But biology is more difficult to forecast than weather. Animals are often wily and hard (or expensive) to track. Populations can grow or disappear quickly. There are also countless species interacting, making matters all the more complicated, and confounding many attempts to make reliable forecasts of ecosystems. We cracked this nut with a new approach that blends NASA satellite data with observations from the general public — sightings of animals like jellyfish and ticks. NASA data provide a scaffolding of the changing conditions, and the crowd-sourced species sightings turn a wide lens on the movement of animals throughout our environment. When combined, using models and machine learning algorithms, the result is a reliable day-to-day forecast of the critters we encounter. The forecasts are available online (eco.bigelow.org), and thousands of people have contributed data. As the environment changes more rapidly, the ability to glance into the future will become ever more valuable, and such forecasts will be a critical tool for adaptation.



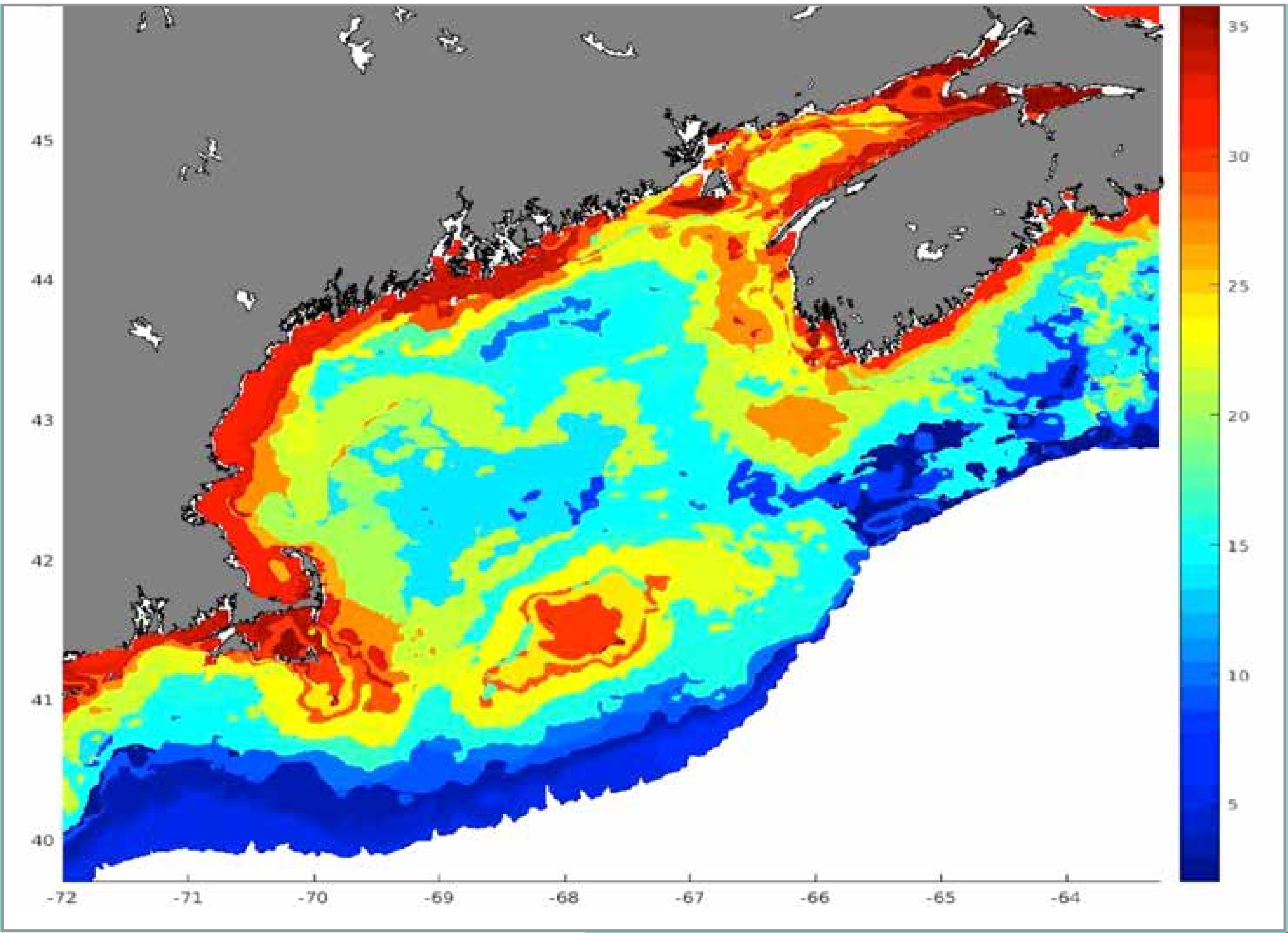
Screen shot of the live jellyfish forecast at https://eco.bigelow.org/jellycast/, showing areas of high or low likelihood of encountering jellyfish

Science PI
Andrew J. Pershing, PhD
Gulf of Maine Research Institute

NASA Technical Monitor
Edward M. Armstrong, PhD
Jet Propulsion Laboratory

Multi and Hyperspectral Bio-Optical Identification and Tracking of Gulf of Maine Water Masses and Harmful Algal Bloom Habitat

University of Maine



An example of spatial patterns formed by 36 different ocean color water types in the Gulf of Maine derived from the multivariate statistical grouping of 19 years of NASA multispectral satellite data

Science PI
Andrew J. Thomas, PhD
University of Maine

NASA Technical Monitor
P. Jeremy Werdell, PhD
Goddard Space Flight Center

The goal of this research is to bring the maximum information content of NASA's ocean color satellite missions to bear on the annual harmful algal bloom problem in the Gulf of Maine. These blooms are costly both to fishermen in terms of lost harvest days and to the monitoring agencies charged with closing impacted coastal regions. Superimposed on this, the Gulf is one of the most rapidly changing pieces of coastal ocean on the planet, and so constant monitoring is required. We have borrowed a neural network technique that is quite new to ocean sciences and merged this with other multivariate statistical techniques to produce novel and new views of the multispectral patterns of surface ocean water color types in the Gulf using 19 years of NASA data. We are now comparing these views to ship-mounted hyperspectral ocean color data in anticipation of the NASA PACE hyperspectral ocean color mission, to examine the additional information afforded by these new data. Both the multispectral and hyperspectral color data are being compared to the harmful algal bloom data we have to investigate their utility as a monitoring and prediction tool.

Missouri Research Infrastructure Development

Missouri University of Science and Technology

REAL-TIME EMBEDDED PARAMETER ESTIMATION FOR AN UNMANNED AIRCRAFT
Dr. Travis Fields, University of Missouri–Kansas City

Research being conducted at the University of Missouri–Kansas City has been developing and testing techniques for estimating the dynamic model of a multirotor and utilizing the model for real time controller adaptation. The dynamic model consists of estimating parameters such as drag coefficients, motor effectiveness, and mass properties. The focus of the research has been on creating high fidelity real time models that can reconfigure the flight controller considering different operational modes.

Building upon the success of the NASA 'Learn-to-Fly' program and the system identification expertise at the NASA Langley Research Center, they have been able to demonstrate successful model identification of nominal and in-flight failure (i.e. motor failure) conditions in less than one second. The research has now expanded into senior mechanical engineering courses, and has been used for exciting outreach and recruitment demonstrations for elementary through high school students. Additionally, the techniques they are developing can be expanded to many other systems including fixed-wing aircraft, parachute systems, and ground robots, thereby potentially increasing safety and improving efficiency for the development of the next generation of unmanned systems.

Unmanned aircraft data collection utilizing a motion capture system

S. N. Balakrishnan, PhD
Missouri EPSCoR Director
Missouri University of Science and Technology

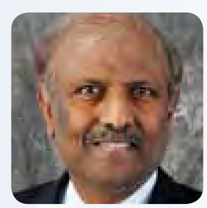
Learning Algorithms for Preserving Safe Flight Envelope Under Adverse Aircraft Conditions

Missouri University of Science and Technology

Google Glass (above) and Microsoft HoloLens (below) augmented reality headsets

Single-Large-Surface Flight Simulator at WSU GAFL

As we have in the past reports, the objectives and the expected impact on the government and industry future plan in aviation as served by the outcome of this study remains the same and restated below. Government and industry agree on the potential of learning algorithms in providing flight safety in the presence of adverse conditions (resulting from, for example, degraded modes of operation, loss of control, and imperfect aircraft modeling) and reducing aircraft development costs. A major roadblock to their widespread adoption is the lack of a-priori, user-defined performance guarantees to preserve a given safe flight envelop in general and commercial aviation. This highly collaborative NASA EPSCoR Missouri project has been addressing this fundamental issue in the utilization of learning algorithms for aerospace applications by establishing a new theoretical framework along with necessary and sufficient conditions for guaranteed flight control safety and resilience in the presence of aircraft adverse conditions. Learning algorithms developed using this framework have the capability to keep the aircraft trajectories within this a-priori determined envelope in the presence of anomalies. Furthermore, we have been developing methods to use these algorithms effectively for the purpose of pilot support as well. In addition to theoretical advancements, flight tests using CJ-144 fly-by-wire Bonanza aircraft will be performed as a part of this project. This research has a high potential to impact a broad range of aerospace and non-aerospace applications utilizing learning algorithms that involve safe and effective vehicle control and crew decision-making in complex and abnormal situations.



Science PI
S.N. Balakrishan, PhD
Missouri University of Science and Technology

NASA Technical Monitor
Susan Frost, PhD
Ames Research Center

Mississippi Research Infrastructure Development

University of Mississippi

Jared Delcamp, PhD examining dye used in his solar cells research

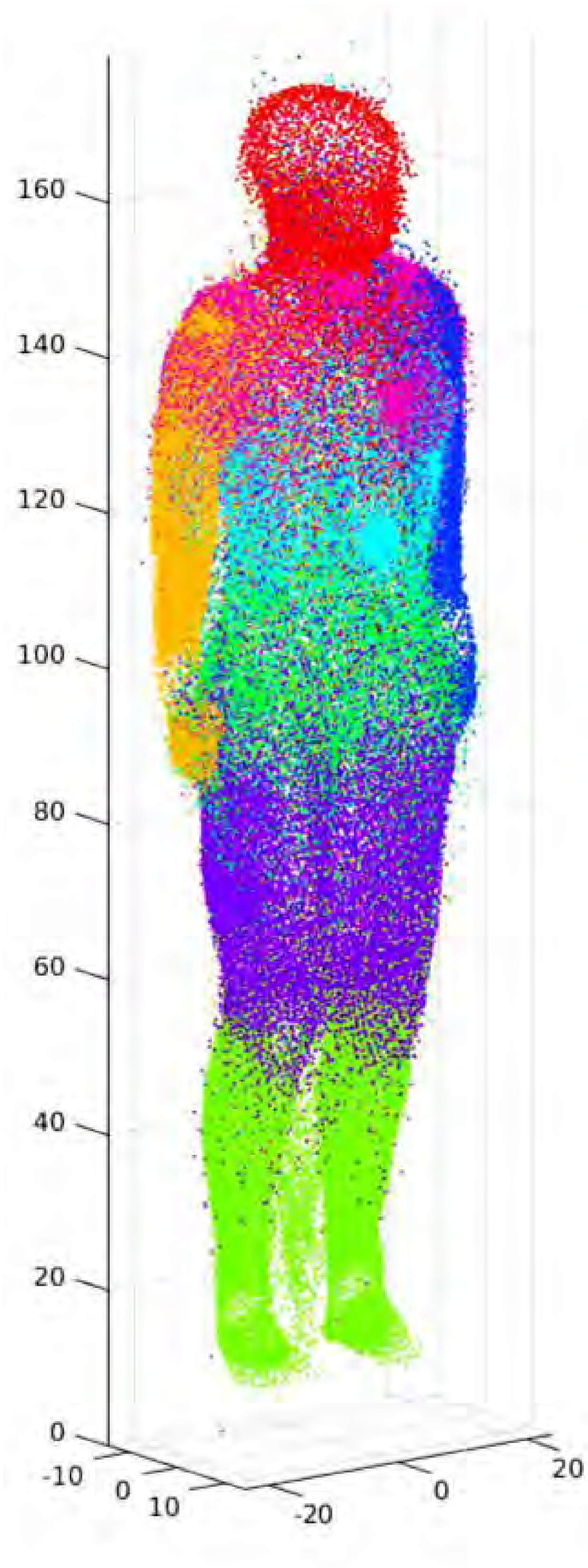
Dye-Sensitized Solar Cells with Halogen Bonding Recognition for High Voltage Systems

We established a new collaboration between the University of Mississippi and Mississippi State University joining computational and experimental expertise to improve solar cell device voltages through control of halogen bonding at the dye-semiconductor interface within dye-sensitized solar cells (DSCs). The team has successfully synthesized new materials for DSCs and are currently workingto DSC devices with these materials.

Nathan E. Murray, PhD
Mississippi EPSCoR Director
University of Mississippi

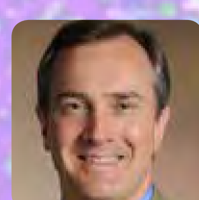
GEANT4 Simulations for Astronaut Risk Calculations

University of Southern Mississippi



Particles from solar-flares and galactic cosmic rays pose significant risks to astronauts on long-term space missions due to their potential to cause damage at the microscopic level. In addition to directly breaking DNA strands, radiation can indirectly damage DNA through generation of free-radicals in the cell nucleus. Geant4 is a toolkit that simulates the transport of radiation through materials, and using Geant4's DNA and chemical software packages, we can calculate the number of DNA strand breaks for a given quantity, rate, and type of radiation. At present, radiation risk to astronauts is measured by a quantity called REID (Radiation Exposure Induced Death). Given the amount of radiation received by an astronaut, and using historical radiation exposure and outcome data, REID can be calculated without reference to any microscopic model of human cells or DNA damage. This project seeks to find correlations between REID and the number of DNA strand breaks or other aberrations. The goal of this work is to better understand the microscopic causes of astronaut risk and better inform future analysis of astronaut safety. Although at an early stage, it is believed that this approach can contribute to understanding the role of DNA damage in outcomes such as cancer. The figure below presents a visualization of the body model used for determination of full body effective dose and REID.

Rendering of the body model used for calculation of full body effective dose. Surface points were calculated from rays passing through muscle tissue points. Each color corresponds to the rays used for points in different muscle regions.

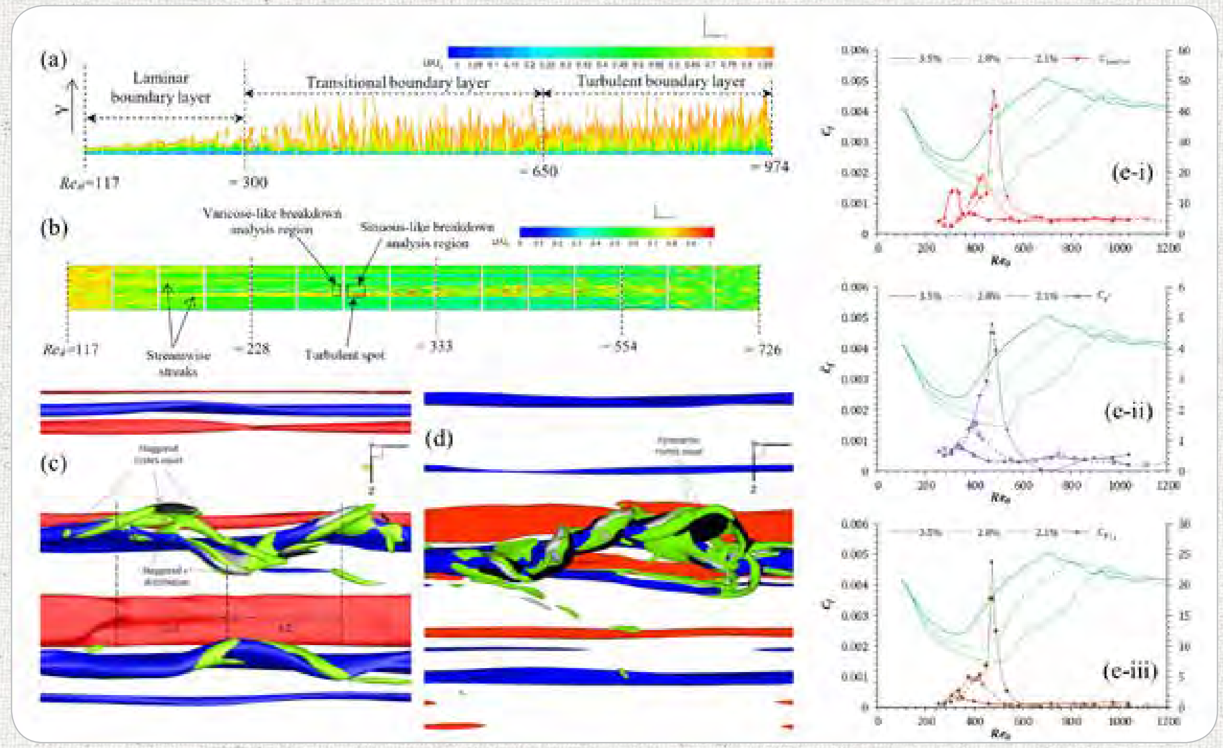


Science PI
Chris Winstead, PhD
University of Southern Mississippi

NASA Technical Monitor
Kerry Lee, PhD
Johnson Space Center

High-Fidelity Loci-CHEM Simulations for Acoustic Wave Propagation and Vibration

Mississippi State University

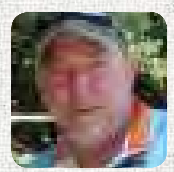


Direct numerical simulation of bypass transition over flat-plate boundary layer. (a) Contours of instantaneous streamwise velocity at the spanwise center plane. (b) Contours of streamwise velocity shown in x-z plane close to the wall. (c) Sinuous-like and (d) varicose-like breakdown of streamwise streak around transition onset. (e) Transition onset marker based rapid and return pressure fluctuations. Ratio of rapid and slow (e-i) pressure Poisson equation source terms; (e-ii) pressure fluctuations; and (e-iii) pressure-strains.

Engineering applications often involve bypass transition, which occurs due to the presence of strong disturbances (such as high free-stream turbulence, large wall roughness elements, flow separation, pressure gradient effects). The bypass transition process entails strongly nonlinear phenomena leading to boundary layer breakdown, hence it cannot be well described by linear theory and remains a modeling challenge. One of the limitations of the existing transition models is the unavailability of a robust bypass transition onset parameter. Bhushan et al. performed temporally developing direct numerical simulations (T-DNS) for bypass transition over boundary layers to evaluate the efficacy of several large-scale flow parameters as transition onset markers. The study identified growth of the near-wall streamwise fluctuations as a viable marker, but the maker failed to satisfy monotonic increase from laminar to turbulent regimes. Ongoing research is focusing on understanding the phenomenological under-pinning's of the transition onset to obtain a robust transition onset marker. DNS results are analyzed to evaluate the interplay between the pressure-strain terms and flow instability mechanisms. Results show that transition initiates at a location where the slow pressure-strain term becomes more dominant than the rapid term. The slow term is responsible for the transfer of turbulence energy from the streamwise component to other components, most importantly the wall-normal. The relative magnitudes of the slow and rapid terms can potentially provide a basis for the development of physically meaningful large-scale parameters that can be used as transition onset markers for Reynolds averaged Navier-Stokes (RANS) simulations.

Science PI
Shanti Bhushan, PhD
Mississippi State University

NASA Co-Technical Monitor
Thomas B. Steva
Marshall Space Flight Center



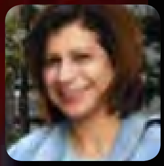
NASA Co-Technical Monitor
Christopher I. Morris, PhD
Marshall Space Flight Center

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

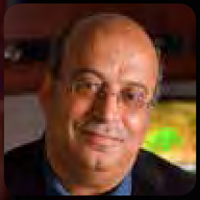
University of Mississippi

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.



NASA Technical Monitor
Marisabel Kelly, PhD
Glenn Research Center



Science PI
Ahmed Al-Ostaz, PhD
University of Mississippi

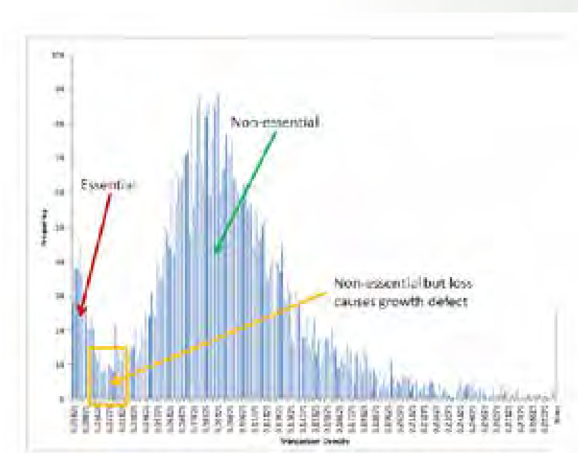
A research associate tests Graphene Reinforced Polymers for Hypervelocity Impact Application.

Assessment of Whole Genome Fitness of Bacteria Under Microgravity

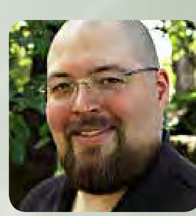
University of Mississippi

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.



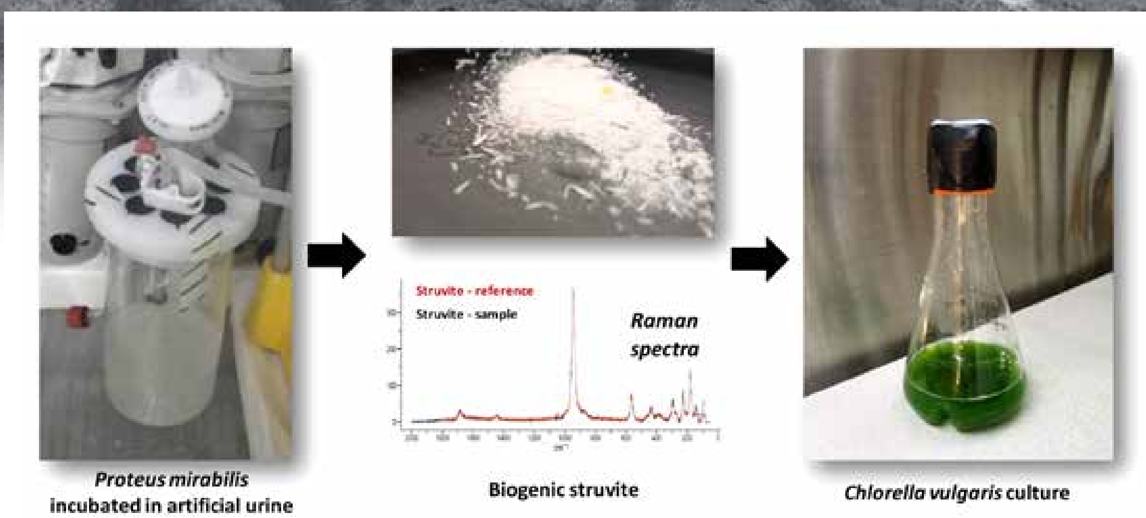
Science PI
Patrick Curtis, PhD
University of Mississippi

NASA Technical Monitor
Melissa Floyd, PhD
Goddard Space Flight Center

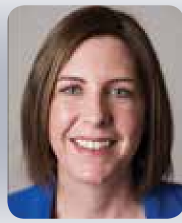
Montana Research Infrastructure Development

Montana State University

Boyd Award: The Cinder Pool in Yellowstone National Park hosts abundant and active thermophilic microbial populations that are used in astrobiology research.



Gerlach Award: Biogenically produced struvite as an alternative source of nutrients for algal growth



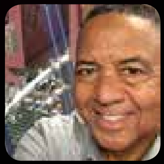
Angela C. Des Jardins, PhD
Montana EPSCoR Director
Montana State University

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

Montana State University

The Artemis prototype that is currently being tested on the ISS

Science PI
Brock J. LaMeres, PhD
Montana State University



NASA Technical Monitor
Willie Williams
Johnson Space Center

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.

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

Montana State University

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

The research in this project aims to produce a computing technology that will dramatically reduce the cost of space systems while simultaneously improving performance and reliability. The harsh space environment has historically mandated custom space-grade parts that can withstand the extreme radiation of space. These space-grade parts are extremely expensive due to the low-volume nature of their manufacturing process. Montana State University (MSU) is investigating how to use commercial electronics to satisfy the requirements of aerospace missions. MSU has devised a computer architecture that dynamically recovers from radiation-induced failures that can be implemented on commercial parts. The use of commercial parts allows the cost of space systems to be reduced by exploiting the high-volume manufacturing nature of these devices. The MSU computing technology has applications in all future space science and exploration missions in addition to commercial applications such as communication networks and Earth imaging.

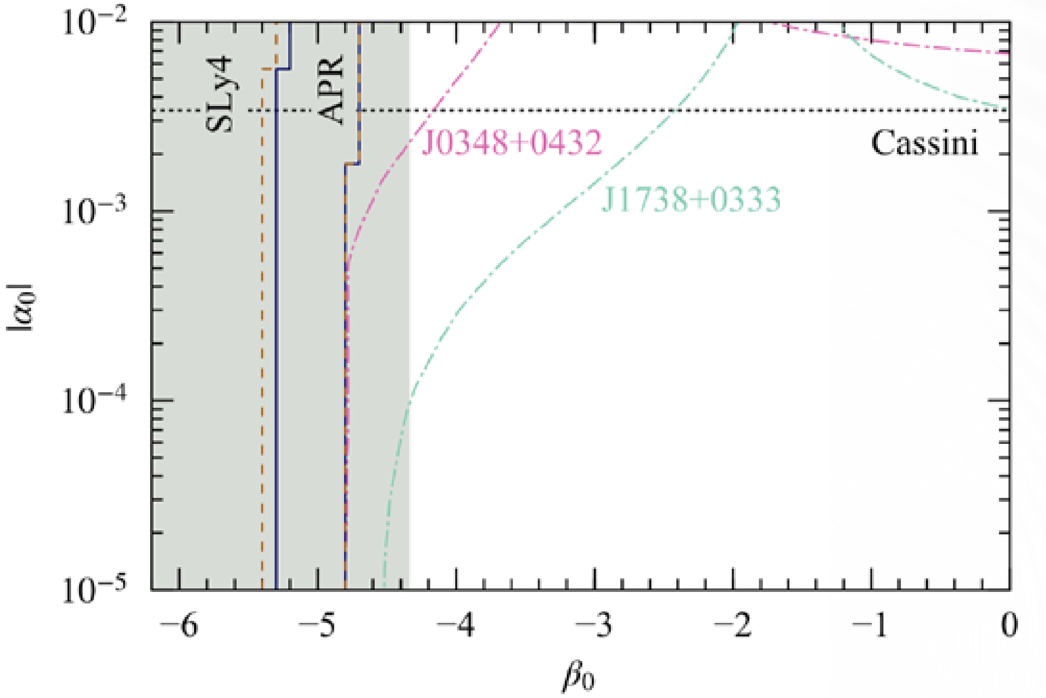
RadSat-g from Montana State University tests a new computer architecture that can recover from faults caused by space

Science PI
Brock J. LaMeres, PhD
Montana State University

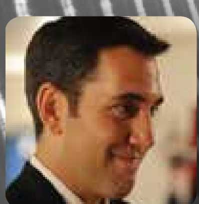
NASA Technical Monitor
Eric A. Eberly, PhD
Marshall Space Flight Center

Exploring Extreme Gravity: Neutron Stars, Black Holes and Gravitational Waves

Montana State University

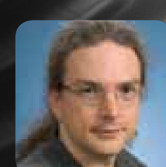


Estimate of how well we can test Einstein's theory of General Relativity with observations from NASA's Neutron Star Interior Composition ExploreR (NICER). The shaded region in this figure are where large deviations from General Relativity are present. Any region to the left and above the solid (dashed) lines can be excluded to 68% confidence with a NICER observation of a neutron star rotating at a frequency of 600 (200) Hz. For comparison, we also included constraints from observations of NASA's Cassini probe at 68% confidence (dotted line), as well as constraints with observations of the binary-pulsar systems J1738-0333 and J0348-0432 (dot-dashed lines). The estimated constraints that we could place with NICER are comparable to those that can be placed with binary pulsar observations. Image from Neutron star x-ray burst oscillations as extreme gravity probes by Hector O. Silva, Nicolás Yunes submitted to Classical and Quantum Gravity Letter (http://arxiv.org/abs/arXiv:1902.10269)



Science PI
Nicolas Yunes, PhD
Montana State University

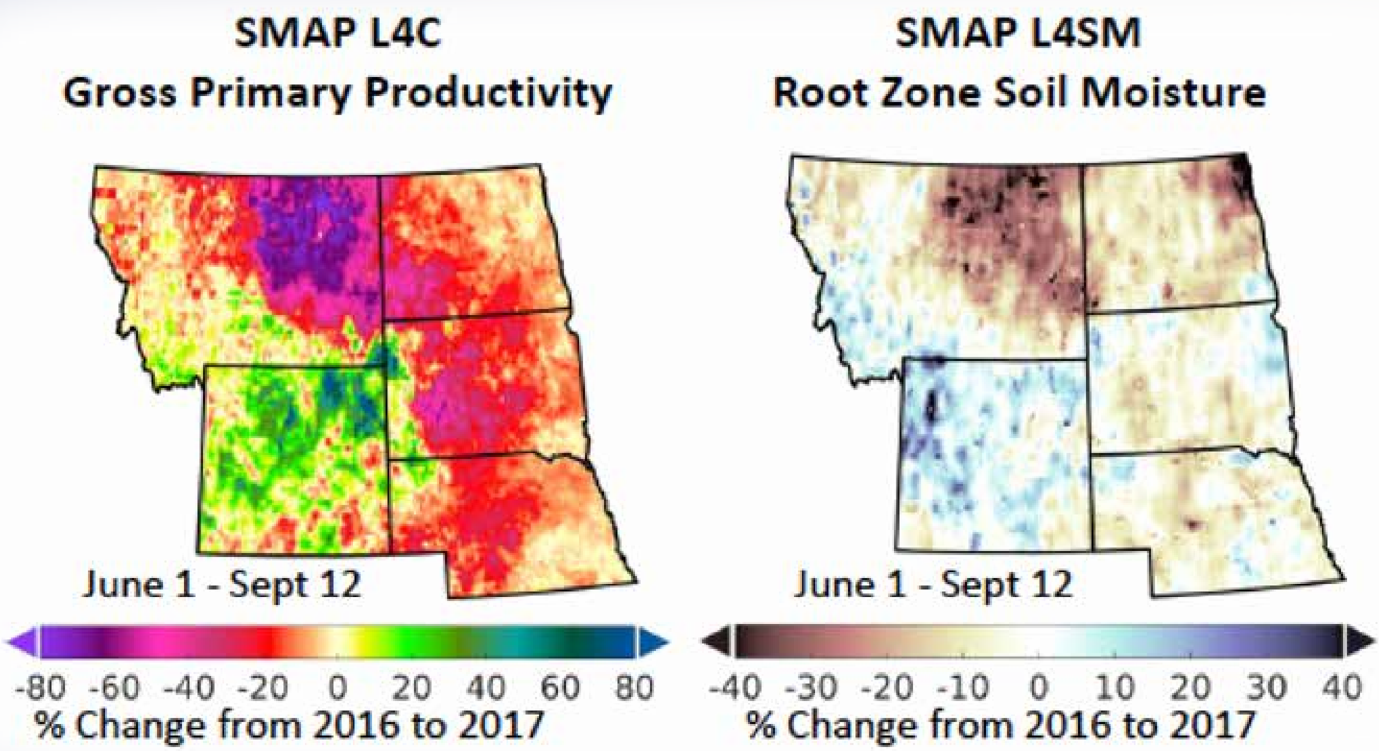
This proposal is focused on (i) nuclear physics in extreme gravity, (ii) experimental relativity in extreme gravity, and (iii) multi-messenger astrophysics in extreme gravity. Regarding (i), we propose to improve and develop new tools to extract the most astrophysics from X-ray data obtained with NASA's Neutron star Interior Composition ExploreR (NICER). These tools will allow for precise constraints on the neutron star equation of state through measurements of their mass and radius. Regarding (ii), we propose to create a framework through which to test General Relativity with both gravitational wave data from the Laser Interferometer Space Antenna (LISA) and X-ray data from NICER in a robust and modelindependent fashion. This framework will allow for consistency checks of Einstein's theory and the search for modified gravity anomalies with neutron stars and black holes. Regarding (iii), we propose to learn about nuclear physics and General Relativity by combining X-ray information from NICER, gammaray information from NASA's Fermi and Swift telescopes and gravitational wave information from advanced LIGO. The proposed work is of direct relevance to NASA's strategic mission to better understand the universe through observation and NASA's mission of discovery and knowledge. The region of the universe where gravity is unbearably strong and dynamically changing (the extreme gravity universe) is one of the last unturned stones. This is in part because extreme gravity objects, like neutron stars and black holes, are difficult to resolve due to their size and distance from Earth. NASA's investments in neutron star astrophysics and in space-borne gravitational wave astrophysics are aimed at resolving such objects and, for the first time, exploring the extreme gravity universe in detail. The focus of this proposal is to aid in this endeavor by developing the tools and the understanding needed to extract the most information from the data.



NASA Technical Monitor
John G. Baker, PhD
Goddard Space Flight Center

Satellite-Guided Hydro-Economic Analysis for Integrated Management and Prediction of the Impact of Droughts on Agricultural Regions

University of Montana



Above is a portrait of the extent of the 2017 Flash drought over the US Northern Plains. The image was obtained by mapping primary production and soil moisture anomalies estimated from the new SMAP based L4C dataset.

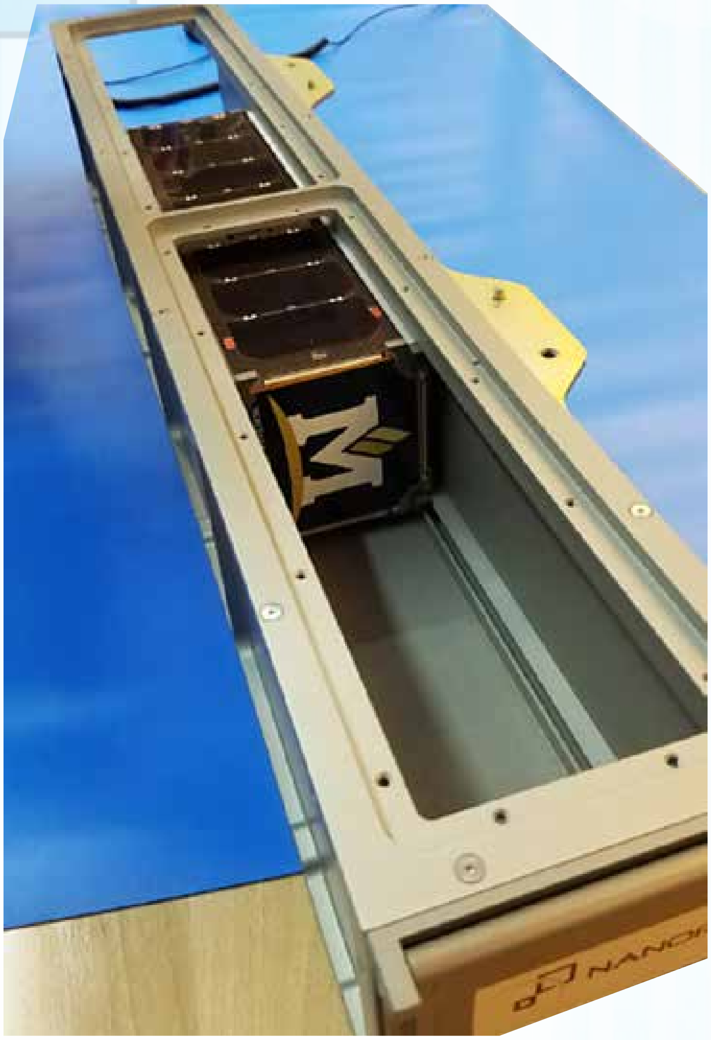
2017 Montana flash drought: A portrait of the drought using new remote sensing products The winter and spring of 2017 were wetter than average, bringing deep snowpacks to the northern Rocky Mountains and high prospects for alfalfa and pasture production. During spring and early summer vegetation growth was excellent compared to previous years. Unfortunately, these wet conditions were followed by an abnormally dry and hot summer, with record number of consecutive days above 90 degrees and no significant rain. These persistent conditions during the 2017 summer generated a virulent fire season in the western US and have caused the collapse of grain crops in the northern Plains. The intensity of the drought has been most dramatic in eastern Montana, with reports of over 50% of grain crops in poor or very poor condition. We used a new Gross Primary Production algorithm based on SMAP L4 retrievals of root zone soil moisture to calculate cumulative production anomalies with respect to 2016 and produce a portrait of the flash drought.

Science PI
Marco P. Maneta, PhD
University of Montana

NASA Technical Monitor
John D. Bolten, PhD
Goddard Space Flight Center

Demonstration of Radiation Tolerant Memory Synchronization within a Reconfigurable Flight Computer

Montana State University



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.

Science PI
Brock J. LaMeres, PhD
Montana State University

NASA Technical Monitor
Eric A. Eberly, PhD
Marshall Space Flight Center

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°			

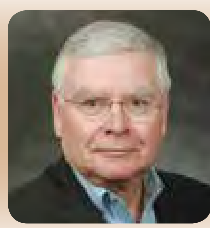
North Dakota Research Infrastructure Development

University of North Dakota

Blanco 4-meter telescope at the Cerro Tololo Inter-American Observatory used to observe 13 nearby galaxy clusters to support research completed by Dr. Wayne Barkhouse of the University of North Dakota

ND NASA EPSCoR programs have helped to put North Dakota on the map in scientific discovery and technology leadership. These cutting-edge, hands-on research endeavors support NASA's Technology Areas (TAs) and the workforce development needs of North Dakota. These projects have both immediate impact and long-term benefits to faculty, students, and industry partners across the state. One recently funded project included an examination of water purification techniques, essential for TA 6: Human Health, Life Support, and Habitation Systems. Through this project, the PI improved biology teaching techniques, including collaborative work in interdisciplinary teams of student researchers. A study in electrical and computer engineering examined microchip cooling techniques, aligning with TA 14: Thermal Management Systems. Through this research, the PI has established industry partnerships and aims to bring new business opportunities to North Dakota through additional research, prototyping, and production. An astrophysics project quantified the impact of the high-density galaxy cluster environment on the evolution of cluster galaxies, aligning with TA 8: Science Instruments, Observatories, and Sensor Systems. This research significantly advanced graduate studies, in that it supported two students' dissertations.This summary is just a snapshot of the impact of ND NASA EPSCoR on North Dakota's evolving research infrastructure.

ND

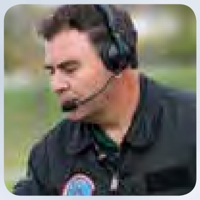


James Casler, PhD
North Dakota EPSCoR Director
University of North Dakota

Multi-Purpose Research Station in North Dakota in Support of NASA´s Future Human Missions to Mars

University of North Dakota

The University of North Dakota (UND) Human Spaceflight Laboratory is developing a Multi-Purpose Research Station in North Dakota in order to expand NASA-relevant research within the state. During the third year of the current NASA EPSCoR grant, UND developed two additional dedicated modules: an Exercise and Human Performance Module to perform research in exercise regimes for long-duration crews spending time on planetary habitats, and a Geology Module designed for learning techniques on how to study geological-relevant samples without the risk of contamination by the crew. During previous years of the current grant, a Plants Production Module to perform research on the production of edible plants for the crew and an Extravehicular Activities Module were developed, completed, and tested. This research includes a collaborative effort among numerous organizations and several NASA Centers. A total of five analog missions have been performed to date, ranging from 10 to 30 days with crews of 3 crewmembers. Longer duration missions are planned for the near future. North Dakota offers a unique environment for this type of research with its climate extremes that are ideal for analog planetary simulations. This permanent experimental research station will help our next generation of explorers reach new worlds beyond Earth.



Science PI
Pablo de León, PhD
University of North Dakota

NASA Technical Monitor
Douglas Gruendel
Kennedy Space Center

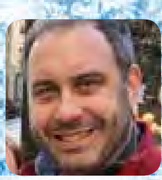
Spacesuited crewmembers launch balloon during Mission 5

Derive Phytoplankton Size Classes, Detrital Matter, Particulate Organic Matter and Particulate Inorganic Matter from Ocean Color Observation

University of North Dakota

Setting up the instruments on the RV Sally Ride, before embarking on a 35-day experiment in North Pacific ocean

Science PI
Xiaodong Zhang, PhD
University of North Dakota

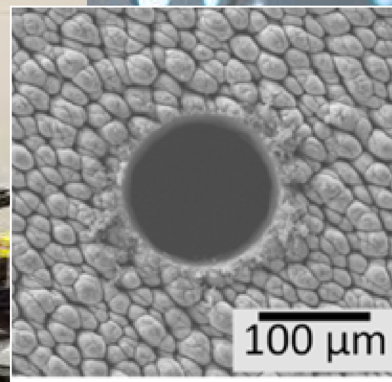


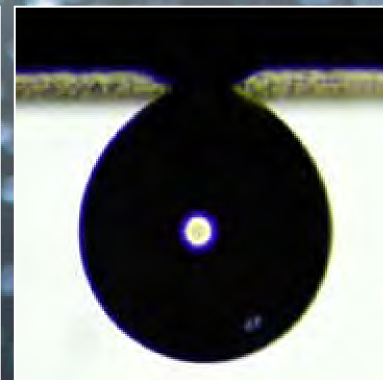
NASA Technical Monitor
P. Jeremy Werdell, PhD
Goddard Space Flight Center

The Earth's oceans have absorbed nearly half of anthropogenic CO2 released into the atmosphere. One of the most important oceanic processes in sequestering atmospheric CO2 is net primary production by phytoplankton that fix inorganic carbon into organic matter in the sun-lit, surface ocean and its subsequent vertical transport to the ocean's interior. To better understand and quantify this biological pump requires detailed knowledge of spatial and temporal variations of phytoplankton community structure and other carbon pools. Ocean color remote sensing has revolutionized our understanding of global distribution of phytoplankton biomass and rates of primary production. However, significant uncertainty remains because (i) primary production varies among different phytoplankton species, which cannot be estimated adequately using a single measure of total biomass; (ii) other carbon pools, such as dissolved organic carbon, also play a role; and (iii) presence of mineral particles alters fluxes of organic carbon. We propose to develop advanced inversion algorithms to infer global distributions of phytoplankton in three size classes (micro, nano, and pico), colored detrital matter, dissolved and particulate matter from remotely sensed ocean color data to support the studies of oceanic sequestration of atmospheric CO2. Dr. Xiaodong Zhang, a Professor with the Department of Earth System Science and Policy at the University of North Dakota will lead this effort as the Science-Investigator. His prior studies have led to the development of individual algorithms based on the field measurements that derive phytoplankton size classes and colored detrital matter from the spectral absorption coefficients and derive size and composition distribution of various biogeochemical stocks from the volume scattering functions. We will refine, revise and combine these individual algorithms into applications that can be used for satellite ocean color observation. Specifically, the developed algorithms will allow the retrieval of (i) phytoplankton concentrations in three size classes of micro (> 20 μm), nano (2 – 20 μm) and pico (< 2 μm) ranges; (ii) absorption at 410 nm and spectral slope of the colored detrital matter; (iii) backscattering by very small particles (of sizes < 0.2 μm); (iv) concentrations of particulate organic matter (POM) and particulate inorganic matter (PIM). The first two products will be estimate from ocean color – derived spectral absorption coefficient and the last two product from ocean color –derived spectral backscattering coefficient. We will test the developed algorithms over global ocean and estimate the associated uncertainty using collocated NASA ocean color observation and field measurements as well as additional field experiments. The proposed project aligns with the areas of interest of the Earth Science Division of the Science and Exploration Directorate at NASA Goddard Space Flight Center (GSFC). In particular, it is relevant to the focus of NASA's Ocean Biology and Biogeochemistry program and NASA's upcoming PACE satellite mission. Dr. Jeremy Werdell at NASA GSFC, the Project Scientist for the PACE mission, will collaborate with us. His research and knowledge on in-water bio-optical algorithm development and validation of remotely-sensed data products will provide well-need expertise on satellite algorithm development and testing with NASA's ocean color data.

Nebraska Research Infrastructure Development

University of Nebraska at Omaha





One of Dr. Craig Zuhlke's students in front of the droplet release system with a picture of a droplet and an image of a laser drilled hole

NASA Nebraska EPSCoR is committed to sustaining long-term, nationally competitive research capabilities. The Nebraska Research Infrastructure Development (RID) program supports research activities addressing both NASA and Nebraska priorities. Research collaborations this year included NASA scientists, industry, and academics, including Dr. Adam Jensen's work as a steering committee member of NASA's Nexus for Exoplanet System Science (NExSS) research consortium and Dr. Jae Sung Park's industry collaboration with Gary Reichlinger of Reichlinger Business Services to manufacture new membrane materials not previously available commercially or even on laboratory scales. Several sub-grant recipient Nebraska researchers also secured non-EPSCoR funding to further their research. The research conducted by the seven seed grant researchers have impacted their universities and the state of Nebraska, as well as demonstrated strong NASA and aerospace related applicability.

Creighton University researchers using drone photography to characterize a Nebraska Sandhills landscape during Dr. Mary Ann Vinton's research on using remote sensing to analyze resilience of natural and social systems in a working landscape

Scott Tarry, PhD
Nebraska EPSCoR Director
University of Nebraska at Omaha

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

University of Nebraska-Lincoln

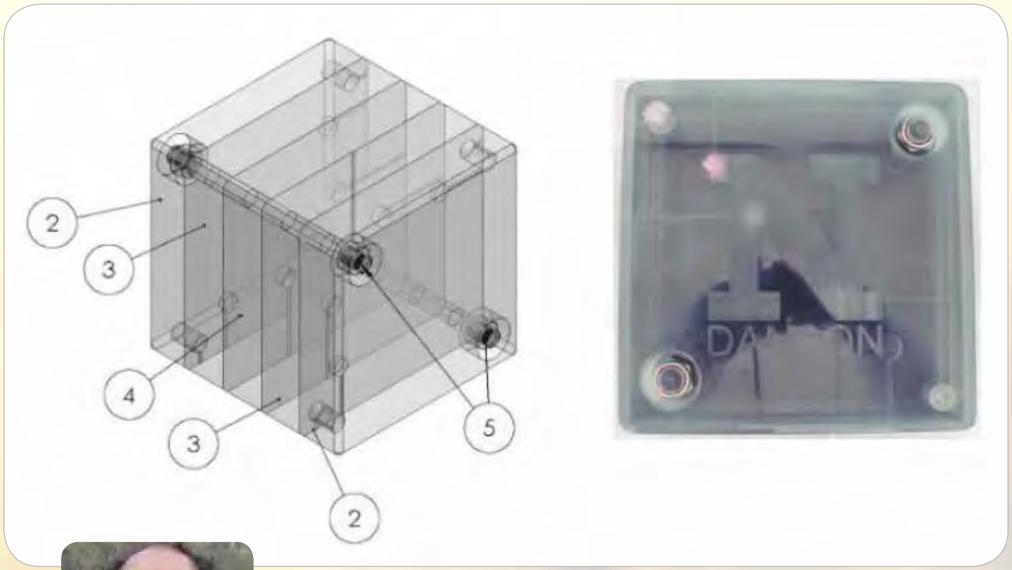
Detecting Neutron Radiation: The Adventures of Solar Neutrons

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. 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



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.

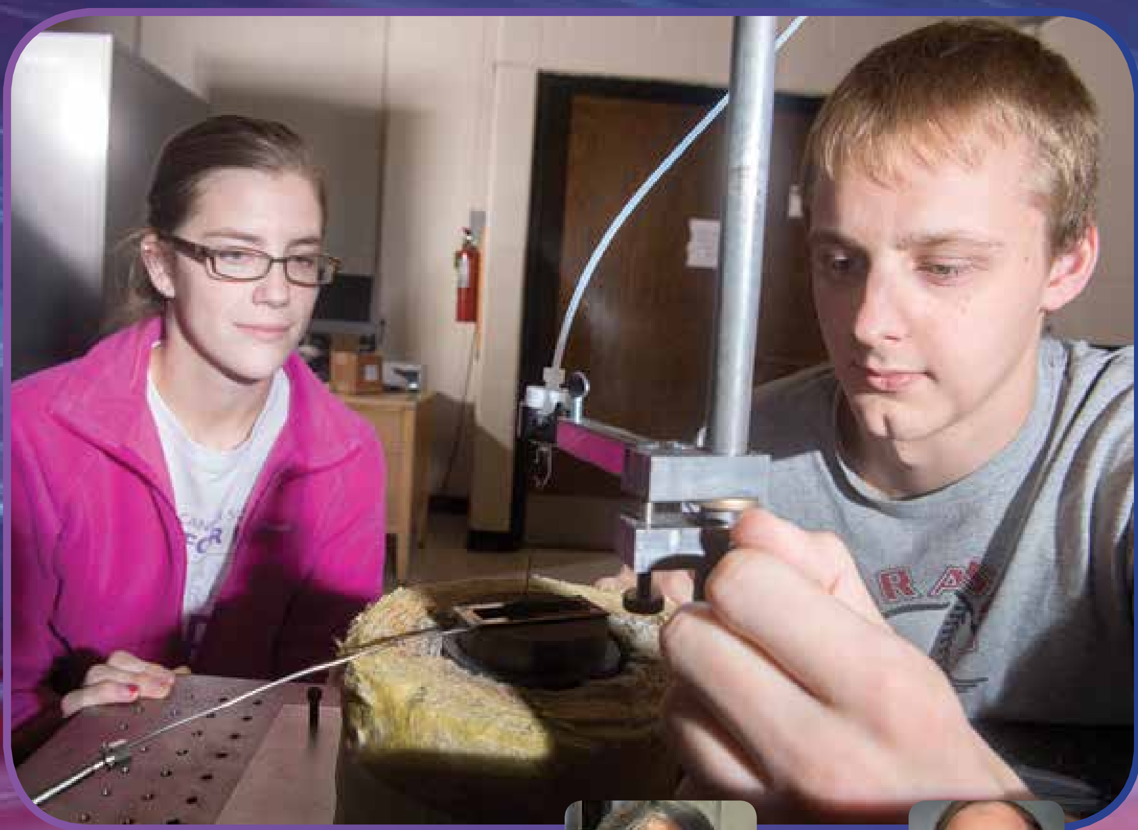
Science PI
Peter Dowben, PhD
University of Nebraska-Lincoln

NASA Technical Monitor
Willie Williams
Johnson Space Center

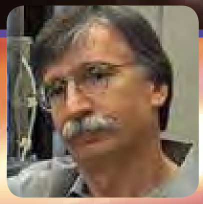
Highly Permanent Biomimetic Micro/Nanostructured Surfaces by Femtosecond Laser Surface Processing for Thermal Management Systems

University of Nebraska-Lincoln

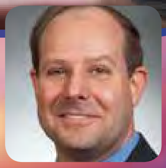
This NASA EPSCoR grant has been the catalyst for over $4.5 million in non-EPSCoR funded research on FLSP surfaces and applications that includes: a study on drag reduction and heat transfer enhancements (ONR); a study on anti-icing properties (Boeing); a study on antibacterial properties (Nebraska Research Initiative); four NASA grants, and a DURIP grant to purchase a new high-powered femtosecond laser with spectral tuning capabilities. The success of our group has been the catalyst for a $500K investment of the College of Engineering in a new 6 mJ femtosecond laser and a laser scanning confocal microscope. Our group is currently negotiating two major industry research grants on FLSP applications for an additional $1.4 million. We expect more grants and successes over the next few years. The NASA EPSCoR funding also had a significant role in the reorganization of the Center for Electro-Optics (CEO; a well-established and well-funded center within UNL) to the Center for Electro-Optics and Functionalized Surfaces (CEFS; CEFS.unl.edu) to reflect the interdisciplinary nature of current research activities. CEFS is a multidisciplinary group of over 30 Faculty, Post-Docs, and graduate and undergraduate students, working on the grand challenge of creating permanent functionalized surfaces for a wide range of applications.



Students work on an experiment to study the heat transfer characteristics of a metal surface functionalized using femtosecond laser surface processing



Science PI
George Gogos, PhD
University of Nebraska-Lincoln



NASA Technical Monitor
Michael C. Halbig, PhD
Glenn Research Center

Growth of Large, Perfect Protein Crystals for Neutron Crystallography

University of Nebraska Medical 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 microgravity are of significantly higher quality compared to earth grown counterparts. The quiescent environment in space has proven to be paramount in resolving the mysteries of the radioprotective MnSOD and harnessing its working for preventing radiation damage.

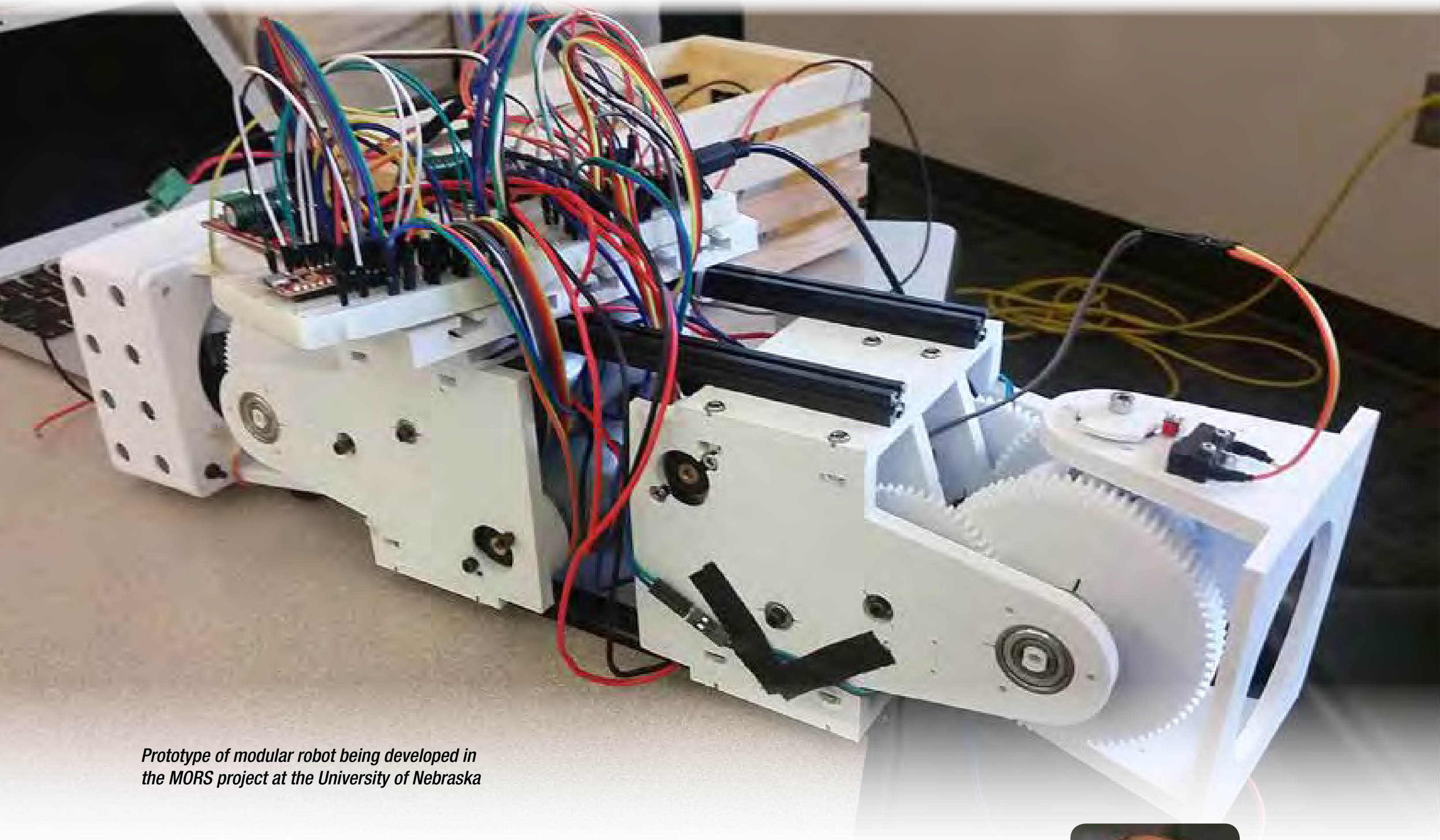
Science PI
Gloria Borgstahl, PhD
University of Nebraska Medical Center

NASA Technical Monitor
Sridhar Gorti, PhD
Marshall Space Flight Center

Preparing human MnSOD crystals for the beamtime experiment at ORNL MaNDi

MORS: Modular Robotic Suit as an Exercise System for Maintenance of Muscle Strength of Astronauts During Long-Term Space Missions

University of Nebraska



Prototype of modular robot being developed in the MORS project at the University of Nebraska

The Modular Robotic Suit (MORS) project is developing a wearable modular that can be used as an exercise countermeasure for astronauts that are at risk of potential muscular atrophy. Towards this objective, the project is developing modular robot hardware along with intelligent algorithms for controlling the robot based on different exercise routines and the user's ability and comfort in doing the exercise. The project is an inter-disciplinary collaboration between researchers from the University of Nebraska in the areas of biomechanics, computer science and mechanical engineering, and NASA scientists at the Johnson Space Center. The first hardware prototype of the robotic device robot (shown in above figure) along with artificial intelligence-based machine learning algorithms for intelligent, real-time control of the robot, and preliminary exercise routines while using the robot are being developed during the first year of the project. The goal of the 3-year project is to provide a lightweight, low-cost device that can be attached to the body of crew members to provide supplementary lightweight routines for exercising different muscles groups in micro-gravity environments similar to those encountered in space.

Science PI
Raj Dasgupta, PhD
University of Nebraska

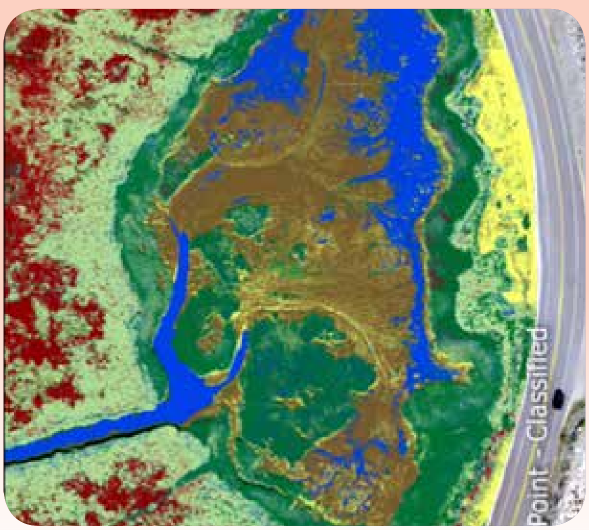
NASA Technical Monitor
Jacob J. Bloomberg, PhD
Johnson Space Center

New Hampshire Research Infrastructure Development

University of New Hampshire

July 2, 2017 UAV Image

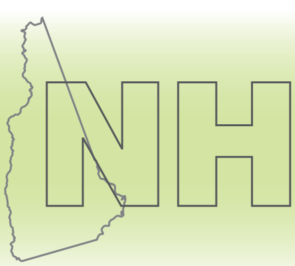
October 28, 2017 UAV Image



Vegetation classification (10/28/2017)

The salt marsh at Odiorne Point State Park sea wall (Rye, NH) in the summer vs. fall of 2017

Sea-Level Rise (SLR) is currently occurring and is projected to accelerate. Mr. Michael Routhier of the Earth Systems Research Center at UNH is developing methodology to assess, characterize, and quantify this phenomenon. This research uses remotely sensed data from Unmanned Aerial Vehicles and from Landsat to determine current and past SLR impacts on the state's regional salt marshes. Salt marshes have many important functions and provide many ecosystem services to local species and humans. Salt marshes provide essential nursery habitat for 75% of fisheries species, protect the shoreline from erosion and wave action, reduce flooding, and protect water quality through the filtering of runoff and the metabolizing of nutrients. The encroachment of SLR into our salt marshes may place these benefits at risk. Fieldwork and desktop spectrometry measurements were conducted in the summer and fall of 2017 in the Odiorne Point State Park salt marsh (Rye, NH). RGB imagery was used in classifying vegetation types: Juncus gerardi (red), Spartina patens (light green), Spartina alterniflora (dark green), Mud (brown), Sand (yellow), and Water (blue). It was determined that the best times to discriminate vegetation types were when phenological differences are at their highest. This research sets a classification benchmark against which future changes in salt marsh vegetation may be tracked.



Antoinette B. Galvin, PhD
New Hampshire EPSCoR Director
University of New Hampshire

Responsive Autonomous Rovers to Enable Polar Science

Dartmouth College

Scientists study climate change by observing the Earth from remote satellites and from permanent ground stations sparsely distributed through the Earth's ice sheets. This project fills in the gap between point observations from ground stations and remote sensing satellites by using a solar-powered robot to measure important characteristics of snow and ice. In this way, measurements made by the robot can 'ground truth' measurements made remotely. We develop instruments for measuring the amount of the sun's radiation that is reflected by the surface; and accumulation and compaction of snow and ice, which relate directly to the mass balance or net mass accumulated in the Earth's largest ice sheets. These instruments are deployed on Dartmouth College's solar-powered Cool Robot and on Dartmouth's newest robot, Frosty Boy. The project involves researchers at Dartmouth College, NASA, the University of New Hampshire, and the U.S. Army Cold Regions Research and Engineering Laboratory, and Dartmouth graduate and undergraduate students. During our 2017 field season, we experienced mobility challenges related to the soft, drifting snow conditions at Summit Camp. Frosty Boy was designed to negotiate these low mobility conditions. Frosty Boy is solar-powered, albeit with panels towed on a sled behind the robot. In 2018, we fielded the robot for the first time and pulled a 100 kg instrument and power sled over 25 kilometers with no immobilizations, representing a significant milestone for polar robotics.

Science PI
Laura Ray, PhD
Dartmouth College

NASA Technical Monitor
Brooke Medley, PhD
Goddard Space Flight Center

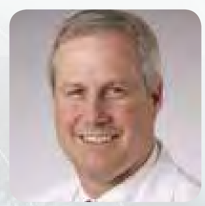
Dartmouth Ph.D. candidates with Frosty Boy during June 2018 Summit Greenland field season

Time Course of Microgravity-Induced Visual Changes

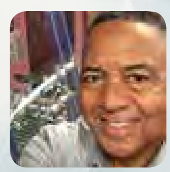
Dartmouth Geisel School of Medicine

During the first full protocol run through, Allison Anderson, PhD self-administers the EyeNetra exam while experiencing lower body positive pressure in the prone position. A research assistant 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.



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



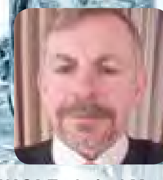
NASA Technical Monitor
Willie Williams
Johnson Space Center

Application of Antifreeze Proteins and Mimetic Peptides in Anti-Icing Surface Coating

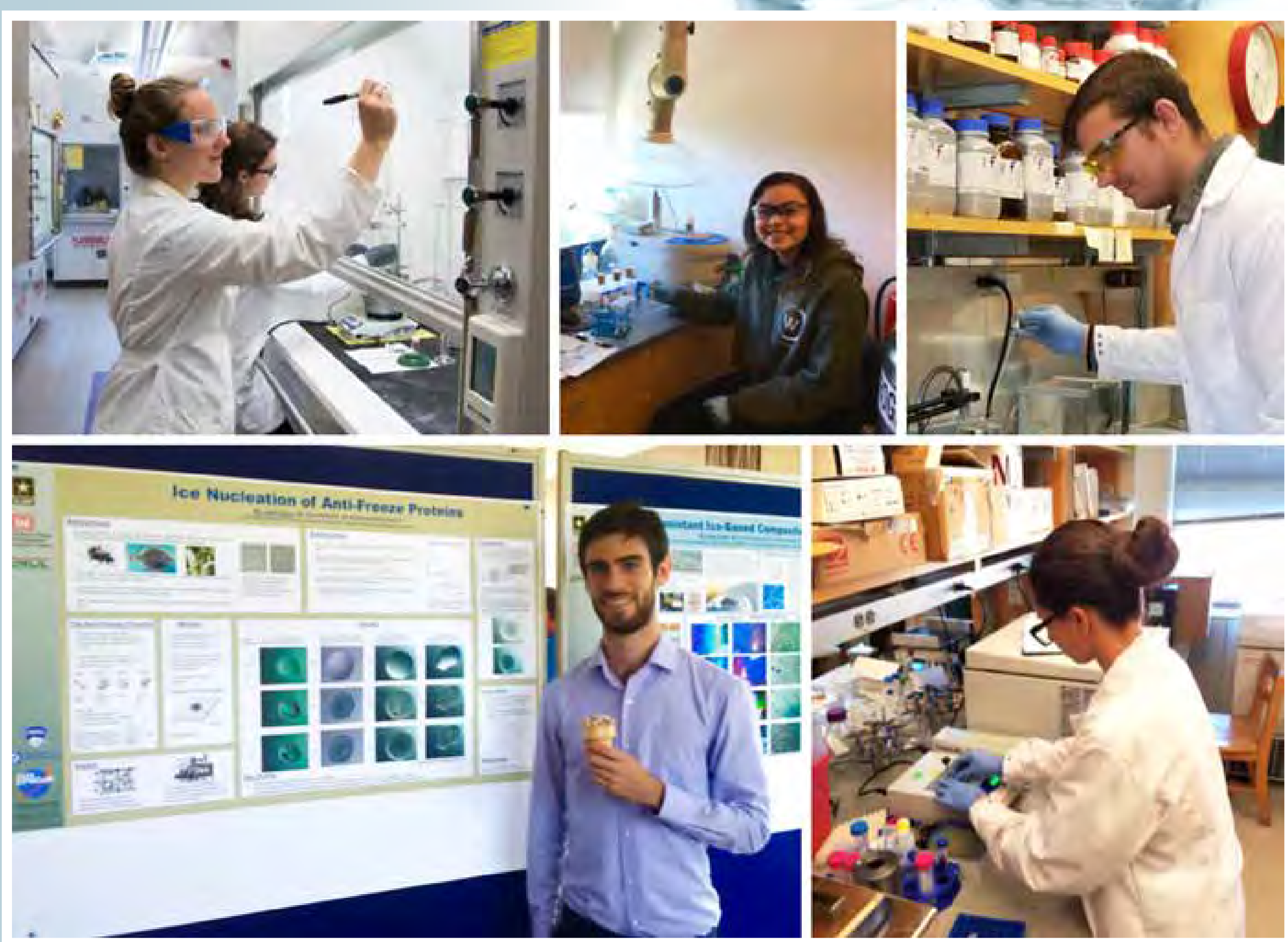
University of New Hampshire

Uncontrolled icing of surfaces can cause catastrophic impacts on ground and air transportation, utility networks, and communication transmissions throughout civilian and military sectors. A main goal of this project is the development of nature-inspired new materials with anti-icing properties, such as antifreeze proteins (or peptides) synthetically integrated with polymer (or glass) components. Antifreeze proteins are ice-binding proteins produced in certain fish, insects, bacteria, and plants that live in cold climates and contribute to their freeze resistance. The research has provided training opportunities for graduate and undergraduate students in four research groups at the University of New Hampshire, Keene State College, and US Army ERDC Cold Regions Research and Engineering Laboratory. The project also contributed to the enhancement of research infrastructure in New Hampshire, as well as STEM education through outreach activities and the development of a new graduate-level academic course.

Science PI
Krisztina Varga, PhD
University of New Hampshire



NASA Technical Monitor
Andrew J. Trunek
Glenn Research Center



Students working on application of antifreeze proteins and mimetic peptides in anti-icing surface coatings

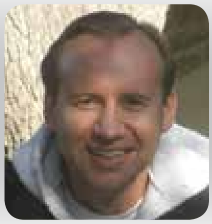
New Mexico Research Infrastructure Development

New Mexico State University

Solar-powered aircraft before flight test

The phrase “to soar like a bird” inspires the imagination. Different from birds which put effort into flapping flight, soaring birds exploit rising airstreams to stay airborne. The objective of this project is to develop an autopilot that commands an unmanned aircraft to fly just like a soaring bird. Air space restrictions put a cap on the maximum flight altitude. To circumvent this limitation, the aircraft is equipped with solar panels which allow for solar cruise from one rising airstream to the next.

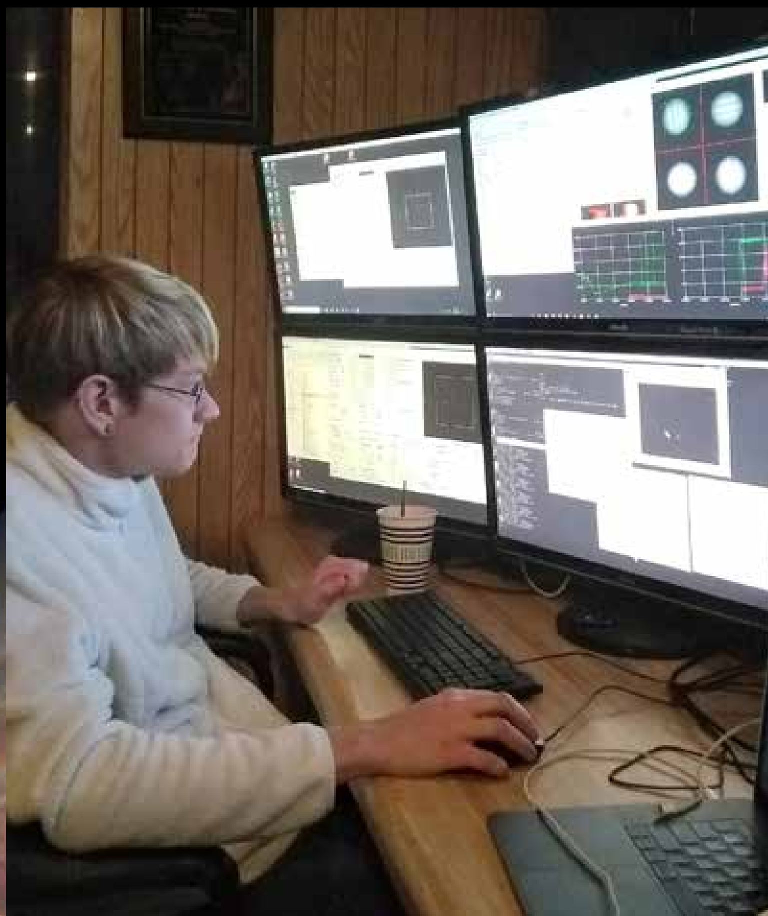
NM



Paulo Oemig, PhD
New Mexico EPSCoR Director
New Mexico State University

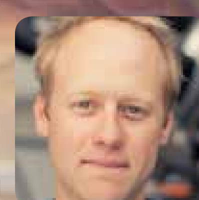
Jovian Interiors from Velocimetry Experiment in New Mexico (JIVE in NM)

New Mexico State University

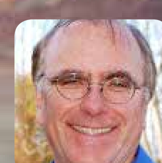


An astronomy graduate student at New Mexico State University observing Jupiter (seen in the upper right) with the JIVE instrument prototype mounted at the Dunn Solar Telescope during opposition in May 2018

Astrophysical objects that pulsate with sound waves, such as the Earth and the Sun, provide windows into their interiors. The properties of the waves teach us about the inner environment which is otherwise completely hidden. It is expected that Jupiter and other giant planets pulsate as well, and the Jovian Interiors Velocimetry Experiment (JIVE) is a project to exploit such sound waves to measure the deep interior of these important solar system behemoths for the first time. An optimized instrument for such a task has been designed and is under construction. The figure shows a recent observation campaign of Jupiter using a science-level JIVE prototype. The instrument (not shown) is mounted on the Dunn Solar Telescope on a large optical table. Critically, the whole apparatus can be controlled by 4 computers from a location far from the optical path so that the sensitive observations are not disturbed. This also allows for training new students on the software control and data acquisition in a comfortable environment.



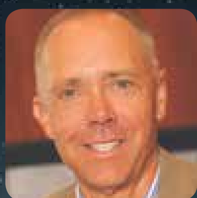
Science PI
Jason Jackiewicz, PhD
New Mexico State University



NASA Technical Monitor
Mark S. Marley, PhD
Ames Research Center

Virtual Telescope for X-ray Observations

New Mexico State University

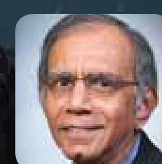


Science PI
Steve Stochaj, PhD
New Mexico State University

Small Satellites Work Together for Big Science

New Mexico State University, the University of New Mexico and NASA's Goddard Space Flight Center are teaming to find a way for two CubeSats, toaster sized spacecraft, to work together to produce big science. The Virtual Telescope for X-ray Observations (VTXO) mission is developing the next generation X-ray telescope using a diffractive optics lens and a high-tech camera sensitive to X-rays. The lens is based on the design of a Fresnel lens, often seen added the the rear windows of RVs, but modified to work with X-rays. This type of lens offers superior resolution but requires a focal length, lens - camera distance, longer than a football field. To work around this physical challenge, VTXO will divide the telescope over two satellites with one carrying the lens and the second a camera. The two satellites must be precisely controlled to maintain alignment not only with each other but with a distant X-ray source. When completed, the VTXO Mission will provide a much clearer view for astrophysicist to study X-ray sources in the Universe. Much of the work for VTXO is performed by students from New Mexico, who are getting the opportunity to be at the forefront of NASA sponsored innovation.

Presentation of the paper entitled VTXO - VIRTUAL TELESCOPE FOR X-RAY OBSERVATIONS at the 9th International Workshop on Satellite Constellations and Formation Flying in Boulder, CO.

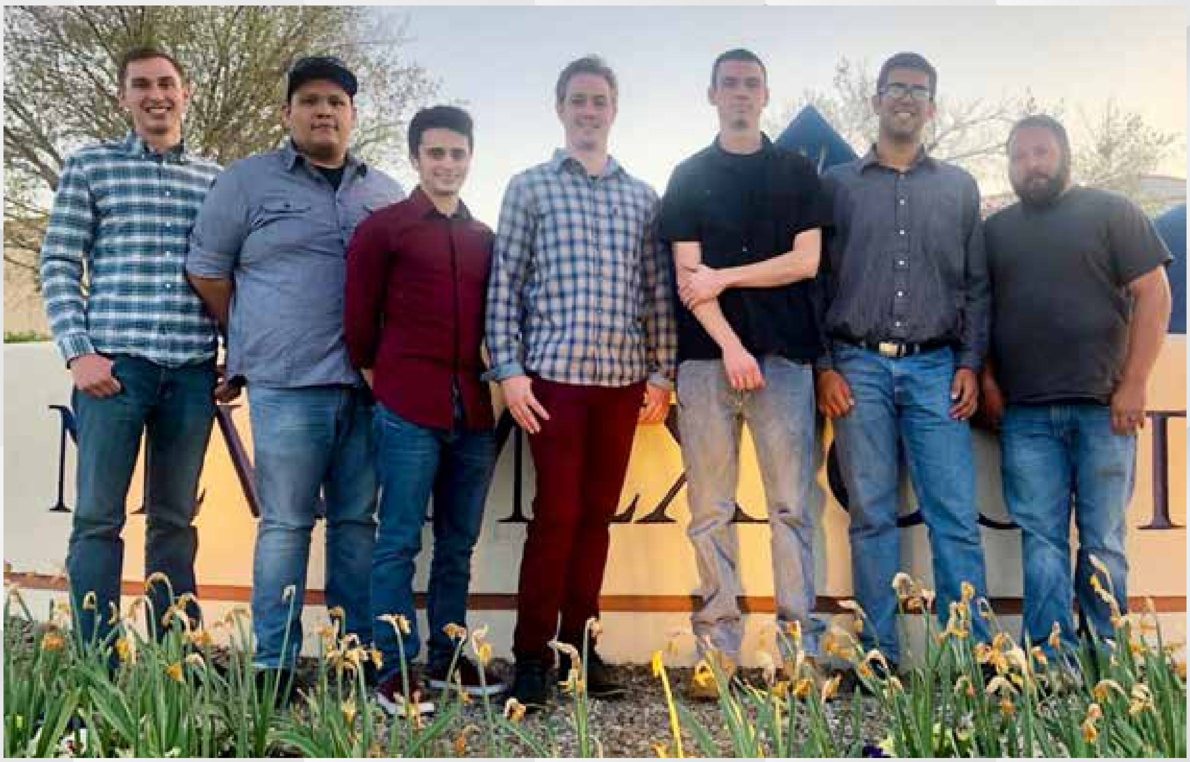


NASA Co-Technical Monitor
Rainee N. Simons, PhD
Glenn Research Center

NASA Co-Technical Monitor
Neerav Shah
Goddard Space Flight Center

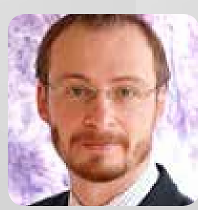
In Orbit Structural Health Monitoring of Space Vehicles

New Mexico Institute of Mining and Technology

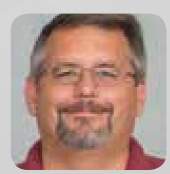


Undergraduate design clinic research team

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.



Science PI
Andrei Zagrai, PhD
New Mexico Institute of Mining and Technology



NASA Technical Monitor
John D. Lekki
Glenn Research Center

Autonomous Structural Composites for Next Generation Unmanned Aircraft Systems

New Mexico State University

This project aims to devise autonomous structural composites (AutoCom) used to build NASA's next-generation self-sustainable unmanned aerial vehicle (UAV). The AutoCom-built UAV is envisioned to autonomously detect damage to minimize downtime for schedule-based maintenance as well as harvest electrical energy from ambient vibration in UAV long-span wings. This multifunctional capability of AutoCom is encoded by embedding multifunctional mechano-luminescence-optoelectronic (MLO) composites into fiber-reinforced polymer (FRP) composites. To complete and optimize the innovative design of the MLO composites, three major research universities, national labs, and NASA's test facility have collaborated in New Mexico jurisdiction. In addition, NASA Armstrong Flight Research Center (AFRC) has collaborated with the research team in New Mexico jurisdiction. If successful, the team envisions tremendous broader impact by applying the MLO composites to various applications (e.g., self-powered monitoring of FRP composites-based structural systems, energy harvesting from biological systems, among many others). More importantly, the AutoCom will be a groundbreaking solution for enhancing structural reliability, safety, and resiliency of UAVs and maximizing its endurance thanks to the additional immune-to-weather energy source supplied from the MLO composites.

Science PI
Donghyeon Ryu, PhD
New Mexico State University

NASA Technical Monitor
Alexander Chin, PhD
Armstrong Flight Research Center

A student is working in LaSMaS at NMT to fabricate MLO composites. He is using a spin-coater for fabricating corrugated P3HT-based self-sensing thin films on PDMS.

Nevada Research Infrastructure Development

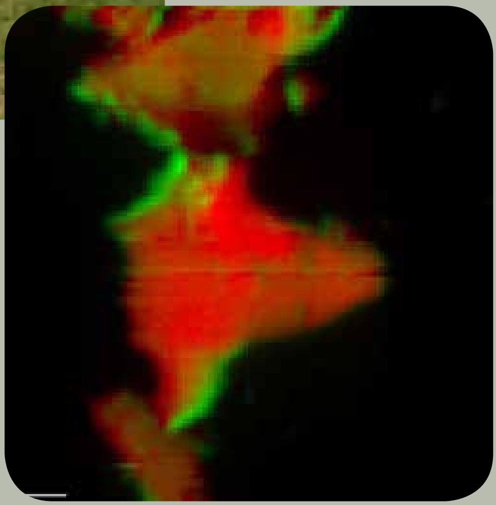
Nevada System of Higher Education

The Nevada NASA EPSCoR Research Infrastructure Development (RID) program has funded diverse research seed grant opportunities this year that are not only improving research infrastructure, but also providing workforce training within the state. Through a solicitation and competitive review process, four seed grants were funded and each has made significant research progress and provided hands-on training for undergraduate and graduate students. This is possibly the largest number of students to benefit from a Nevada NASA EPSCoR RID award in a single year (i.e., 17 students and one postdoctoral scholar). The research projects are expanding capabilities in geosciences, microbiology, robotics, and spacecraft air quality detection. The geoscience and microbiology projects are looking at Mars surrogates on Earth to improve our understanding of the composition of Mars surface materials and whether life can exist in extreme saline and/or perchlorate environments comparable to Mars. The robotics project is working on a socially appropriate navigation system and an evaluation system on the social appropriateness of robot behavior. The spacecraft air quality project is a close collaboration between Nevada faculty and the NASA Glenn Research Center to establish NASA-relevant particle and fire smoke characterization capabilities in Nevada. This project has already delivered a procedure that allows the NASA Saffire team to design sensor-specific data acquisition software. Across these four projects, three are collaborating with NASA scientists at three different NASA centers. Growing NASA collaborations and enhancing Nevada's research capabilities are two critical goals of the NV NASA EPSCoR RID program.

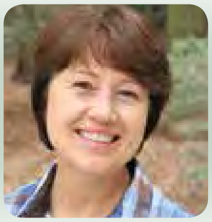
Analysis of Iron-rich X-ray Amorphous Weathering Products on Earth and Comparisons to Measurements from Mars

Reddish, iron-rich soils in the Klamath Mountains, California, may contain materials similar to materials found on Mars.

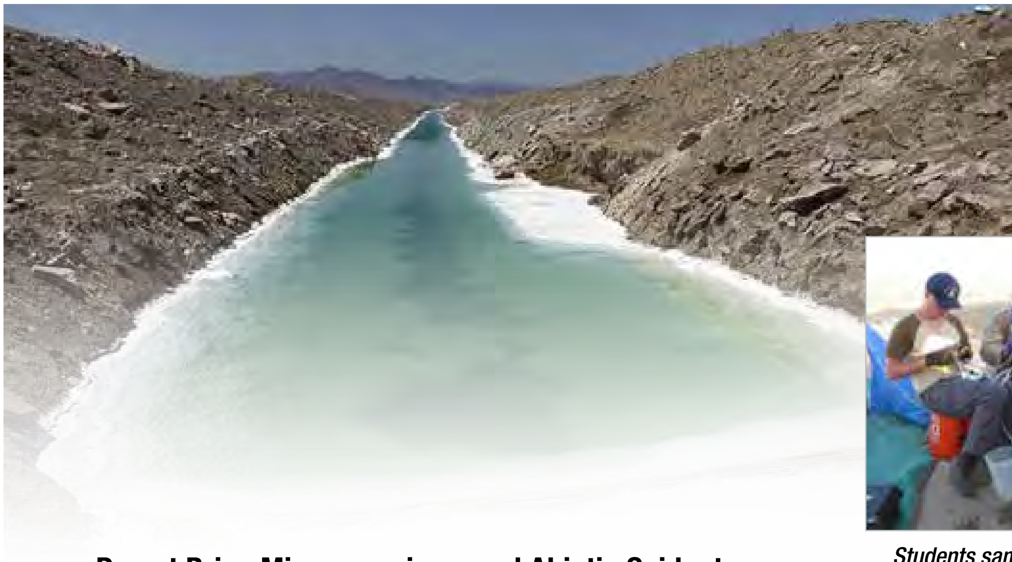
This funding supported research in the recently deglaciated ultramafic rocks in the Klamath Mountains, as well as in the arid Pickhandle Gulch in Nevada. Weathered materials from these environments were separated and analyzed for comparisons with weathered materials from Mars. The project helped support and provide educational experiences for four students in Nevada, built a relationship with a NASA center, and provided preliminary data for a proposal for future funding from NASA. Johnson Space Center is collaborating in the future NASA proposal and will specifically provide Transmission Electron Microscopy (TEM) analysis of iron-rich samples to determine their potential as analogs to Martian surface materials.



Oxidation state of iron (red = ferrous, green = ferric) of the clay-sized fraction; from ALS beamline 10.3.2.



Lynn Fenstermaker, PhD
Nevada EPSCoR Director
Nevada System of Higher Education



Brine channel at Bristol Dry Lake, CA

Students sampling a deep well at Bristol Dry Lake

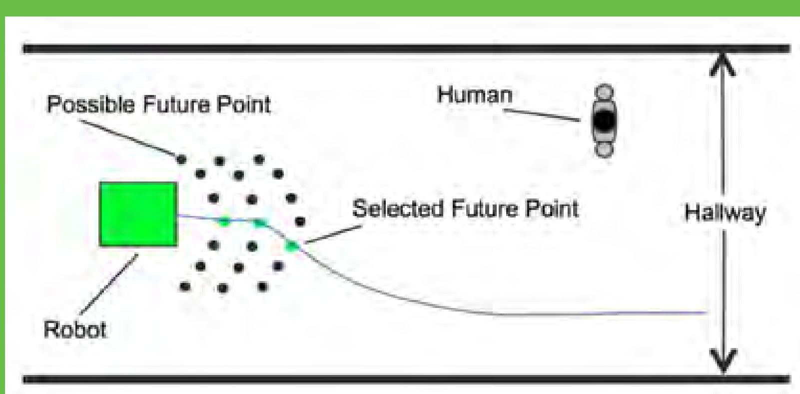
Desert Brine Microorganisms and Abiotic Oxidants: New Analog Research Capacity for Nevada

Our goal is to evaluate rare natural brines for their potential utility as analogs to explore the physiological limits for life. This highlight focuses on recent field activities at Bristol Dry Lake near Amboy, California. Waters from this site contain among the highest calcium concentrations of any natural environment on Earth. Our assessment of this site will provide insights concerning the limits of habitability and guide NASA's ongoing evaluation of the potential for life in the cosmos.

Infrastructure developed includes a new academic/industry relationship between the Nevada System of Higher Education and Standard Lithium Ltd. Further contributions include enhanced methods for life detection in terrestrial materials with properties likely to be encountered off the Earth. The work affects multiple disciplines by combining industrial concerns with biology, chemistry, and hydrology. The human resource impacts include the training of workers for space science (two graduate students [both first-generation college and one a disabled veteran], two undergraduates, and a female young investigator). Physical resources include the validation of methods for culturing of extremophilic microorganisms and application of environmental chemistry to Mars-analog samples.

Socially Aware Navigation Using Nonlinear Multi-objective Optimization

For socially assistive robots (SAR) to be accepted into complex and stochastic human environments, it is important to account for subtle social norms. For this project, we proposed a novel approach to socially aware navigation (SAN), which garnered significant interest from the Human-Robot Interaction (HRI) community. We used a multi-objective optimization tool called the Pareto Concavity Elimination Transformation (PaCcET) to capture nonlinear human navigation behavior, which is a novel contribution to the community. We used autonomously sensed, distance-based features that capture the social norms and associated social costs of a given trajectory point toward the goal. Rather than use a finely tuned linear combination of these costs, we used PaCcET to select an optimized future trajectory point associated with a nonlinear combination of the costs. Existing research in this domain concentrates on geometric reasoning and model-based learning approaches that have their own pros and cons. Our approach is distinct from prior work in this area. In a simulation, we showed that the PaCcET-based trajectory planner not only can avoid collisions and reach the intended destination in static and dynamic environments, but it also considers a human's personal space in the trajectory selection process.



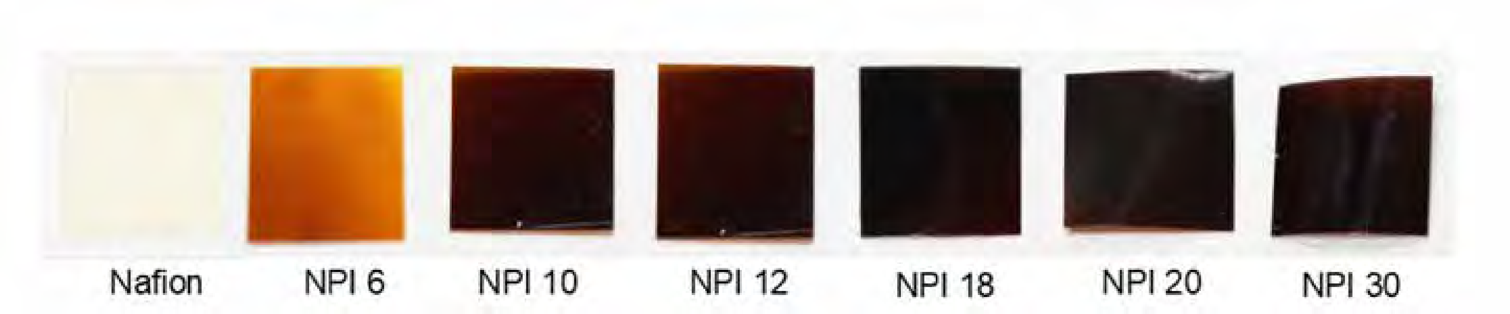
Navigation planner selects a socially-optimal short-term trajectory (green dots) to pass a person in the hallway

Advanced Electroactive Polymer Actuators and Sensors for Aerospace Robotic Applications

University of Nevada, Las Vegas

This project focused on development of ionomer materials with improved thermal properties and good ion-conductivity for space applications. This was achieved by blending of Nafion®, a high ion-conductivity ionomer, with Polyimide (PI), which is known for its superior thermal and mechanical properties (patent pending). Several factors were found to be significant in producing homogenous blends, such as concentration ratio and casting temperature. Blend films of Nafion®/PI at several concentration ratios are shown in the figure below.

The accomplishments in this project demonstrated the incorporation of PI in Nafion® with a bottom-up approach for the first time. The developed blend films show improved thermal and mechanical properties while maintaining good ion conductivity. This research is of great importance to the further development of advanced materials, and is expected to facilitate research and development in fields of smart materials, robotics, aerospace and other industrial applications. Additionally, new teaching material was developed as a parallel effort. Course content was developed for two courses at UNR, one course at TMCC and a special course at UNLV, taught in Spring 2016. The UNLV special course focused on characterization methods and instrumentation to investigate active materials system applications. Other significant impacts from this project include: a greater than 8:1 return on federal funding through the award of eleven new projects; 10 referred publications, 12 conference publications and 2 book chapters; 34 presentations at meetings; and research experience for 11 students.t



Optimized Nafion®/PI blends ranging from 6 wt% PI (NPI 6) to 30 wt% PI. Nafion® on left

Science PI
Kwang Kim, PhD
University of Nevada, Las Vegas

NASA Technical Monitor
Kumar Krishen, PhD
Johnson Space Center

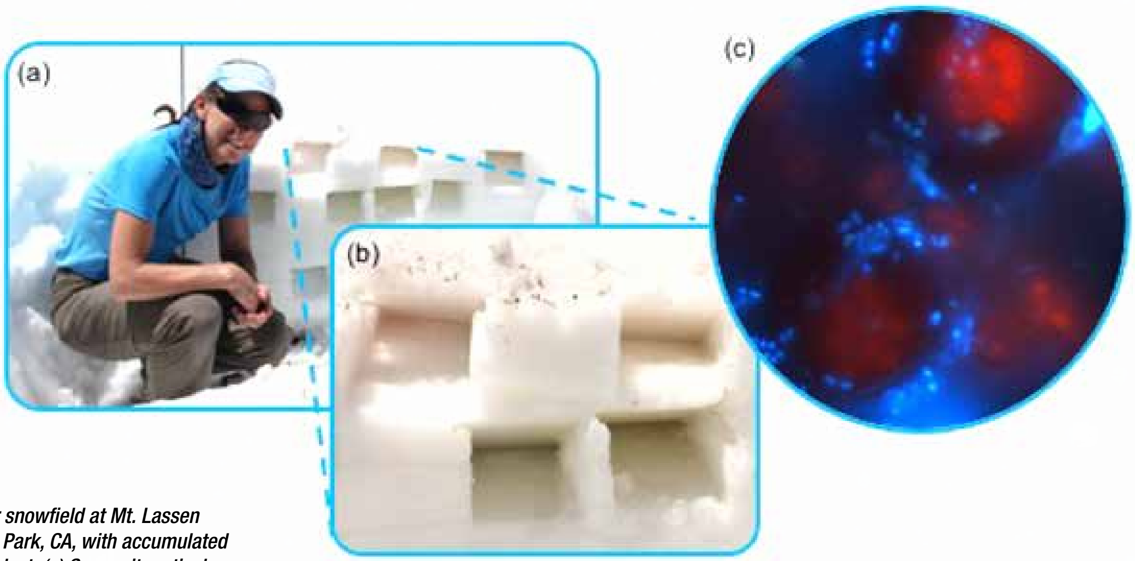
Building Capacity in Interdisciplinary Snow Sciences for a Changing World

Desert Research Institute

The Snow Albedo Connection to Life, Light and Dust

Snow is a viable habitat for different kinds of microscopic lifeforms, particularly so, in summer when high light levels and increased liquid water content promote development of conspicuous (visible) algal blooms (Fig. 1). In fact, algal growth stimulates a complex food web that includes bacterial, protistan grazers, fungi and small invertebrates (e.g. nematodes) in the ephemeral snowpack environment. Dust (deposited from local and long distance sources) accumulates through the snowpack season, and we hypothesized that it may bring mineral elements including iron, an essential micronutrient for life, to the snow. Our interdisciplinary team conducted a study to evaluate the mineralizing capacity of a snow algal-bacterial co-culture. Our findings revealed that the snow algae, Chloromons brevispina and its bacterial partners, were able to grow faster and increase the rate of an iron-containing mineral dissolution in laboratory experiments. The results indicate that these snow-associated microbes may obtain growth-limiting micronutrients from aeolian deposition, which was our original hypothesis. This suggests a positive feedback loop for snowpack with decreased albedo (ability to reflect light) in which dust may stimulate accumulation of algal biomass, and these elements will collectively increase the melt rate of snow.

These findings are communicated in the manuscript: Harrold, ZR, EM Hausrath, AH Garcia, AE Murray, O Tschauner, J Raymond, S Huang. 2018. Bioavailability of mineral-bound iron to a snow algae-bacteria co-culture and implications for albedo-altering snow algae blooms. Appl. Environ. Microbiol. doi:10.1128/AEM.02322-17.



Summer snowfield at Mt. Lassen National Park, CA, with accumulated surface dust. (a) Snow pit vertical profile (~ 2 ft.) reveals (b) a pink and deeper yellow-green pigmented snow algae; and (c) fluorescent micrograph of nucleic acid-stain (DAPI) snow sample showing algae (naturally autofluorescent chlorophyll appears red) and bacteria (light blue-stained cells). Photograph of A. Murray (Science PI), with permission.

Science PI
Alison Murray, PhD
Desert Research Institute

NASA Technical Monitor
Brian Cairns, PhD
Goddard Space Flight Center

Advanced Transport Technologies for NASA Thermal Management/Control Systems

University of Nevada, Reno

Student of UNLV with the PC-HEX apparatus he developed

The goal of this project is to develop reliable, light -weight and low-power thermal management systems for precision temperature control of critical NASA electronic systems. This project develops high-performance, two-phase mechanically-pumped fluid loop (2φMPFL) systems. The 2φMPFL can maintain the temperature of several components to within precise limits even if their heat generation varies by a wide amount. The porous metallic wick used in the heat-acquiring and isothermalizing evaporator is a key component of the 2φMPFL system.

In this project, a quasi-two-dimensional experimental setup has been developed to study two-phase fluid flow in porous media to benchmark computational fluid dynamic (CFD) simulation tools. A scalable and performance-effective technique for enhancing steam condensation heat transfer rate and critical heat flux limit was also developed. A new technique to measure the size distribution of droplets on flat plates was developed by applying a droplet detection method to images of condensate-drops on the sample surface.

Demonstration labs on the design and applications of heat pipes were created and demonstrated to approximately 145 community college students who are considering entering an engineering field. The students gained background information on thermal heat pump applications.

Science PI
Miles Greiner, PhD
University of Nevada, Reno

NASA Technical Monitor
Eric Sunada, PhD
Jet Propulsion Laboratory

Life in Salts: A Multidisciplinary Investigation of Microorganisms and Biosignatures in the Death Valley Salt Pan

Desert Research Institute

A sample showing the sulfidic sediment at depth and the green cyanobacteria layer under the evaporite surface (scale bar 5cm)

Dr. Henry Sun explains the project to the curious public while conducing fieldwork in Death Valley.

On Mars discharges of brine from regional aquafers have recently been suggested as a cause for the recurring slope lineae (RSL), a proposal which, in turn, raises the possibility of extant life. The Death Valley salt pan is an analog to the RSL in that, due to low elevation and tectonic tilt, its southern end is at the level of the water table. The high evaporation at the surface continuously draws nutrient-rich groundwater upward through the thick evaporite deposit to sustain a layered halophilic microbial community. At depth, oxygen-consuming heterotrophic bacteria turn what is already anoxic groundwater anaerobic, creating the environment for sulfate reduction. Near the sediment surface, an anoxygenic cyanobacterium, Chloroflexus sp., thrives by using sunlight as energy source and hydrogen sulfide as electron donor. In conjunction with scientists at NASA centers, the team has begun evaluating the habitability of the RSL and using the Death Valley saltpan as a test bed for planetary life detection technologies. As first step of the initiation of this project, the team perceived permission to sample the Badwater, Death Valley National Park, evaporate deposit. The sampling effort providing an opportunity to educate the public (~60-90 people) about the exploration of extant life on Mars and using the Death Valley evaporite material as a substitute for likely similar materials on Mars (see figures below). NASA collaborators who have participated on this project thus far include: Aaron Noel (JPL); Christopher McKay (ARC) and Alfonso Davila (ARC).

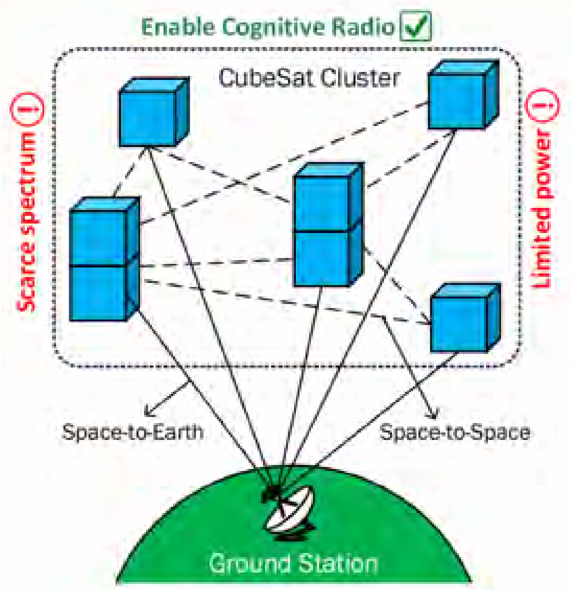
Science PI
Henry Sun, PhD
Desert Research Institute

NASA Technical Monitor
Luther Beegle, PhD
Jet Propulsion Laboratory

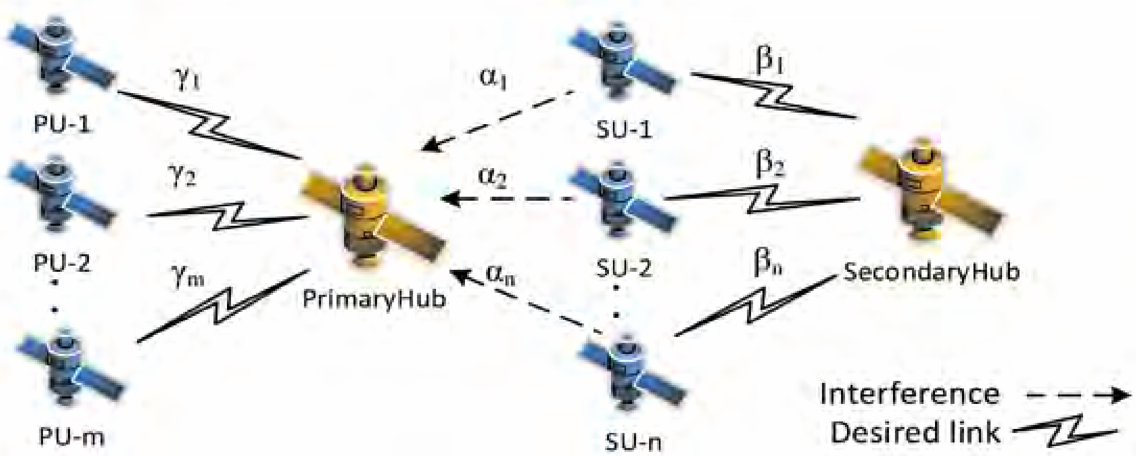
Oklahoma Research Infrastructure Development

Oklahoma State University

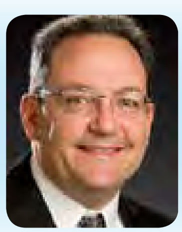
The project Cognitive Radio Systems for Small Satellites Communication Networks sought to provide a significant near term advance in the state of the art communication for small resource-limited spacecraft (e.g., CubeSats) and supported optimized, efficient and reliable communication links for NASA science and human space exploration missions. CubeSats present their own set of challenges as they are very small, resource limited platforms that can work in clusters or constellations. This is very unique as opposed to much of the current published research, which is more oriented towards terrestrial platforms with ever-increasing computational resources. Given the importance of dynamic interference temperature for network performance in Cognitive Radio (CR) networks, we studied the performance of these network of cluster of CubeSats forming a primary network while considering interference from another cluster of CubeSats that forms the secondary network. The work served as a steppingstone to more ambitious future implementations and it also contributed to "Communications, Navigation, and Orbital Debris Tracking and Characterization Systems" Technology Area identified in the 2015 NASA Technology Roadmap. The Oklahoma NASA EPSCoR Research Initiation Grant (RIG) impacted both research and education infrastructure at Oklahoma State University in the form of 1) publications, 2) research collaboration with NASA centers for larger projects (e.g., National Science Foundation), 3) improvement of courses in School of Electrical and Computer Engineering.



Small satellites communication system model



Cognitive Radio for small satellites communication systems



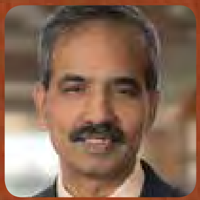
Andrew S Arena, Jr., PhD
Oklahoma EPSCoR Director
Oklahoma State University

Radiation Smart Structures with H-rich Nanostructured Multifunctional Materials

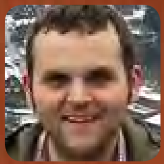
Oklahoma State University

An Oklahoma State University startup company that sells a materials-strengthening additive became a real company after licensing the technology from Oklahoma State University Technology Development Center. The company applied for and was awarded a National Science Foundation Phase I Small Business Innovative Research grant worth $224,988. MITO has the opportunity to win an additional $750,000 based on the technical and commercial success within the next one year. This nano-additive was partially developedunder the NASA EPSCoR grant. Dr. Ranji Vaidyanathan is the technical adviser for the startup and Prof. Richard Gajan, Thoma Family Clinical Assistant Professor in the School of Entrepreneurship at the Spears School of Business, was a faculty mentor. MITO also received an additional $400K from an Oklahoma State alumni angel investment group (Branded Ventures), $50K from the Venturewell group (funded by the Lemelson Foundation, a group encouraging student entrepreneurship), $40K from the nCourage group (a group encouraging women entrepreneurs) and $50K from the Rice Business Plan alliance. MITO is currently establishing its manufacturing facilities at the Meridien Technology Center in Stillwater, OK. In 2017, MITO won several prestigious business plan competitions at Rice University, Baylor University and Oregon Venture competition. The image below was taken when MITO team won 2nd place at the 2017 President's Cup for Creative Interdisciplinarity at Oklahoma State University.

MITO is currently establishing its manufacturing facilities at the Meridien Technology Center in Stillwater, OK. In 2017, MITO won several prestigious business plan competitions at Rice University, Baylor University and Oregon Venture competition. This image was taken when MITO team won 2nd place at the 2017 President's Cup for Creative Interdisciplinarity at Oklahoma State University.



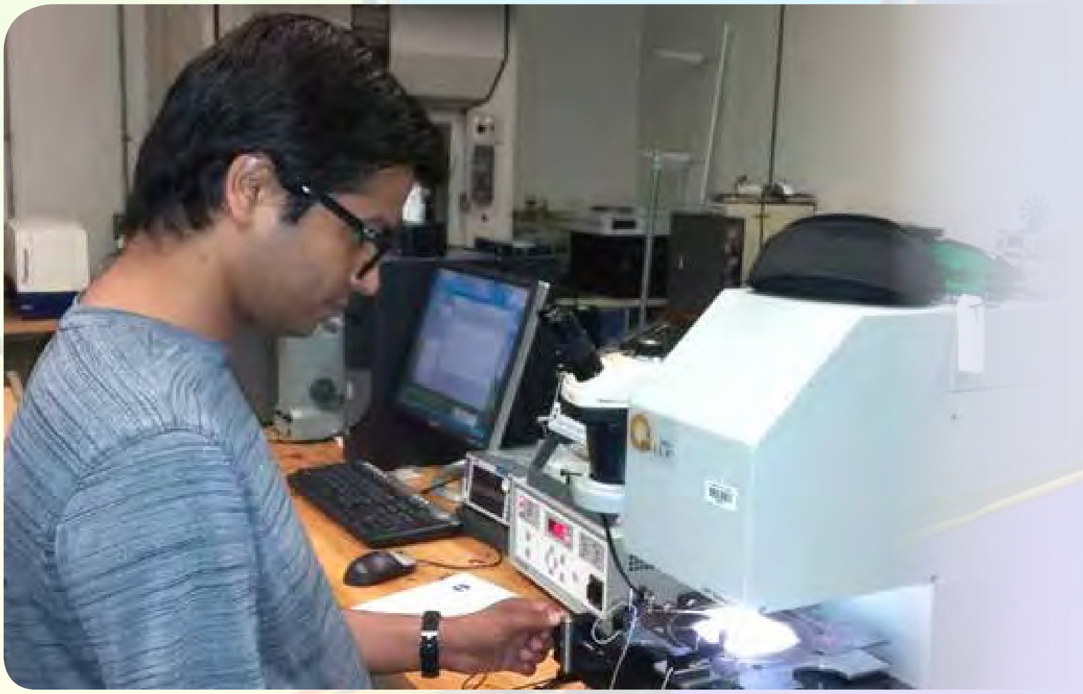
Science PI
Ranji Vaidyanathan, PhD
Oklahoma State University



NASA Technical Monitor
Jeremiah "Jay" McNatt
Glenn Research Center

Extracting the Photonic Spectrum for the Long Range Exploration of Space: A Hybrid Photovoltaic Photon Upconversion and Biological System for Energy Production and Life Support

University of Tulsa



A student in Physics at the University of Tulsa performing solar cell characterization at the Oklahoma Photovoltaic research Institute Laboratory

Science PI
Parameswar Hari, PhD
University of Tulsa

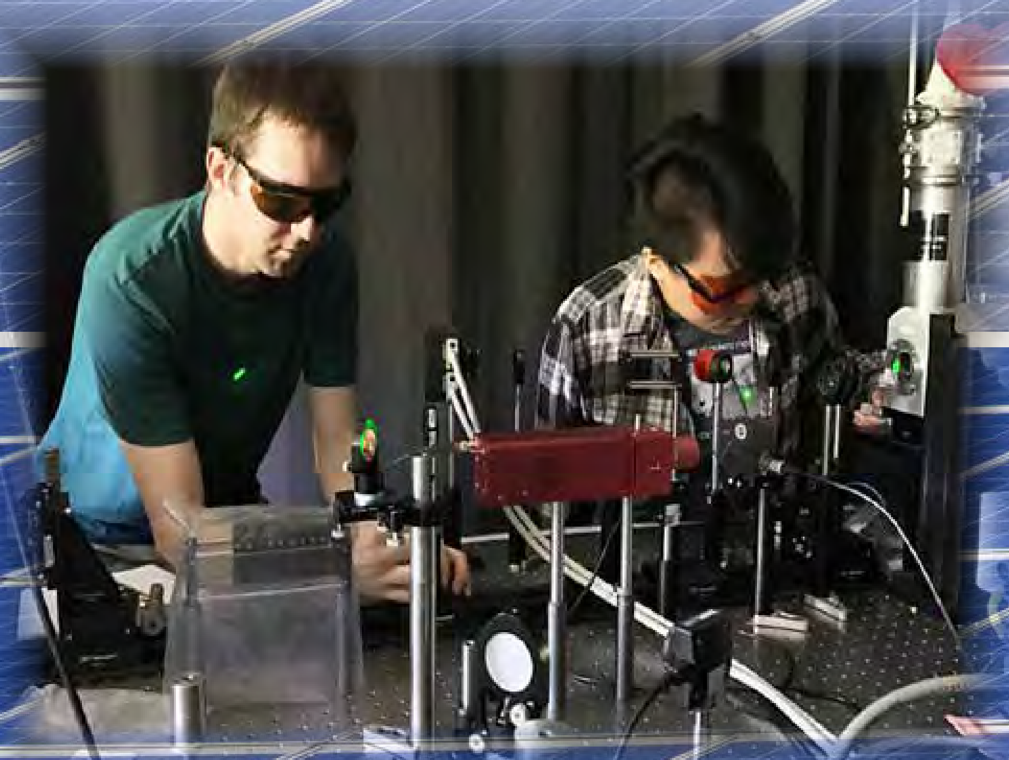
NASA Technical Monitor
Jeremiah "Jay" McNatt
Glenn Research Center

The main goals of this study are achieved by developing a new biologically based life support system, capable of increasing microorganism production by converting normally unused wavelengths of sunlight into those useful by photosynthetic microorganisms. To demonstrate the feasibility of the algae growth for extended flight, we designed a laboratory prototype with a layer for absorbing and converting harmful ultraviolet and infrared light into wavelengths that facilitates algae growth. During the second year of this study, we tested microalgae and cyanobacteria using different electromagnetic wavelengths and established the optimum conditions for growth. The growth study are significant because cultures of edible microalgae were grown using wavelengths that is either supplied directly from the sun or have been converted by nanoparticle layers on the top of the algae reactor to facilitate algae growth. Algae growth studies were centered on the selection of nanoparticles in the form of a thin film, which take wavelengths in the near ultraviolet and infrared ranges, and converts them into wavelengths useful for the algae layer. Finally, we designed solar cells with large band gap, which allows for power cogeneration from the wavelengths unused by the algae system.

High Efficiency Dilute Nitrides Solar Cells for Space Applications

The University of Oklahoma

This program is investigating the potential of a new material for inclusion in next generation multi-junction solar cells (MJSCs) for space. Current MJSCs are limited by the ability to successfully capture the sun's energy since the constituent materials or "junctions" do not harness the suns energy equally across its emission spectrum, which is a perquisite for high power conversion. A method proposed for improvements is by adding another 4th junction that "breaks up" the suns energy further improving the performance of the MJSC. The dilute nitrides material–GaInNAs–has a number of practical properties that make it a candidate for this 4J including its compatibility with existing systems, and an absorption energy well matched to the largest region of loss in the solar spectrum. Despite its promise, GaInNAs has several issues in terms of materials quality that reduce performance. Here, a process to reduce these issues in lightweight flexible GaInNAs is being developed using hydrogen to reduce defects in the material, and the stability of this process to space conditions is being tested. If successful, this project will produce a new generation of solar cells that push the power conversion of MJSCs close to 50%.



Aligning the luminescence system in preparation of temperature dependent electroluminescence measurements of hydrogenation GaInNAs solar cells at the University of Oklahoma

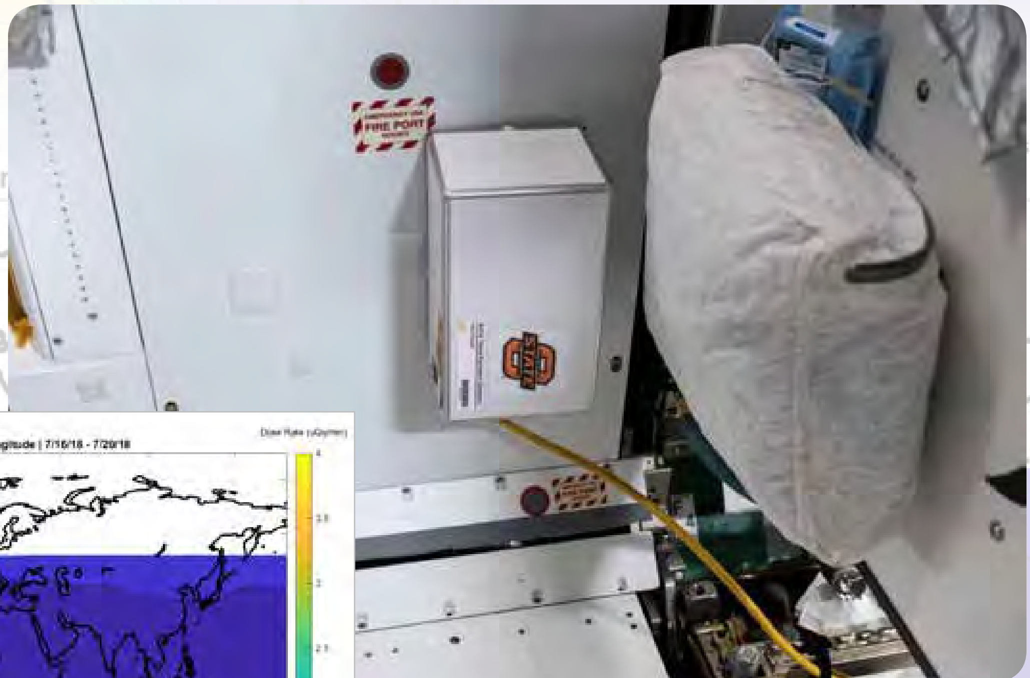
NASA Technical Monitor
Jeremiah "Jay" McNatt
Glenn Research Center

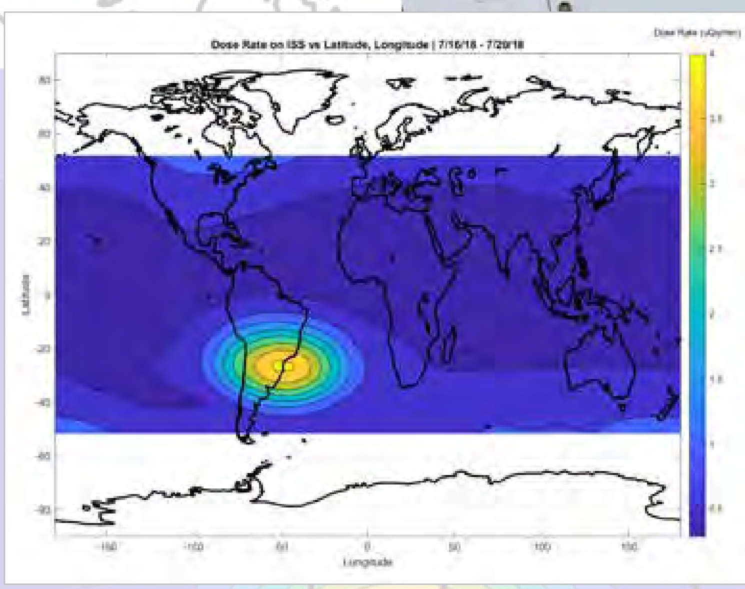
Science PI
Ian R. Sellers, PhD
The University of Oklahoma

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

The University of Oklahoma

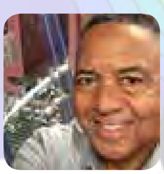
Science PI
Eric Benton, PhD
The University of Oklahoma





Above: The Active Tissue Equivalent Dosimeter deployed in Node 3 of the ISS

Left: Dose rate as a function of orbital location of the ISS as measured by ATED from data acquired between 7/16/2018 to 7/20/2018



NASA Technical Monitor
Willie Williams
Johnson Space Center

The risk to astronaut health and safety from chronic exposure to ionizing radiation in space is one of the biggest challenges to long duration human exploration missions like missions to the Moon or Mars. During spaceflight, astronauts are exposed to levels of ionizing radiation that are significantly higher than those present on the ground, and NASA needs to monitor radiation exposure both for purposes of astronaut health and to better plan future space missions. During summer 2018, the Radiation Physics Laboratory at Oklahoma State University successfully tested a new, compact radiation detector called the Active Tissue Equivalent Dosimeter (ATED) aboard the International Space Station (ISS). About the size of a shoebox, ATED responds to radiation in much the same way that human tissue does, allowing the instrument to properly measure the amount of energy that exposure to ionizing radiation deposits in astronauts' bodies. ATED sampled the radiation environment inside the ISS once every 30 seconds. This data was recorded by a computer inside the ATED instrument and periodically transmitted to the ground.

ATED was developed by OSU graduate students Oliver Causey and Bryan Hayes, working under the direction of Dr. Eric Benton and was jointly supported by the NASA EPSCoR program and OSU. Benton hopes that ATED will also find use aboard aircraft flights, where ionizing radiation, while not as intense as in space, is still not well understood.

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

Oklahoma State University

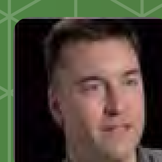
Filament extrusion set up (top and side views)

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.

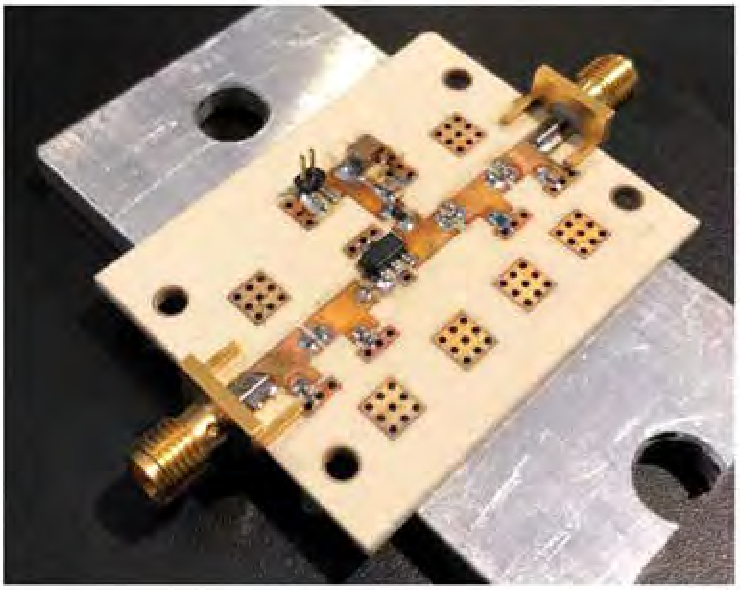
Science PI
Ranji Vaidyanathan, PhD
Oklahoma State University

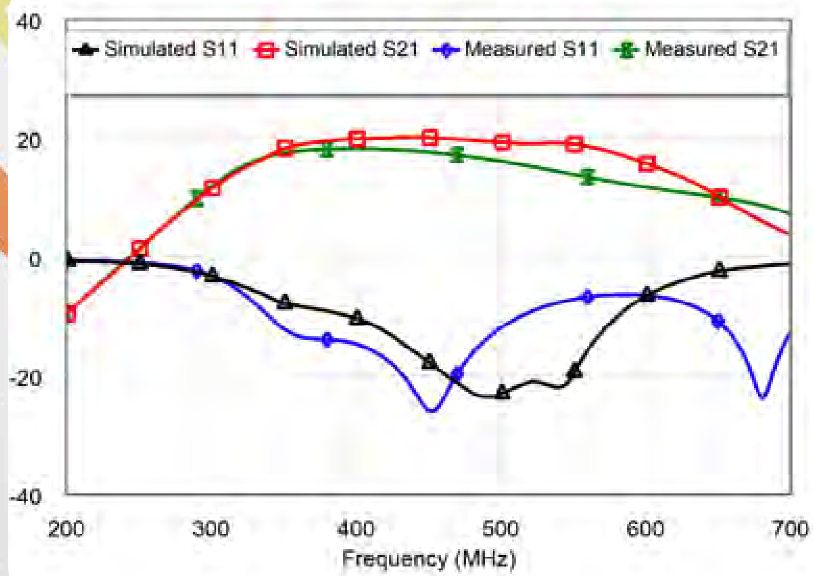


NASA Technical Monitor
Laurence Thomsen, PhD
Langley Research Center

Space-Borne Antennas and Circuits for Condensed Radars and STEM (SPACERS)

University of Oklahoma



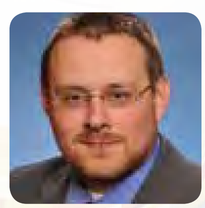


Stage 1 amplifier: Fabricated prototype on the top and measured results on the bottom

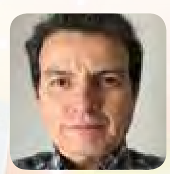
Imagine having an array of satellites orbiting far away planets providing valuable two- and three- dimensional fine scale radar imagery of the planet's surface, including ecosystem structures and biomass. That may sound very futuristic, but technologically, we are not far from realizing it.

The proposed technical goals of the SPACERS program will help transfer NASA's advanced digital beamforming radar instrument from an airborne platform to space. This will provide the genesis of a new class of observations suitable to meet the science goals for terrestrial and planetary exploration. Synthetic aperture radar (SAR) measurements are applicable to a number of science study areas ranging from ecosystem structure, surface and sub-surface topography, soil freeze-thaw, ice sheet composition, glacier depth, and surface water, among many others. In particular, their measurements can provide unique information on vegetation volumes and densities that can be used to map aboveground biomass, forest cover, disturbance from deforestation and degradation, forest recovery, and wetland inundation, helping to quantify carbon release into the atmosphere. Spaceborne SAR systems will allow global mapping of topography and long-term monitoring of dynamic processes. Satellite data are at least one order of magnitude cheaper than airborne data, and this is particularly true for inaccessible areas of the Earth.

The future is bright and the SPACERS team is excited about being involved in the development that will enable new levels of remote sensing for terrestrial and planetary exploration.



Science PI
Hjalti H. Sigmarsson, PhD
University of Oklahoma



NASA Technical Monitor
Rafael F. Rincon, PhD
Goddard Space Flight Center

Puerto Rico Research Infrastructure Development

University of Puerto Rico

Prof. Ram S. Katiyar was recently named Fellow of the American Ceramic Society (Class of 2018). He is a Professor of Physics at the University of Puerto Rico, Rio Piedras Campus, where he established an Advanced Materials Research Laboratory for synthesizing nanostructured materials/films utilizing sol-gel, pulsed laser deposition, and RF sputtering techniques; and characterizing them using Raman spectroscopy, X-ray diffraction, dielectric studies, and other non-spectroscopic techniques. Among his most notable research, Katiyar has successfully designed novel room temperature multiferroics with magnetoelectric switching at small magnetic fields and having large magnetoelectric coefficients that may have commercial potential in nonvolatile memories and sensor applications. He is also deeply involved in the fabrication and characterization of thin film oxides for Li-ion and Li-S rechargeable batteries for space exploration applications.

Prof. Ram S. Katiyar in his office holding the plaque naming him Fellow of the American Ceramic Society, Class of 2018.

Gerardo Morell, PhD
Puerto Rico EPSCoR Director
University of Puerto Rico

Enabling Technologies for Water Reclamation in Future Long-Term Space Missions: Wastewater Resource Recovery for Energy Generation

University of Puerto Rico

The research goal of this project is to develop multifunctional water purification membranes for the removal of contaminants from wastewater. These membranes are fabricated with dual function to withstand bacterial growth and also serve as a catalytic platform. The purpose of this is to generate purified water while generating electricity and other valuables from wastewater, but also preventing membrane biofouling to achieve long-term operation.

This project is performed in direct collaboration with the NASA Ames Research Center and is aligned to the Human Exploration and Operations Mission Directorate that states as a goal: to perform basic research proving new insights into problems affecting people on the Earth and understanding and developing the systems and protocols necessary for humans to venture beyond low Earth orbit for extended durations.

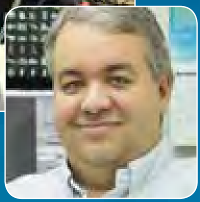
Through this project, we have been able to leverage our previous efforts in the area of water purification while generating electrical current as a next-generation of technology to support life on earth and beyond. This project has enabled the acquisition of state of the art instrumentation that is unique to the University of Puerto Rico at Rio Piedras campus. This allows for collaborations with other researchers in Puerto Rico and Mainland U.S. Moreover, the instrumentation acquired is of interest to the local industry, thus opening up new venues for collaboration and possible revenues for reinvestment. Last but not least, students working on this project have been able to successfully compete for other research opportunities, such as fellowships and internships.

Right: Graduate student at the NASA Ames Research Center synthesizing materials for the conductive membranes

Graduate research assistant performing experiments in an HPLC

Prof. E. Nicolau and a graduate student working on next-generation water purification membranes for NASA exploration missions at UPR's Molecular Sciences Research Center.

NASA Technical Monitor
Michael Flynn, PhD
Ames Research Center



Science PI
Eduardo Nicolau, PhD
University of Puerto Rico

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

University of Puerto Rico

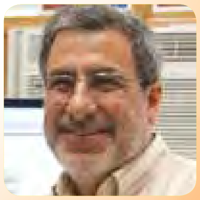
On July 12-13 2018, the University of Puerto Rico at Rio Piedras received the visit of a NASA representative, Mr. Willie Williams, who traveled to the Island in order to assess the progress of a project that is being carried out in the College of Natural Sciences and that will be sent next year to the International Space Station.

With a grant of $100,000 awarded by NASA EPSCoR, a group of UPR professors and students are developing a device that seeks to improve the process of purification of urine to transform waste into energy through the oxidation of ammonia.

“Ammonia is produced from the urea in urine through an oxidation process that may have complications in space due to microgravity. Hence, we will carry out an electrochemical experiment in the International Space Station to learn how this process works in space”, explained Dr. Carlos Cabrera, who is a full professor at UPR and the science lead of the project.

During NASA’s visit, Mr. Williams found that everything is on track for this project and that it will be ready for next year. “Yes, they are on the right track, although there is one more thing they must do, they need to obtain those electronics, but they have already found the person who will help them and it was guaranteed that everything will be ready on time”, he said.

Willie Williams discussing the progress of the NASA EPSCoR ISS project with students



Science PI
Carlos Cabrera, PhD
University of Puerto Rico

NASA Technical Monitor
Willie Williams
Johnson Space Center

Development of Nanoporous Adsorbents for Aqueous Phase Separations in Life Support Systems

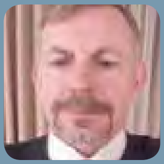
University of Puerto Rico

Professors Hernández-Maldonado, Chen, and Tarafa (from left to right) from the University of Puerto Rico are designing superior adsorbent materials to remove problematic compounds from reclaimed water and also recover active medical drugs from SDSS units already used or that will be used in NASA space exploration missions.

The availability of sufficient potable water and medications to provide life support during space missions is of utmost importance. Reclaiming water in portable and closed-volume applications is certainly not an easy task, particularly in space missions where limit to weight and volume is mandatory. However, scientists from the University of Puerto Rico are developing nanoporous adsorbent materials to be used as filters for onboard treatment of water as well as for the recovery of medical products from portable Synthetic Drug Synthesis Systems (SDSS). The products of this project are expected to pave the way for the development of new terrestrial wastewater treatment technology based on adsorption to remove persistent contaminants and the enabling of portable synthesis systems for onsite medication production, particularly for remote areas with little or no resources, and even to help with the general global demand for medications.

Science PI
Arturo J. Hernandez-Maldonado, PhD
University of Puerto Rico

Co-NASA Technical Monitor
Michael Flynn, PhD
Ames Research Center



Co-NASA Technical Monitor
Andrew J. Trunek
Glenn Research Center

Rhode Island Research Infrastructure Development

Brown University

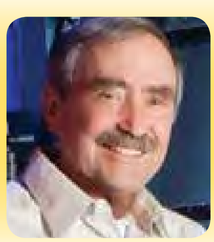
Background: Photograph taken during the laser measurements of ice reflectivity, which will be used to detect seismic activity on a surface remotely (University of Rhode Island, Department of Ocean Engineering)

Remote Sensing of Subsurface Structure of Extraterrestrial Bodies using Laser Doppler Velocimetry Measurements of Rayleigh Waves

(University of Rhode Island)

This NASA-RID sub-award to URI provided the resources to exploit laser vibrometry technology for measurement of Rayleigh or interface waves with application to the estimation of the elastic medium properties of the substructures of a planetary body or satellite including ice. This award engaged three MS students and 8 undergraduate students to work with a state-of-the-art laser vibrometer. Polytec, Inc. provided this device for this effort at a reduced cost. The measurements of these waves with the laser were compared to motion measurements by high resolution and high sensitivity accelerometers from PCB Piezotronics, Inc. The award allowed the construction and testing of a laboratory set-up called the "Interface Wave Test Facility." The students also measured the reflectivity of ice and a photo is shown below. In addition to the interface wave measurements, the award provided resources to develop and test a chirped laser pulse generator as a low-power, small footprint solution for portable LIDAR application. The small, very light-weight and low power system would be practical for launch to a satellite like Europa.

The wearable anti-motion sickness device is embedded in a 3D printed housing that is clip-compatible with most existing audio and VR headsets.



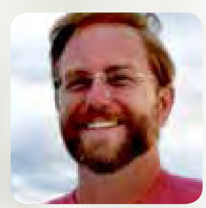
Peter H. Schultz, PhD
Rhode Island EPSCoR Director
Brown University

New Methods to Assess the Environmental and Floral/Faunal Responses to Impacts on Earth

University of Rhode Island

Above is a URI undergraduate and RI-Space Grant Summer Research Scholar preparing samples from a loess sequence in Buenos Aires province of Argentina. The samples are being prepared for magnetic mineral analysis to characterize the environmental changes associated with a meteorite impact event.

We have known about the thick sedimentary sequences of Argentina since Charles Darwin disembarked from the HMS Beagle and trekked across Buenos Aires province in 1833. However, our ability to study these sequences has been restricted to outcrops, road cuttings, and quarries that, at best, provide a 20-meter glimpse of what was once a landscape filled with unique mammals that evolved in isolation from the rest of the connected world. In addition to a rich fossil record, the exposures contain meteorite impact glasses from at least 7 different events during the last 10 million years, suggesting that at times it was far from being a tranquil landscape. Through our partnership with Foraco International SA, a mining services and drilling company, our project will recover a sedimentary sequence that extends into the previously inaccessible depths of mid-Pliocene Argentina. In doing so, the recovered sequence will provide unique teaching and research opportunities by providing the first samples recovered from depths beyond those previously attainable and from a time period that spans the last major warm period in Earth's history, a major change in the South American fossil record, and a significant meteorite impact event.



Science PI
Clifford W. Heil, Jr., PhD
University of Rhode Island

NASA Technical Monitor
Cynthia Evans, PhD
Johnson Space Center

South Carolina Research Infrastructure Development

College of Charleston

Astronauts and others living in extreme environments have high oxidative stress and iron levels that increase disease risk. Iron-binding polyphenol antioxidants show promise for preventing DNA damage and oxidative stress due to these high iron levels during and after space flight, and polyphenol antioxidants are readily available in the diet or as supplements. Our research will establish iron binding as a cellular mechanism for polyphenol antioxidant activity, identify the most potent antioxidants for future animal or human supplementation studies, and support graduate student training in NASA-related work. Our work has the potential to significantly impact human health, both for space travelers and for the general public. Measuring polyphenol antioxidant activity and developing predictive models for this behavior will enable selection of the most promising antioxidants for future studies, a long-standing goal of antioxidant research. One Ph.D. student conducting this research is a South Carolina native, and funding this research will allow him to complete this project prior to graduation. Additionally, this funding allowed us to establish a mammalian cell culturing facility in the Department of Chemistry, a departmental user facility that will extend chemical research into biological systems and greatly increase research impact.

Clemson University Principal Investigator, Dr. Julia Brumaghim, and graduate students: top - removing cells from cryogenic storage; middle - setting up the chemistry tissue culturing facility; and right - working in the biosafety cabinet for mammalian cell culturing.

Cassandra Runyon, PhD
South Carolina EPSCoR Director
College of Charleston

Development of the Virgin Islands Center for Space Science at Etelman Observatory: Research, Education, and Economic Development through Promotion of NASA's Vision

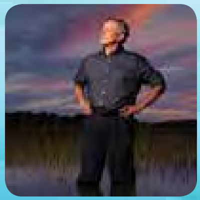
University of the Virgin Islands and College of Charleston

Generation-GW: Diving Into Gravitational Waves, June 5-9, 2017

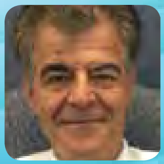
Unveiling the Physics Behind Extreme AGN Variability, July 10-14, 2017

Establishing the Etelman Observatory and Science Center at the University of the Virgin Islands St. Thomas campus has raised the profile of UVI in the international astrophysics research community. Through this elevation of UVI's profile as an astrophysics Research University we have successfully hired a research scientist to operate the Etelman Observatory's Virgin Islands Robotic Telescope which contributed to the follow-up observations of the world's first source detected in both gravitational waves and electromagnetic radiation, GW170817. UVI's increased status in the international astrophysics research community also benefited the university by being able to recruit high-quality researchers and teachers to support the University's new 4-year degree program in physics. Without the work made possible through this first NASA-EPSCoR grant award to UVI in 2013, none of these subsequent activities would have been possible. Perhaps the ultimate demonstration of UVI's new status as a significant university for world-class research into astrophysics and astrophysics-enabling technologies, were two international astrophysics conferences, hosted by UVI during the summer of 2017. Despite, never-before having hosted such as astrophysics conference, UVI hosted two conferences in the span of 4 weeks during the summer of 2017, drawing some 120 astrophysicists from all over the world to UVI's St. Thomas campus. The first conference, "Generation-GW: Diving Into Gravitational Waves" focused on discussion of the new discovery by the Laser Interferometric Gravitational Wave Observatory (LIGO) of gravitational wave sources (in 2015) and what the future field of gravitational wave astrophysics might encompass. The second conference, "Unveiling the Physics Behind Extreme AGN Variability" focused on expanding our understanding of the nature of Active Galactic Nuclei (AGN), super-massive black holes at the cores of galaxies that emit brightly across the electromagnetic spectrum. These two conferences demonstrated to the world that UVI is a new and significant participant in the world's astrophysics research community

Co-Science PI
David Morris, PhD
University of the Virgin Islands



Co-Science PI
J. Hakkila, PhD
College of Charleston

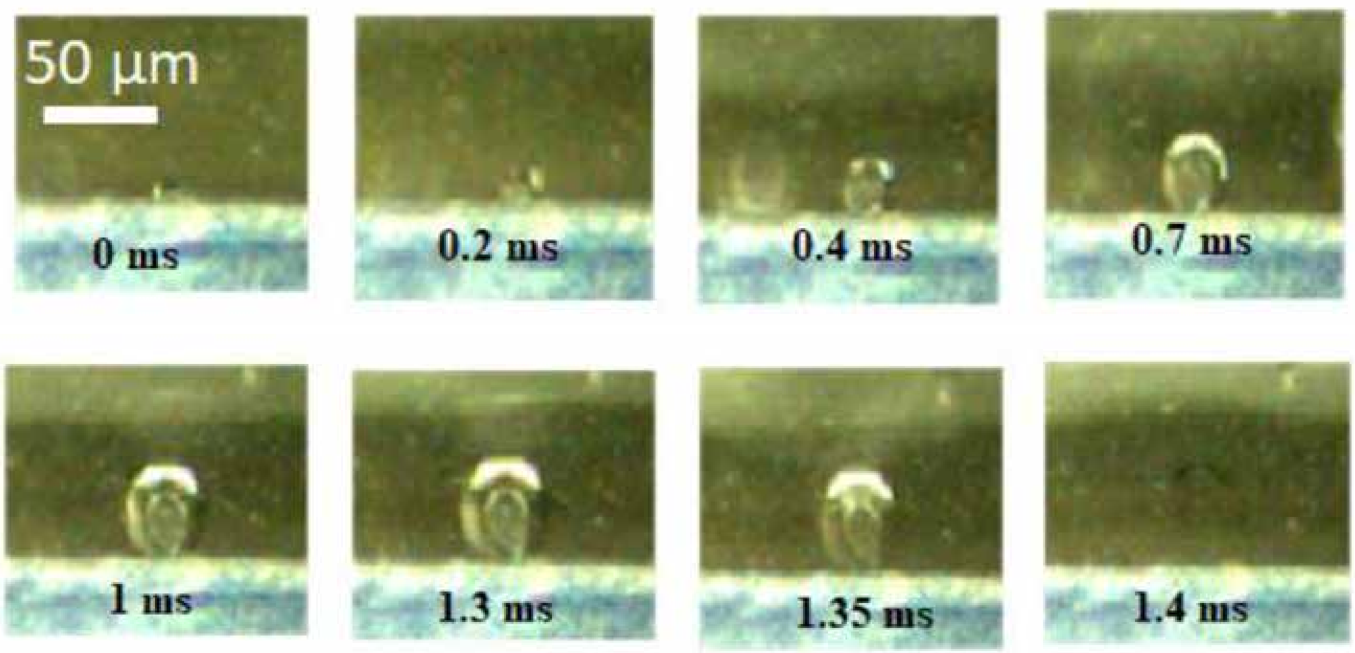


NASA Technical Monitor
Ali Shaykhian, PhD
Kennedy Space Center

Explore a Unified, Ultra-Efficient and Gravity-Insensitive Flow Boiling Pattern for Space Missions

University of South Carolina

- This project aims to address NASA's needs in two-phase technologies by creating a new, unified and ultra-efficient flow boiling pattern that is especially favorable for applications in microgravity.
- SiNW enables gravity-insensitive bubble departure mechanism (enhances bubble nucleation site density and departure frequency; reduces bubble departure diameter).
- In addition, SiNW regulates flow regime development (Reduces the transitional flow boiling regimes (slug/churn/ wavy) to a single annular flow).
- Thus, the physical insight this study provided on the flow boiling SiNW microchannels on flow regulation and system performance enhancement using different working fluids can pave the way for development of next generation high performance gravity insensitive twophase heat sinks for space applications.



As demonstrated in this NASA project, bubbles are rapidly ejected out, NOT detached by buoyance force in the Si Nanowire-structured microchannels.

Science PI
Chen Li, PhD
University of South Carolina

NASA Technical Monitor
Ted Swanson, PhD
Goddard Space Flight Center

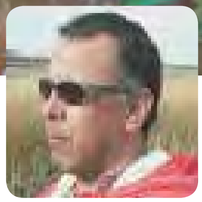
Temporal and Spatial Variability of Floodplain Currents by In-Situ Observations, Radar Interferometry and Numerical Simulations

College of Charleston

View of the floodplain from bank of the Congaree River, water depth ~0.5 m; water is flowing from the floodplain toward the river

This NASA-EPSCoR study investigates the temporal and spatial variability of flood water circulation over the Congaree River floodplain, at the Congaree National Park. This objective is being met through a three part study that includes radar remote sensing of the water surface elevation over the entire floodplain, direct field measurements of water surface slope, water current speed and direction, and 3D numerical simulations of water flow. Although this project started in January we already developed the flow domain for numerical simulations, installed field instruments and we have initial maps of water surface elevation (Figure 1). As the study progresses we will to enhance and refine our observations and analyses to provide greater mechanistic insight on the how floodplain currents vary with time and water level, and how that can be expected to change in response to climate change. Results gleaned here are likely transferable to other floodplain systems. Hence, this work is relevant to SC and it's multitude of floodplain systems, and to floodplains throughout the world that are susceptible to natural and human induced changes to the land surface and hydrologic systems.

NASA Technical Monitor
Thomas R. Holmes, PhD
Goddard Space Flight Center

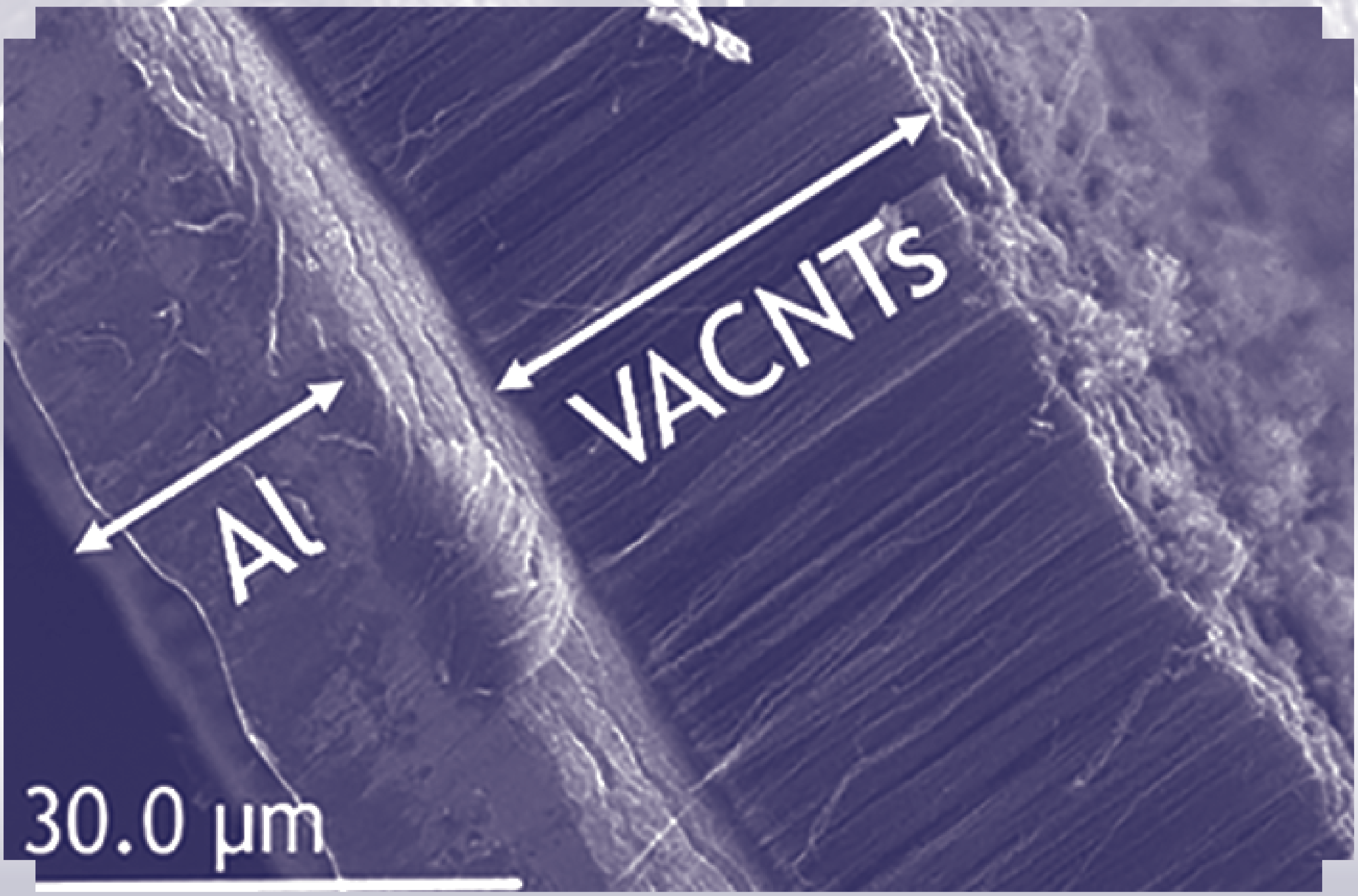


Science PI
Raymond Torres, PhD
College of Charleston

Nanomaterials-Based Hybrid Energy Storage Devices and Systems for Space Applications

Clemson University

This collaborative project between Clemson University (Clemson) and Orangeburg-Calhoun Technical College (OCTech) will address NASA's needs in energy storage and thermal management technologies through engineered nanomaterials. Building upon >30 years of multidisciplinary experience in nanomaterials and advanced manufacturing, the proposed work will establish a sustainable consortium within the state of SC to enhance its research competitiveness in energy storage technologies. This project will use NASA EPSCoR funding in the next three years to produce: 1) safe and environmentally friendly Li-ion cells with high energy density and long life by engineering interfaces within the electrodes (through nanocarbon, nano-Si, and Li-rich compounds), 2) battery thermal management materials (based on boron nitride or BN derivatives), and 3) blueprints for assembling individual battery cells and thermal barriers into packs, that are needed for NASA missions, and integrated with an efficient battery management system.



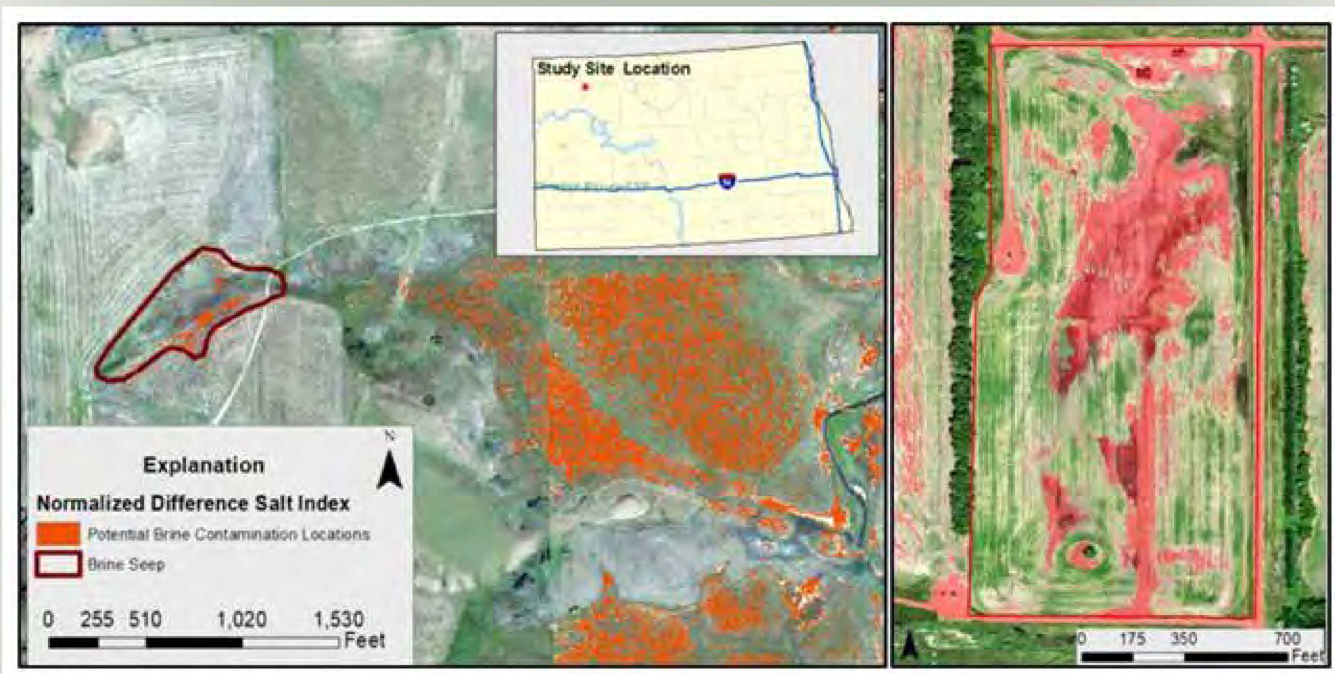
A cross-sectional scanning electron microscope image of an aluminum current collector coated with vertically aligned carbon nanotubes. The coated aluminum electrodes enable superior battery performance compared to bare aluminum electrodes. Image from PI's lab.

Science PI
Apparao Rao, PhD
Clemson University

NASA Technical Monitor
John W. Connell, PhD
Langley Research Center

South Dakota Research Infrastructure Development

South Dakota School of Mines & Technology

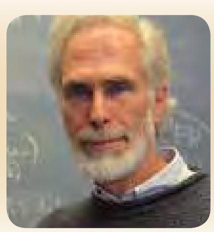


Maps showing detection examples of brine impacted soils (left) in naturally occurring seeps and (right) brine spills from oil extraction in the Northern Great Plains

Project students collecting soil samples in Clark County, South Dakota, to look at naturally occurring brine seeps and their impact on South Dakota soils and agriculture

In the Williston Basin, the water produced as part of oil and gas extraction is a highly saline brine. The properties of this brine are variable both spatially and temporally. Brine has the potential to irreversibly damage agroecosystems and freshwater resources. Minor shifts in soil salinity often go undetected while they degrade grassland productivity, alter plant communities, and reduce plant diversity. Shale-oil wells, pipelines, storage structures, and every-day activities release often un-noticed quantities of brine before, during, and after oil or gas extraction. These brine releases have a cumulative effect because soil salinity changes are abiotic stressors of grasslands. As a result, brine impacted areas possibly could be detected using remote sensing techniques and indices which estimate ‘greenness’ via Landsat data and other NASA remote-sensing products. This pilot project demonstrated that impacted soils can be identified or, if known, monitored using a fused dataset approach which combined salt indices and results of principal component analysis along with static geospatial data. This research is aligned with the NASA strategic goal of advancing our understanding of Earth.

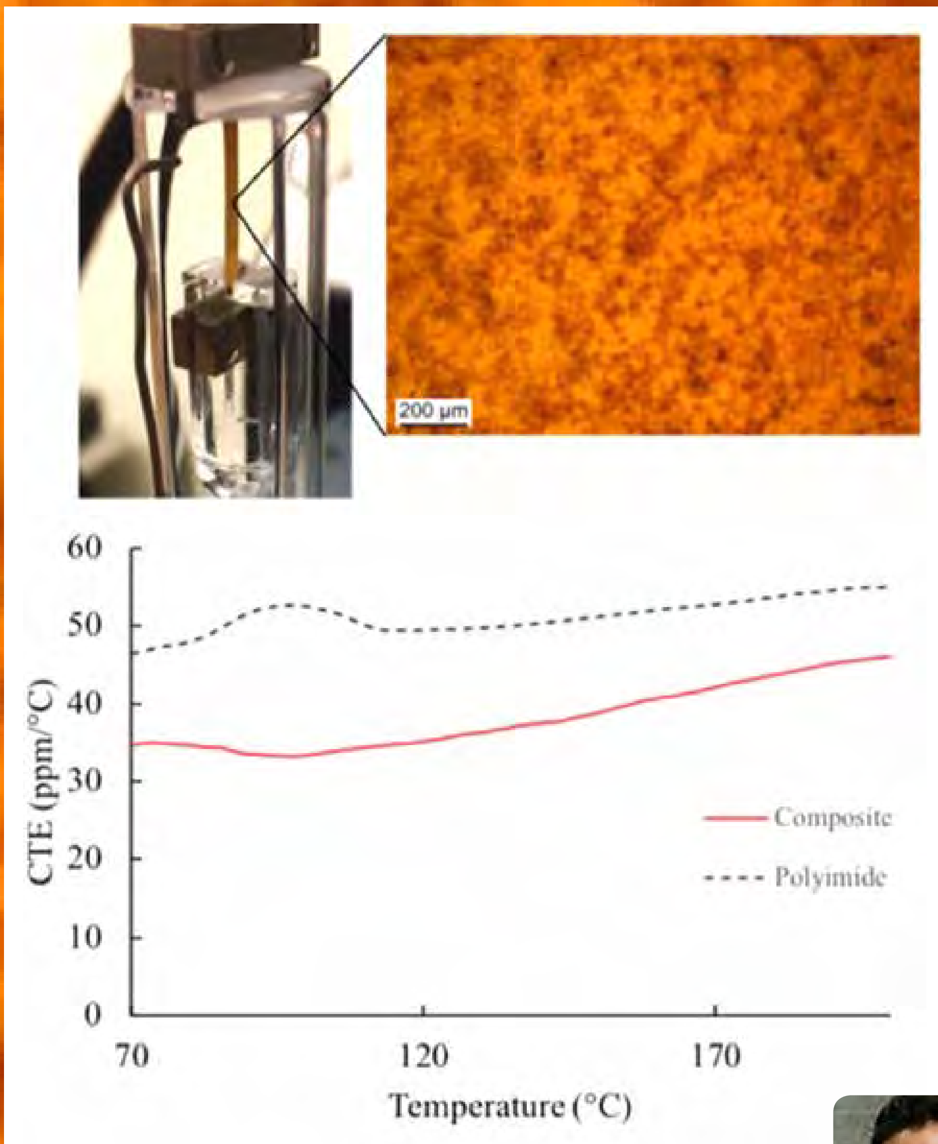
SD



Edward Duke, PhD
South Dakota EPSCoR Director
South Dakota School of Mines & Technology

Development of Direct-Write Materials, and Electronic and Electromagnetic Devices for NASA Printable Spacecraft

South Dakota School of Mines and Technology



Printed polyimide-17 vol% negative CTE particle composite demonstrated 25% reduction in CTE.

Printed Composites with Tailored CTE

Satellites can undergo temperature changes greater than 200°C, causing on-board material systems to expand and contract. Interfaces between different materials experience stress during these cycles, which can lead to failure of critical satellite components. Efforts at the South Dakota School of Mines and Technology have led to the production nanoscale materials that contract while heating and expand while cooling, referred to as negative thermal expansion. Scientists have incorporated these materials into inks that, when printed, produce a polyimide matrix-negative thermal expansion filler composite that can have a tailored coefficient of thermal expansion. The effect is pronounced enough that at 17 percent of the composite volume, the nanomaterials reduce the composite CTE by 25%. Applying these inks as films below electronic components can reduce the thermal stress experienced during thermal excursions, prolonging the lifetime of those systems.

Science PI
Dimitris E. Anagnostou, PhD
South Dakota School of Mines & Technology

NASA Technical Monitor
George E. Ponchak, PhD
Glenn Research Center

Advanced Bioelectrochemical Module (BEM) for Waste-to-Electricity Generation During Long-Term Space Exploration

South Dakota School of Mines & Technology

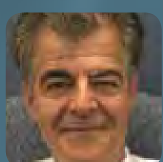
Dr. Gadhamshetty's team working on a bioelectrochemical module for manned space missions

Long-term, manned space missions are challenged by waste-treatment and power requirements. During space missions, each crew member typically generates approximately 4 pounds of solid wastes each day. This waste is a burden to space missions, as it increases fuel consumption and creates nuisance and health concerns due to pathogens. The South Dakota Mines approach will use isolated unique microorganisms isolated from the deep levels of the Sanford Underground Research Facility (SURF) as test subjects to develop an advanced biological module generates electric power from solid wastes in a single step.

This multidisciplinary NASA project has become a reality only due to the exceptional range of interdisciplinary researchers—catalysis, extremophile biology, environmental and chemical engineering, and nanotechnology – from the SDSM&T, South Dakota State University, University of South Dakota, and several industries businesses. The research team has originally received Research Initiation Grant from SD NASA EPSCoR in 2015 to develop the collaborations within SD and with NASA researchers and to obtain preliminary results.

The project addresses three prime focal areas identified for research and economic development in South Dakota – energy and environment, value-added agriculture and agribusiness, and materials and advanced manufacturing.

Science PI
Venkata Gadhamshetty, PhD
South Dakota School of Mines & Technology



NASA Technical Monitor
Ali Shaykhian, PhD
Kennedy Space Center

Wireless Body Area Network in Space: Development of Wireless Health Monitoring System with Flexible and Wearable Sensors

South Dakota School of Mines & Technology

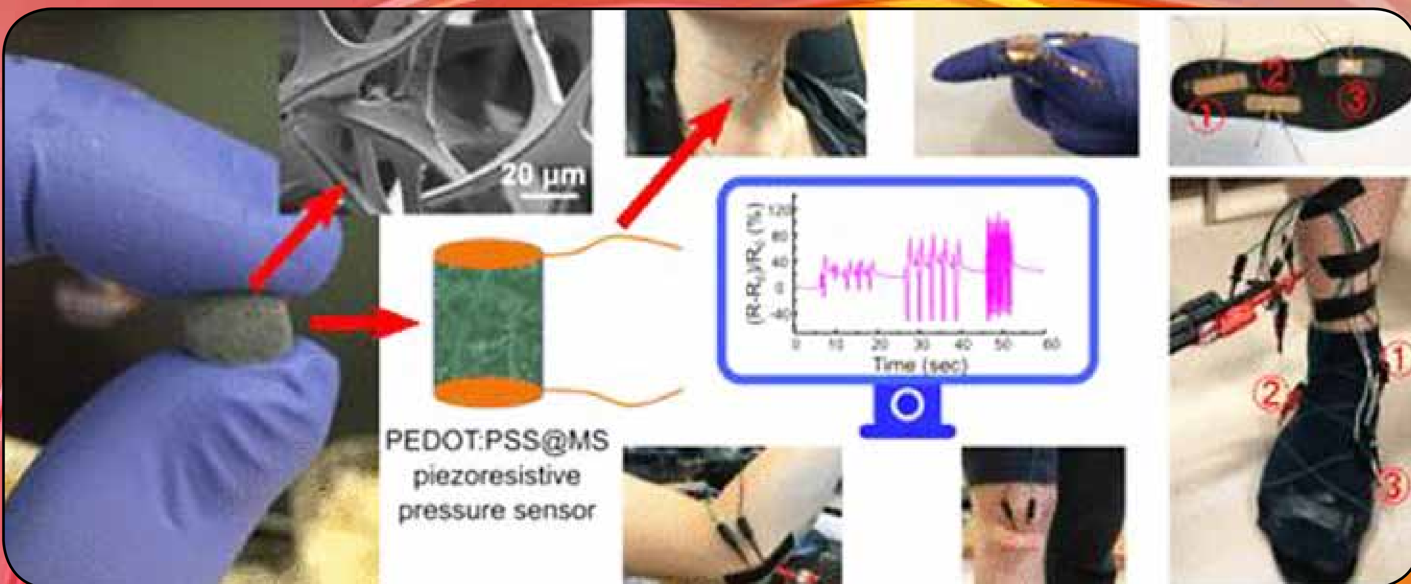
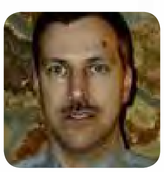


Illustration of wireless body area network with different types of sensors

Science PI
Yanxiao Zhao, PhD
South Dakota School of Mines & Technology



NASA Technical Monitor
William (Cy) Wilson, PhD
Langley Research Center

Researchers have developed a cost-efficient and scalable approach to prepare a highly flexible and compressible conductive sponge tactile sensor for monitoring a variety of human motions including speaking, finger bending, elbow bending, and walking. (ACS Applied Materials & Interfaces, DOI: 10.1021/acsami.8b00457)

Virgin Islands Research Infrastructure Development

University of the Virgin Islands

The US Virgin Islands (USVI) was designated as an independent NASA EPSCoR jurisdiction in 2016. This designation coincided with a coordinated effort by the University of the Virgin Islands (UVI) to emphasize physics education by offering a new bachelor of science in physics degree program. It is rare for a university of UVI's size (2000 undergraduates) to offer a B.S. in physics and rarer still for a historically black university (HBCU) of such a small size to offer such a program. Yet the growing number of students enrolling in physics classes and engaging in research at UVI's Etelman Observatory suggested an opportunity for growth in this area. Support from the USVI-EPSCoR RID program has helped UVI to provide administrative support of the new physics B.S. program, faculty research release time, and, critically, student research projects in astronomy, computational analysis, and associated engineering disciplines. The culmination of years of hard work and support from the NASA-EPSCoR program was witnessed in May 2019 as UVI graduated its first ever B.S. in physics recipients at its spring commencement ceremony. UVI now has 11 additional declared physics majors preparing to graduate in the next 2 years, and more students becoming involved in the program each semester. NASA EPSCoR's continued support of physics and astronomy at UVI remains critical to educating the next generation of physicists, astronomers, and engineers in the USVI and we look forward to many more graduates in the years to come.

University of the Virgin Islands physics faculty with UVI's first graduating class of undergraduate physics students

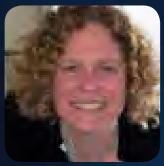
David C. Morris, PhD
Virgin Islands EPSCoR Director
University of the Virgin Islands

UVI BurstCube: Developing a Flight-Ready Prototype Gamma-Ray-Burst Detection Nanosatellite at the University of the Virgin Islands

University of the Virgin Islands

A student presents results of his team's project at the 2019 California Polytechnic State University's Cubesat Developer's Workshop in San Luis Obispo California, April, 2019.

Science PI
Antonio Cucchiara, PhD
University of the Virgin Islands



NASA Technical Monitor
Georgia A. De Nolfo, PhD
Goddard Space Flight Center

A Univeristy of the Virgin Islands student traveled to the California Polytechnic State University in San Luis Obispo, California in April 2019 to participate in the Cubesat Developer's Workshop in advance of his impending summer workshop in aerospace engineering at NASA-Goddard Space Flight Center and his continuing role in UVI's new cubesat development lab on the UVI St. Thomas campus. the student, who hails from the island of St. John in the USVI, takes a ferry to St. Thomas each morning, followed by a bus across St. Thomas to come to UVI each day, and the return trip each day after classes finish. Despite the long day of travel, he is one of the top students in UVI's new physics program and is involved in peer-instruction activities at UVI as well as working in the cubesat research program. In 2018, UVI was awarded a 3-year NASA-EPSCoR grant to develop a 3U cubesat to detect gamma-ray bursts, exploding stars that can be seen from across the Universe due to their extreme brightness. The UVI Gamma-Ray Experiment for Astrophysical Transients (UVI-GREAT) program is giving students the opportunity to get hands-on experience in a wide array of engineering disciplines as well as physics, astronomy, and computer science, all of which enhance their education and provide them directly marketable talents that appeal both to graduate schools and potential employers.

Vermont Research Infrastructure Development

University of Vermont

"Expanding the concept of the Critical Zone from terrestrial to planetary systems: what can we learn about weathering on Mars?"

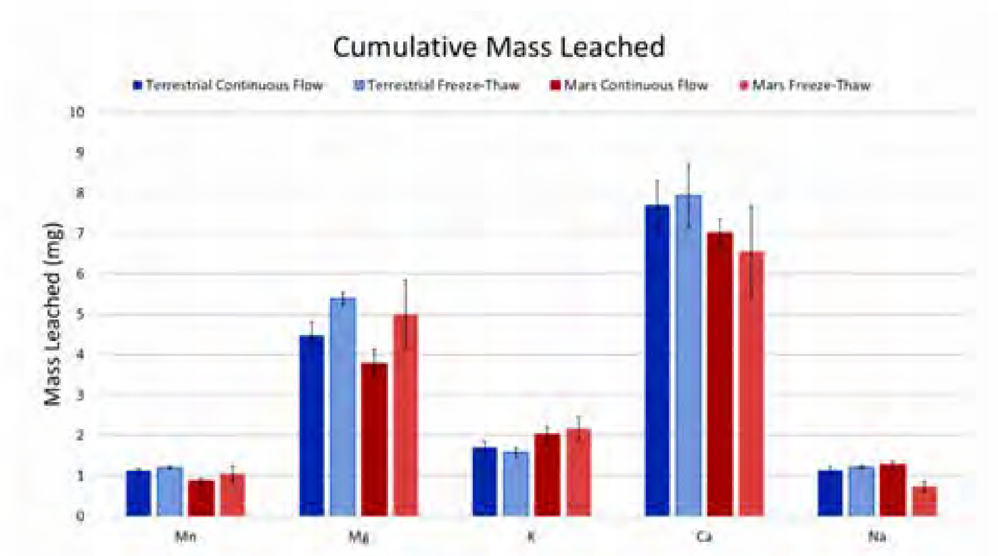
Julia Perdrial (lead-PI), Nicolas Perdrial (co-PI) Department or Geology, University of Vermont

This pilot study generated preliminary data on weathering on Mars to support a full proposal to the planetary science division at NASA. Using the concept of the terrestrial Critical Zone (CZ), which is the zone spanning from the top of the tree canopy to the actively cycled ground water, we designed analogue experiments that capture weathering conditions on Mars more realistically than previous approaches. Mars exploration for colonization is a research priority for NASA, specifically for the planetary science division.

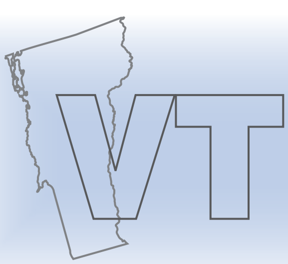
The goals for this project were:

- Design and test analogue experiments that simulate weathering on Mars more accurately that previous approaches by including CO2 rich atmosphere (vs. terrestrial atmosphere) and by simulating freeze-thaw events (vs. continuous flow weathering).
- Establish a fruitful collaboration with NASA researchers and prepare a collaborative proposal to NASA where our data will be included.

As hypothesized, freeze-thaw cycles increased weathering rates and weathering intensity. Under CO2 atmosphere weathering was accelerated, however, weathering intensity remained similar to Earth atmosphere. In summary, the principal parameter affecting weathering was the freeze-thaw dynamics.

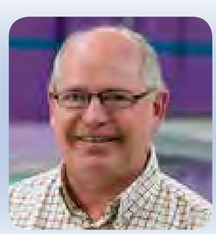


Total leached mass of selected analytes after ca. 500 pore volumes of weathering in the various conditions



In Memoriam

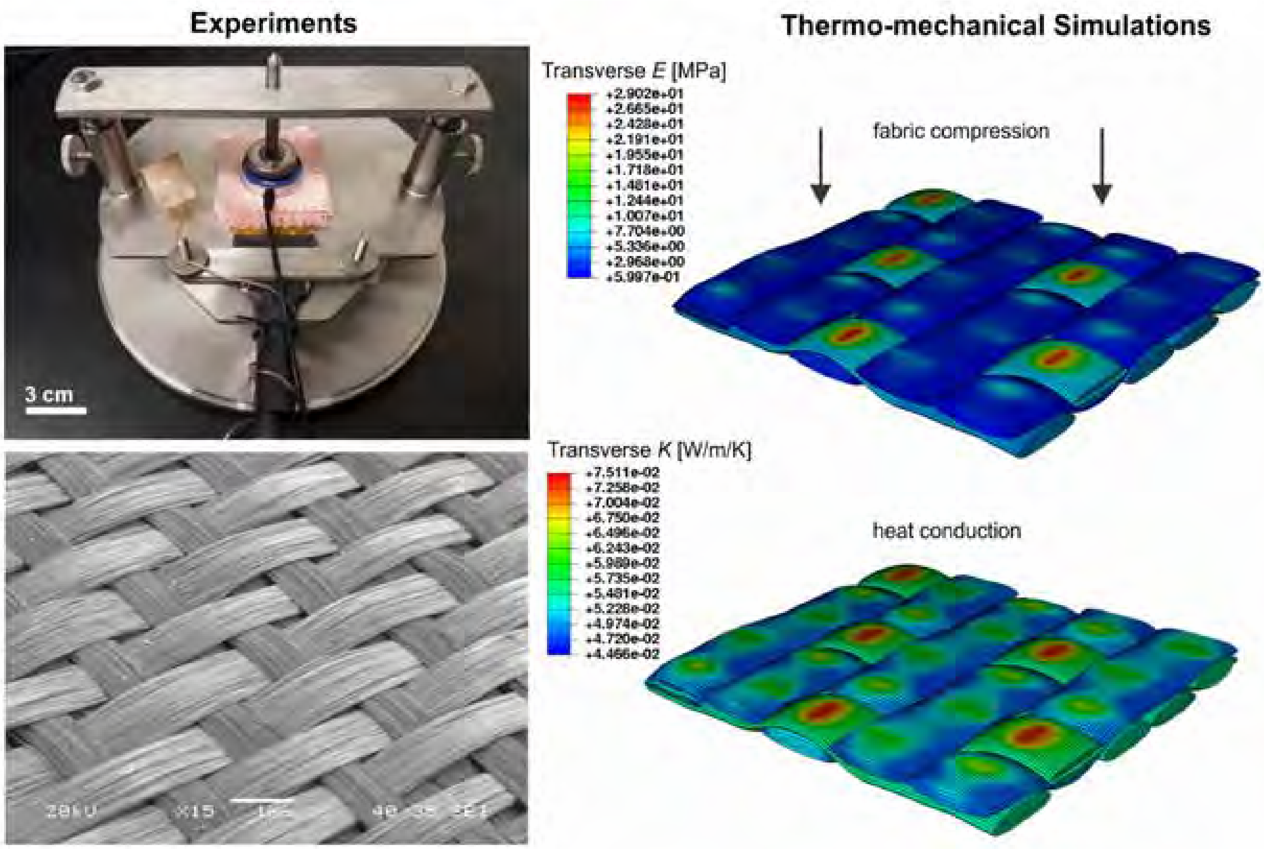
Darren Hitt, PhD
Vermont EPSCoR Director
University of Vermont



Jeffrey Marshall, PhD
Vermont EPSCoR Director
University of Vermont

Flexible Thermal Protection Systems: Materials Characterization and Performance in Hypersonic Atmospheric Entry

University of Vermont



Experimental and computational studies of anisotropic heat conduction through twodimensionalwoven ceramic fibers for inflatable aerospace structures

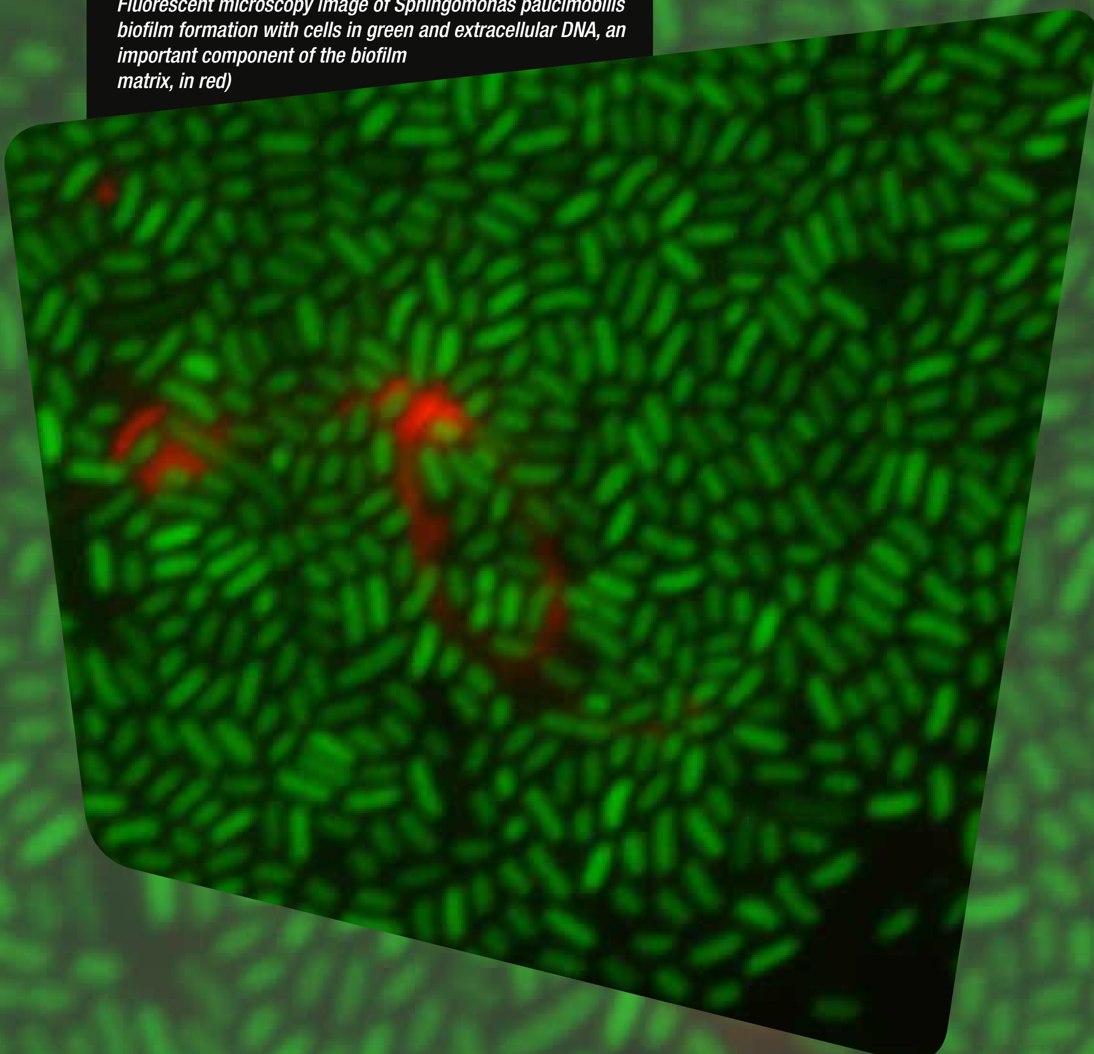
Science PI
Frederic Sansoz, PhD
University of Vermont

NASA Technical Monitor
Anthony Calomino, PhD
Langley Research Center

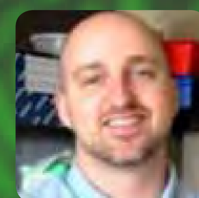
Flexible thermal protection materials are of significant interest for hypersonic inflatable aerodynamic decelerators being developed by NASA for future Mars missions. A key technological component is a heat-resistant skin fabric comprised of two-dimensional woven ceramic fibers that must withstand harsh aero-thermal atmospheric entry conditions. A predictive and basic understanding of heat conduction processes in complex woven-fiber ceramic materials, however, is currently lacking. This research combines experimental and computational studies of anisotropic thermal conductivity in flexible 5-harness-satin woven ceramic fibers, using the hot-disk transient plane source method and advanced thermo-mechanical finite-element analysis. Using this methodology, we characterize the pressure dependence of the heat-conduction anisotropy through yarns and find the thermal gap conductance at the yarn-air interfaces. Different states of thermal exposure (static and hypersonic heating) are studied. This approach is shown to be applicable to a wide range of relevant high-temperature flexible ceramic materials, such as flexible Hi-Nicalon silicon-carbide and Nextel 440 alumina fabrics.

Characterization and Modeling of Biofilm Development by a Model Multi-species ISS Bacterial Community

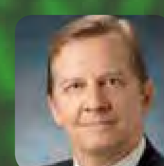
University of Vermont



Fluorescent microscopy image of Sphingomonas paucimobilis biofilm formation with cells in green and extracellular DNA, an important component of the biofilm matrix, in red)



Science PI
Matthew Wargo, PhD
University of Vermont



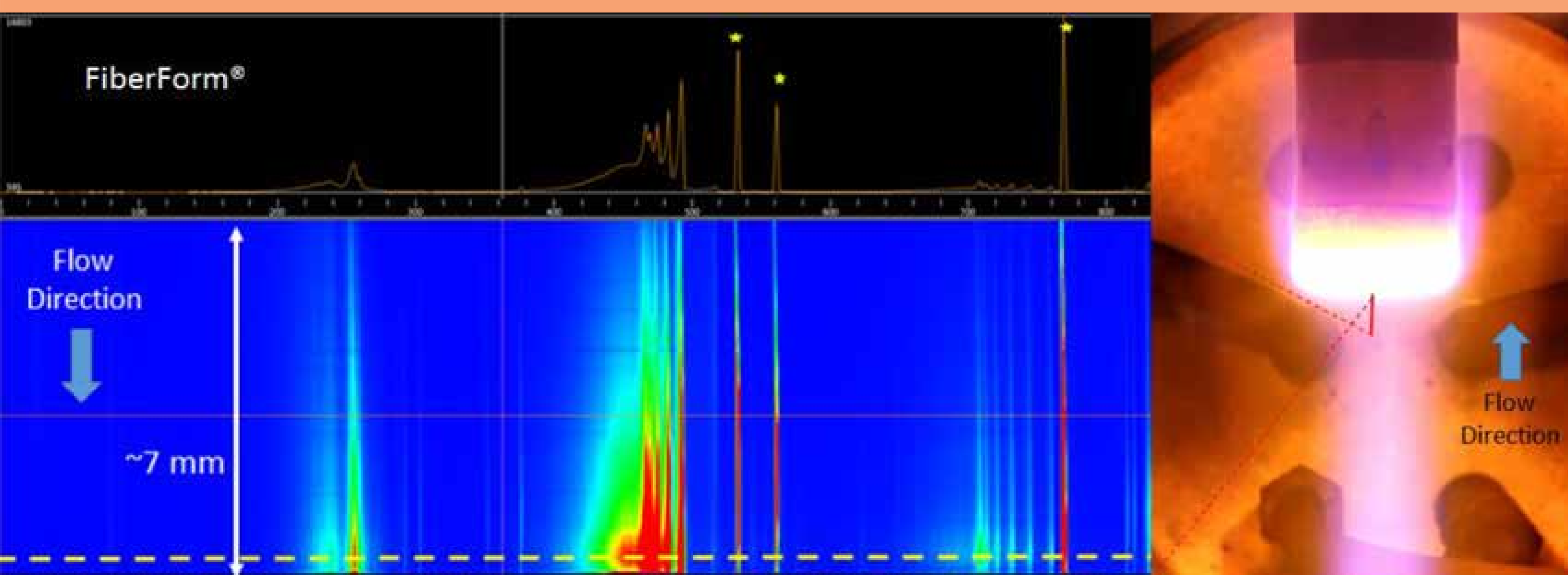
NASA Technical Monitor
Mark Ott, PhD
Johnson Space Center

The microbial biofilms that grow in our potable water systems impact our lives everyday by changing water chemistry, altering pipe corrosion, and serving as a potential reservoir of infectious bacteria. We have used common tap water bacteria, derived from the International Space Station potable water system, to generate an experimentally tractable model for bacterial interactions in potable water systems. Under some circumstances, e.g. overgrowth of a pathogenic organism, it would be beneficial to eliminate the biofilm or specifically ablate one or more members of the community. Our work has shown that the biofilm mass is tolerant to removal of individual species, highlighting functional redundancy, and that specific removal of bacteria from pre-formed biofilms using biological agents (bacteriophage or predatory bacteria) is hampered by the conditions of the biofilm. Our goal is to combine microbiologic experiments, agent-based computational modeling, and specific biological and physical perturbations to determine how these bacteria generate a community that is robust to different starting conditions and resilient to perturbations.

Critical Gas-Surface Interaction Problems for Atmospheric Entry

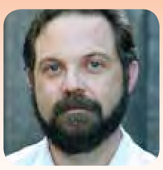
University of Vermont

One aspect of this research effort involves the study of graphite ‘nitridation’ (the formation of nitrogen compounds through the action of ammonia) and nitrogen recombination. It was shown that numerical efforts could not match surface recession rates from arc jet experiments and flight data (NASA Stardust mission) unless an assumption that the baseline carbon material of the PICA TPS, FiberForm®, was assumed to be fully (or at least highly) catalytic to nitrogen recombination. However, while early work performed by other researchers showed that carbon nitridation was present in side arm reactor tests it could not illustrate any nitrogen recombination. This side arm reactor work was repeated in a collaborative effort between UVM and Stanford Research Institute (SRI). Again, graphite nitridation was obvious but no real indicator of nitrogen recombination surfaced for temperatures up to 1300 K. Work done in UVM’s 30 kW ICP Facility in the Plasma Test and Diagnostics Laboratory showed the contrary. While measured carbon nitridation matched the work of Marschall et al.and SRI, UVM illustrated that appreciable N atom recombination is present for graphite temperatures around 1800 K. This thrust presents a need to probe a handful of species in the carbon-nitrogen gas surface interaction chemistry system: N atom, C atom, N2, and CN. All of these are intended to be probed within the chemically reacting boundary layer above hot samples of FiberForm® and PICA char. Latest results illustrated below show spatially resolved emission spectroscopy of CN (central stronger signal is from ?v= 0 CN (B-X) vibrational band). Here we can see we get ample signal and spatial resolution to resolve where the CN resides, is mostly formed, and depletes. This data, coupled with measurements of the other species mentioned above, will provide an invaluable set of information for numerical validation and will, moreover, elucidate on this question of what temperature graphite (somewhere between 1300 and 1800 K) nitrogen recombination starts to proceed.

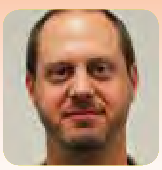


Near surface CN production near a FiberForm® (graphite-based PICA based material) in an argon-dilute nitrogen plasma

Science PI
Jason Meyers, PhD
University of Vermont



NASA Co-Technical Monitor
Michael J. Wright, PhD
Ames Research Center



NASA Co-Technical Monitor
Scott C. Splinter
Langley Research Center

West Virginia Research Infrastructure Development

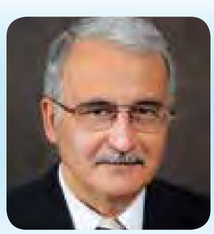
West Virginia University

Characterization of the Viable but Non-Culturable State of Francisella tularensis

Dr. Deanna Schmitt, assistant professor of biology at West Liberty University (WLU), and Dr. Fredrick Damron, assistant professor of Microbiology, Immunology, and Cell Biology at West Virginia University (WVU), are investigating how the potential biowarfare agent Francisella tularensis enters into a state of dormancy, known as the viable but non-culturable (VBNC) state. Since most conventional diagnostic tests for infectious agents depend upon cultivation of the bacteria, VBNC bacteria are a serious threat to public health. Therefore, understanding how VBNC F. tularensis survive and persist in the environment and how they can be resuscitated back to an easily-detected, culturable form is paramount to the safety of our nation. WLU undergraduate students, Kailee Cunningham and Jacob Pancake, have identified culture conditions that induce VBNC F. tularensis and are collaborating with Dr. Damron's laboratory to identify gene expression changes associated with this state. Kailee and Jacob also recently presented their research at the annual meeting of the West Virginia Academy of Science.

West Liberty University undergraduate students identifying culture conditions that induce VBNC F. tularensis.

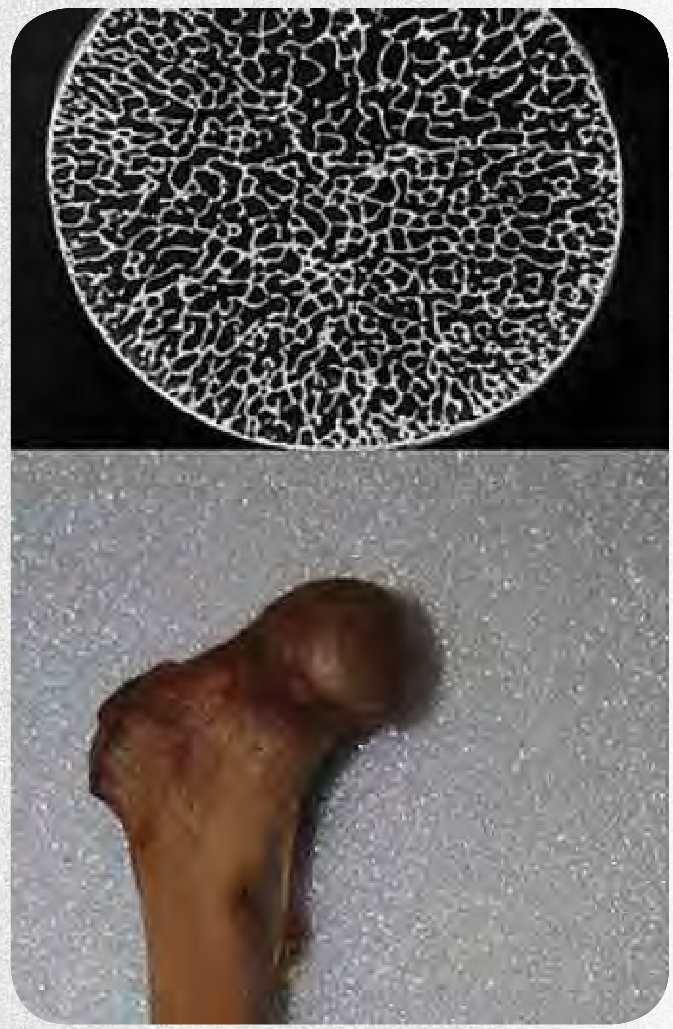
Significance: Many medically important bacterial species are capable of entering into a VBNC state. As result, these pathogens can go undetected during quality control testing of foods, drinking water, and "clean" areas (hospitals, manufacturing centers) resulting in a serious threat to public health. The work in progress in this project will help us understand how bacteria survive in this VBNC state and how they can be resuscitated in order to improve detection and elimination of these pathogens.



Majid Jaridi, PhD
West Virginia EPSCoR Director
West Virginia University

An Investigation of Bone Density and Strength in Non-Human Mammals

The goal of the current NASA WV EPSCoR seed grant is to understand the effects of varying levels of physical activity on bone density and strength, and the biomechanical trade-offs that exist to minimize energetic demands, such as a reduction density through the study of non-human mammals. Bone health is an area of concern to NASA space research. Therefore, studying bone health in other mammals provides an opportunity to understand the extent of physical activity that increases bone density and strength. This study funded by NASA WV EPSCoR uses a different approach by investigating differences in non-human mammals and takes into consideration implications for biomechanical interpretations of bone density selection for tissue economy. A trade-off may exist between minimizing energy demands by reducing density among mammals with varying levels of travel while insuring the integrity of the skeleton. Understanding the precise activity types that induce the greatest bone density and strength will help specialists develop specific exercise regimens to mitigate bone loss.



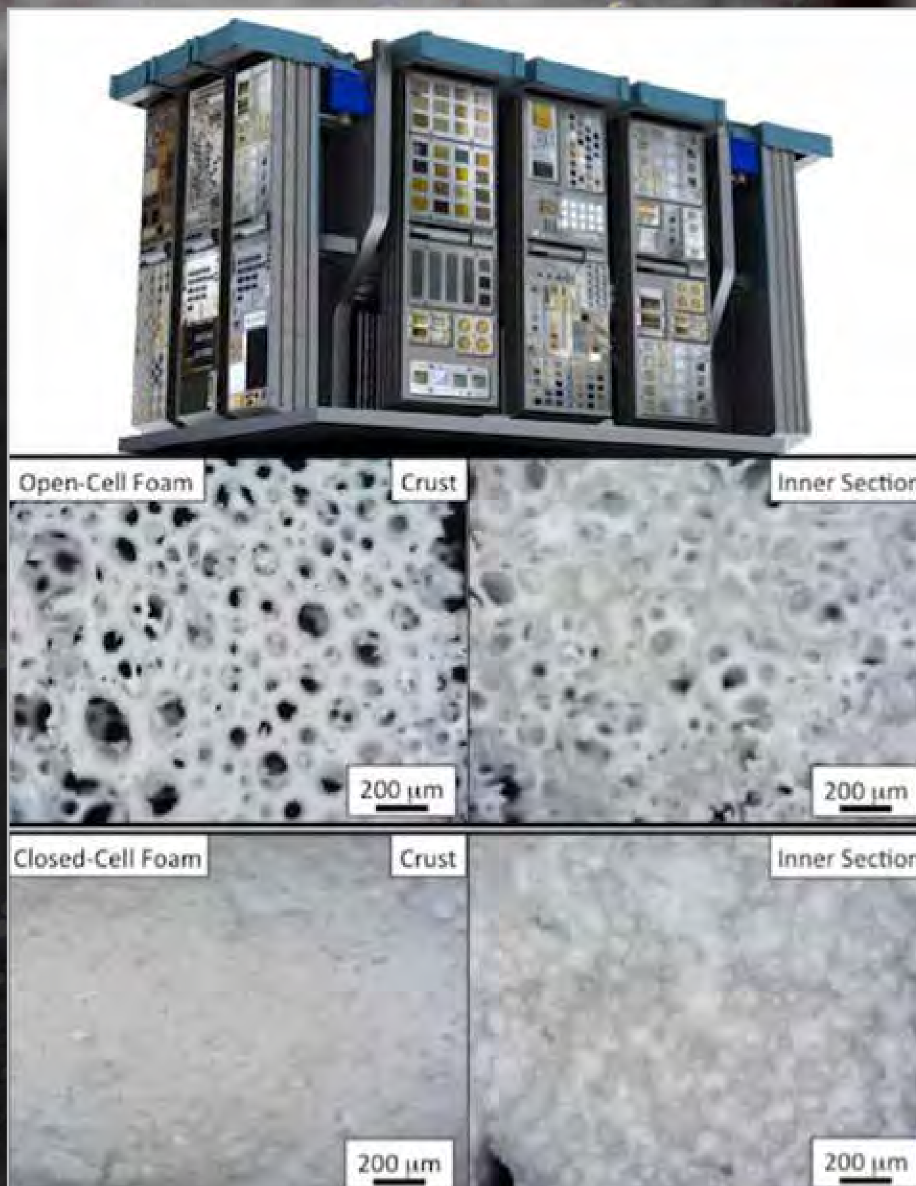
3D Printed Titanium Dioxide Foams Under Extreme Environment Exposure at Low-Earth Orbit

West Virginia University

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.

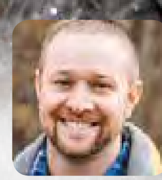
The proposed experimental work will be accomplished by using the MISSE–FF platform at the ISS to expose the Earth-printed foam samples at LEO conditions. Potential degradation mechanisms will be investigated, upon return to Earth, using a suite of characterization methods. These degradation data for 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.



TiO2-based 3D Printed Foams for Exposure in MISSE-FF at LEO

Science PI
Konstantinos Sierros, PhD
West Virginia University



NASA Technical Monitor
Justin R. Morris
Goddard Space Flight Center

Fast Traversing Autonomous Rover for Mars Sample Collection

West Virginia University

The project will be conducted through a tight collaboration between West Virginia University (WVU) and NASA Jet Propulsion Laboratory (JPL) with project members from both sides. The project will leverage WVU's autonomous rover, Cataglyphis, the only robot to successfully complete NASA's Sample Return Robot Centennial Challenge, and JPL's Athena rover and simulators in completing the proposed research tasks. In particular, the WVU team will work closely with JPL's Mobility and Robotic Systems Section in performing rover research and conducting joint experiments at WVU, JPL's Mars yard, and in the red rock deserts of southern Utah. The lessons learned through these efforts will be used to support MSR trade studies currently being conducted by JPL Mars Program Formulation Office.

Science PI
Yu Gu, PhD
West Virginia University

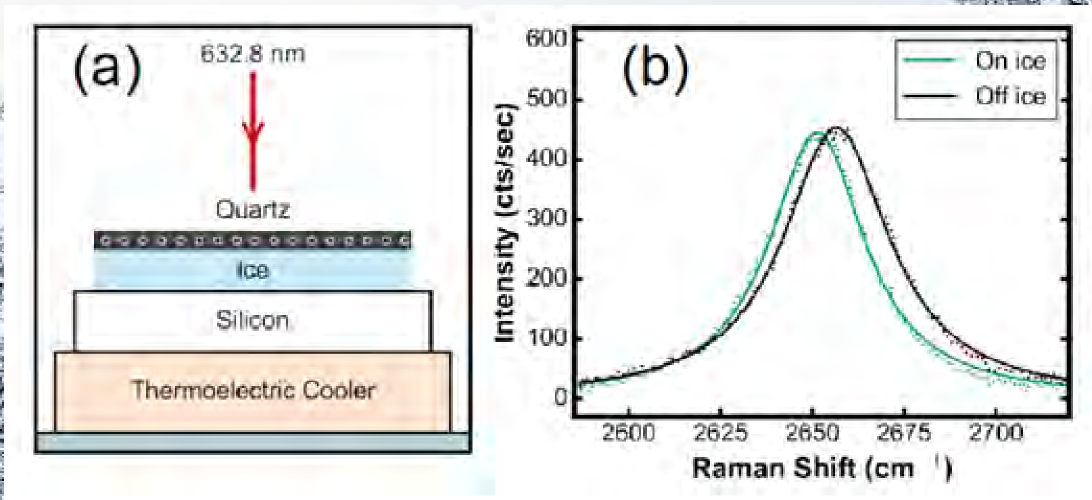
NASA Technical Monitor
Heather Justice
Jet Propulsion Laboratory

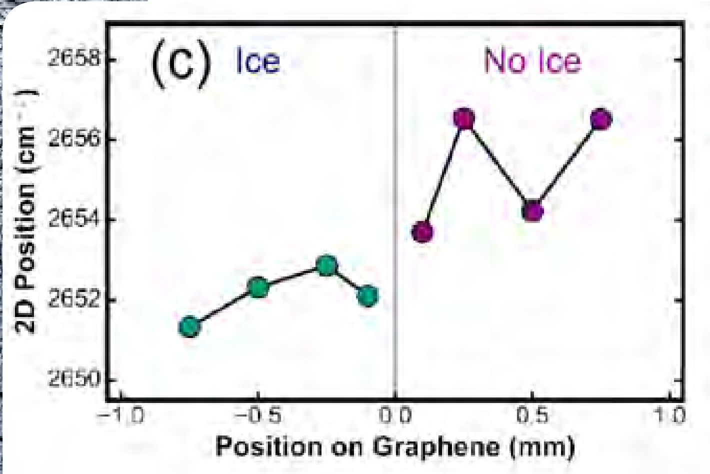
Systems-level innovation will be emphasized throughout the project: that is, leveraging unique opportunities provided by the MSR mission to support novel rover autonomy capabilities. In addition, the project will emphasize end-to-end development and demonstration in realistic physical environments. In general, the project will advance the-state-of-the-art in autonomous robot operation in cluttered environments with severely limited onboard resources, which is well aligned with NASA's technology roadmap in robotics and autonomous systems. Through this research effort, technologies, infrastructure, and expertise closely related to NASA planetary rover missions will be developed at WVU, which in turn will improve West Virginia's competiveness in pursuing future NASA funded research projects.

JPL's Athena rover on the Mars yard

Wyoming Research Infrastructure Development

University of Wyoming





(a) Implementation of the monolayer carbon experiment

(b) Raman shift (and corresponding fit) with and without ice and

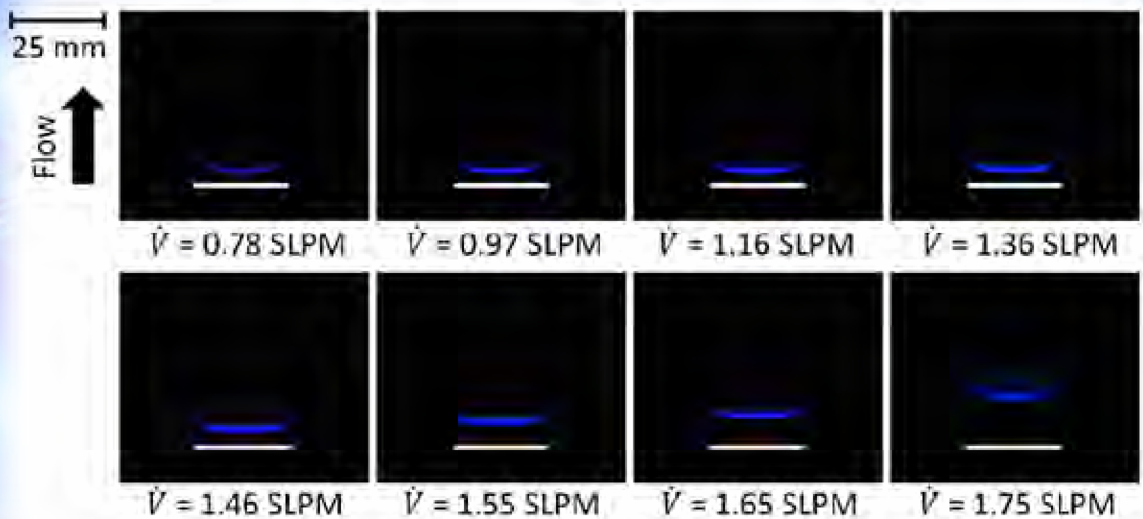
(c) Raman shift center position of the so-called 2D carbon feature with and without ice at different locations along the monolayer carbon surface

Ice adhesion on surfaces such as airplane wings and control surfaces, electrical and communication wires, buildings, and roadways impedes the proper functioning of several economic and environmental elements of our society. To mitigate ice accumulation on various surfaces, a better and more complete understanding of ice adhesion needs to be developed through rigorous experimentation. Unfortunately, previous ice adhesion strength measurements, nearly all of which rely mechanical torque techniques, do not agree with one another, which has greatly hindered the development of a deep understanding of the physics behind how ice adheres to a surface. In this project, we have proposed, and now shown, that ice adhesion can be measured via optical spectroscopy. Using a single, atomic layer of carbon (graphene), we observed that the vibrational spectrum is changed when ice is grown on the carbon. When varied with temperature, this change of the vibrational frequency closely tracks with the density of ice. We are currently trying to confirm and expand on this exciting development using hysteretic, contact angle, and dynamic force measurements. If we can show that the optical and mechanical techniques produce complementary information, we plan to use the spectroscopic technique to measure ice adhesion in harsh environments.

Shawna McBride, PhD
Wyoming EPSCoR Director
University of Wyoming

Experimental and Numerical Investigation of Terrestrial Stable Cool Flames for Improved Understanding of International Space Station Droplet Combustion Experiments

University of Wyoming



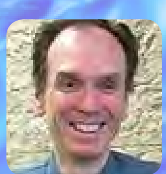
Images of stable fuel-lean cool propane flames at 17.3 kPa pressure, taken with a 2 second exposure time

Low temperature (or “cool”) flames have recently received increased attention because of their importance in advanced combustor designs, such as Homogeneous Charge Compression Ignition (HCCI) engines, as well as their role in autoignition and engine knock. This research seeks to complement and provide terrestrial insights into ongoing research being conducted by the Combustion Branch at the NASA Glenn Research Center (GRC) on cool flames in microgravity aboard the International Space Station (ISS). Cool flames have been established for heptane, which is a single component liquid fuel surrogate for logistical fuels of widespread importance, and laser diagnostic techniques have been implemented to study these flames in a non-intrusive way. Additionally, chemical kinetics models which describe flame chemistry have been reduced to isolate cool flame chemistry, allowing for the numerical simulation of cool flames and assessment of model performance. This work advances the understanding of low temperature combustion by providing novel experimental and numerical modeling insights, thereby advancing efforts towards improving combustion efficiency and combustor design in widespread power applications.

University of Wyoming Ph.D. candidate prepares optics for formaldehyde PLIF visualization of heptane cool flames

Members of the Belmont Energy Research Group (BERG) at the University of Wyoming

Science PI
Erica Belmont, PhD
University of Wyoming



NASA Technical Monitor
Daniel L. Dietrich, PhD
Glenn Research Center

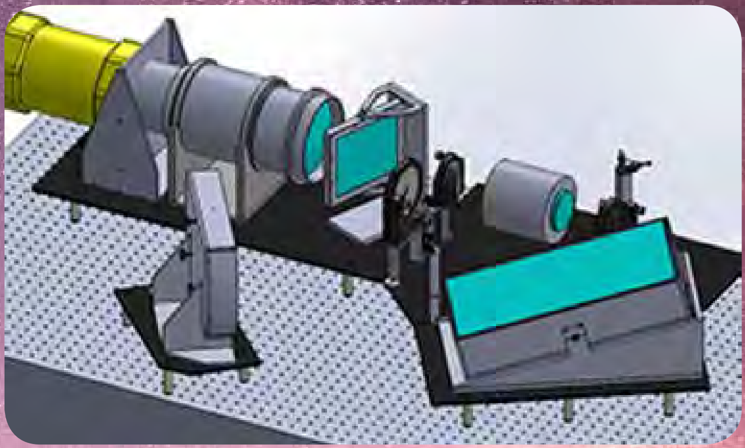
Igniting a New Era of Planet Discovery with FHiRE: A Precision Spectrograph at the WIRO Telescope

University of Wyoming

Extrasolar Planet Studies using FHiRE (Fiber High Resolution Echelle spectrograph) University of Wyoming physics and astronomy researchers are engaged in the search for extrasolar planets. Michael Pierce, a UW associate professor of physics and astronomy has designed and is building a spectrograph (FHiRE), an instrument used to obtain detailed information about star movement near planets, in collaboration with Indiana University. University of Wyoming colleague Hannah Jang-Condell will use the spectrograph to detect extrasolar planets. A spectrograph separates light into a frequency spectrum and records the signal with the use of a camera. The instrument provides a detailed chemical composition of the stars and measures the precise velocities, or speeds, at which the stars are moving. One of the methods of detecting exoplanets is to measure the Doppler effect as the star moves in response to a planet. The Doppler effect is the change in frequency or wavelength of a wave for an observer who is moving relative to the wave source or "the tiny wiggle in a star's speed created by a planet going around a star (Pierce)." The FHiRE spectrograph eventually will play a key role in NASA's Transiting Exoplanet Survey Satellite (TESS), which is expected to discover thousands of exoplanets in orbit around the brightest stars in the sky. In a two-year survey, TESS will monitor more than 200,000 stars for temporary drops in brightness caused by planetary transits. While the TESS satellite will be able to detect planets around stars from space, the operation needs solid, ground-based research to determine if what TESS is detecting really are planets, and that's where the FHiRE spectrograph comes in. At approximately 1,000 pounds and measuring 3x6", the spectrograph will be sealed in a vacuum to eliminate fluctuations in pressure and temperature. As Pierce explains, "Otherwise, the instrument would expand and contract with temperature change. It would destroy its ability to measure movement of the stars. This is an exceedingly precise instrument. We'll isolate it from the environment. We'll operate it remotely from downtown." The instrument will be housed in a facility that will be built to connect with the existing observatory. "This instrument is very challenging to make, which makes it exciting," Pierce says. "It allows our department to go in a different direction like the TESS project." It will help us characterize the properties of stars and help us better understand the planets.

Dr. Chip Kobulnicky showing University of Wyoming undergraduate students the University of Wyoming's 2.3 meter telescope, the facility that will be home to the FHiRE high precision radial velocity spectrograph

Science PI
Hannah Jang-Condell, PhD
University of Wyoming



Shown is a 3-D computer-aided design, by Michael Pierce, a UW associate professor of physics and astronomy. The spectrograph provides a detailed chemical composition of the stars and measures the precise velocities, or speeds, at which the stars are moving. Hannah Jang-Condell, UW associate professor of physics and astronomy, will use FHiRE to detect extrasolar planets.

NASA Technical Monitor
Elisa V. Quintana, PhD
Glenn Research Center

National Aeronautics and Space Administration

www.nasa.gov

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