National Aeronautics and
Space Administration

INSPIRE - ENGAGE - EDUCATE - EMPLOY

EPSCoR and MIRO:
Enabling NASA's Research Mission

Stimuli 2019-2020

Established Program to Stimulate Competitive Research
MUREP Institutional Research Opportunity

Mike Kincaid
Associate Administrator
Office of STEM Engagement

NASA's investment in research, technology and innovation has been the forerunner of our nation's workforce pipeline and STEM engagement. NASA's human **lunar exploration plans** under the Artemis program call for sending the first woman and next man to the surface of the Moon by 2024 and establishing sustainable exploration by the end of the decade. The agency will use what we learn on the Moon to prepare for humanity's next giant leap – sending astronauts to Mars. As this effort progresses, research and innovation will play an integral role in tackling issues associated with exploration beyond low-Earth orbit.

Research conducted by both EPSCoR and MIRO are in support of our nation's overarching goals. NASA and the Office of STEM Engagement (OSTEM) have made tremendous strides in streaming OSTEM research projects to better serve our communities and provide the best return for our constituents, the American taxpayers. OSTEM has established an "enterprise approach" to its projects and has implemented a mix of NASA experts and OSTEM funded researchers to function/collaborate across the agency. Through our enterprise approach, both a workforce pipeline and STEM engagement capability is achieved that leads to collaborations among OSTEM projects aimed to benefit K-12, public outreach, student challenges, and MSI and HBCU targeted projects.

Both EPSCoR and MIRO programs offer a wide variety of opportunities for researchers to join the NASA team to conduct research and engage students. The primary goals of these research are to support the NASA Mission Directorates. The NASA EPSCoR program awards Congressionally mandated research and development Cooperative Agreements to eligible colleges and universities, while MIRO also brings diversity by awarding research grants to Minority Serving Institutions. The impact of these two projects is long term and far reaching. By helping establish the state-of-the-art infrastructure needed to conduct the cutting-edge research it funds, EPSCoR and MIRO are contributing to the self-sustenance of U.S. competitive R&D capabilities while also stimulating partnerships between government, higher education and industry. The EPSCoR research and MUREP MIRO research testimonies success published in this Stimuli document.

We hope you will enjoy, and be inspired by, this year's combined EPSCoR and MIRO Stimuli.

Mike Kincaid
Associate Administrator
Office of STEM Engagement

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Office of STEM Engagement (OSTEM) Logo on the Cover

From upper left clockwise:

Science Mission Directorate (SMD) represented by the James Webb Space Telescope;

Space Technology Mission Directorate (SMD) represented by a Mars rover;

Aeronautics Research Mission Directorate (ARMD) represented by the X-59 QueSST;

Human Exploration and Operations Mission Directorate (HEOMD) represented by an astronaut.

A graphic is placed on the outer, upper corner of research project pages (Research, R3, ISS and MIRO) to indicate the project's Mission Directorate (MD) alignment. It will contain the color of the MD quadrant(s).

Research Infrastructure Development

Jeppie Compton
National Project Manager
NASA EPSCoR

NASA EPSCoR Research Infrastructure Development (RID) awards provide funds to the eligible jurisdictions enabling them to build and strengthen relationships with NASA researchers, industries and other government research institutions. Jurisdiction research infrastructure development needs vary greatly from supporting junior faculties to enhance their research skills to writing proposals. RID funds contribute to the jurisdiction's development of researchers; helping them to develop research proposals in preparation to compete for NASA and Non-NASA research awards, funds sub-research awards, conference and symposiums participation, and researcher travel to NASA Centers and other jurisdictions' priorities and requirements. The RID awards have three-year base period of performance with a potential of one-year no cost extension. Awards are granted in the amount of $150,000 to $175,000 per year. NASA intends to increase the funding for RID awards to $200,000 per year and extend the period of performance from three to five years, pending funding availability and approval.

EPSCoR RID Table of Contents

Alabama RID

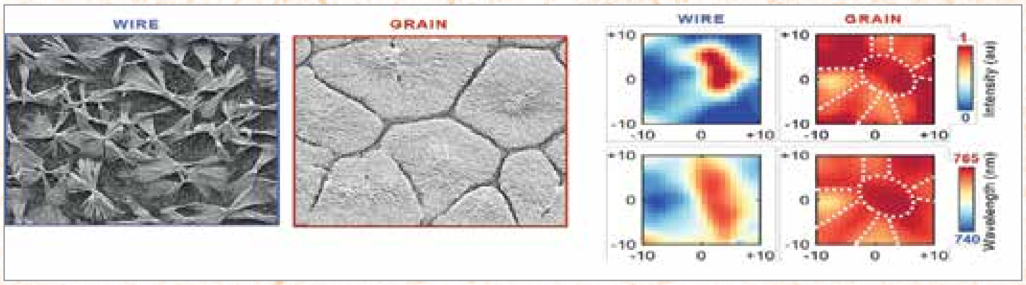
The University of Alabama in Huntsville

Dale Thomas, PhD
Alabama NASA EPSCoR Director
The University of Alabama in Huntsville

The five selected participants in the Alabama RID seed grant program are young Alabama faculty progressing toward their career goals to have their work published, to write successful proposals, to win patents, to engage in collaborative work with researchers at NASA Centers and other universities and to involve a diverse group of students in their work. Here are some highlights from current recipients.

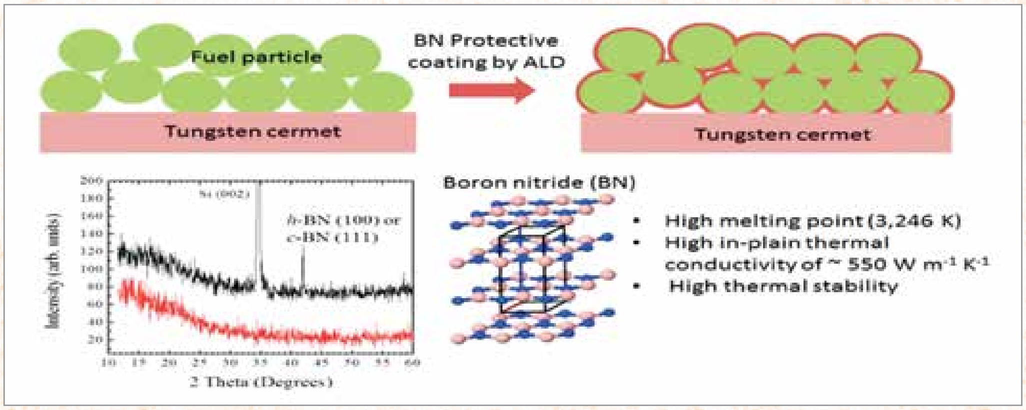
Dr. Kannatassen Appavoo, The University of Alabama in Birmingham

Funding from this Research Infrastructure Development grant allowed our group to dedicate time to enhance both our fabrication and optical microscopy capabilities. We are now able to fabricate a novel high-performance light-absorbing/light-emitting nanomaterial using a low-cost solution-processed method and we are able to characterize our nanomaterial with sub-micron resolution. As shown below, correlating morphology and optical performance with such lateral resolution provides us with the necessary information to understand structure-property relationship and better evaluate the effect of external conditions such as humidity and radiation on our materials. Importantly, we will soon be able to study devices fabricated from of our hybrid perovskite nanomaterial in situ, that is probing dynamics of carriers in real time.



Dr. Yu Lei, The University of Alabama in Huntsville

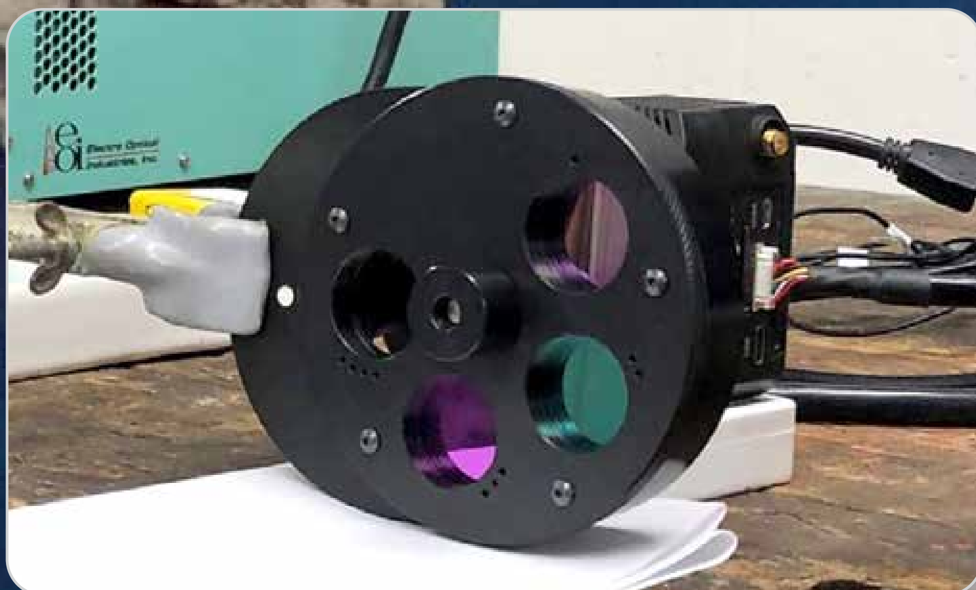
We have developed new atomic layer deposition (ALD) chemistry to deposit 2-dimensional boron nitride (BN) thin film, which has a melting point of 2,973 °C (5,383 °F) and an in-plain thermal conductivity of ~ 550 W m-1 K-1, making it a promising material for coating materials for the nuclear thermal propulsion (NTP) system.



Alaska RID

University of Alaska Fairbanks

Denise Thorsen, PhD
Alaska NASA EPSCoR Director
University of Alaska Fairbanks



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. 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.

Arkansas RID

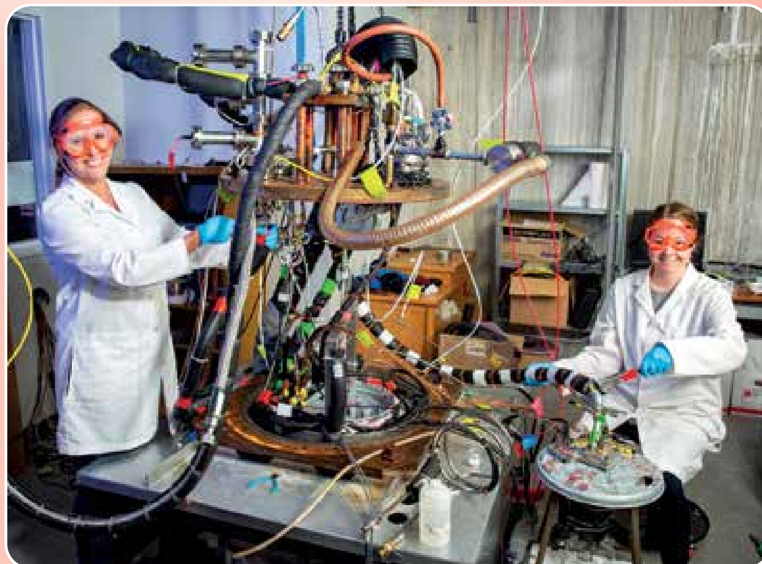
University of Arkansas at Little Rock

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

Stability and Distribution of Methane Clathrates on the Surface of Mars

By Vincent Chevrier

The presence of methane, the simplest hydrocarbon molecule, in the Martian atmosphere was detected in 2004. However, the processes by which methane is released into the atmosphere and the nature and location of potential reservoirs have not yet been clearly identified. One of the most likely hypotheses is the presence of methane clathrates, i.e. gas molecules (methane) trapped in 'cages' formed by a lattice of water ice molecules. One then understands all the interest of these structures as potential resources of both water and energy for future manned missions. Thus, methane clathrate stability conditions should be an additional criterion for the selection of future landing sites for crewed spacecrafts. We work therefore on mapping the clathrates' stability on the surface and subsurface of Mars. We use a thermodynamic modeling code named CSMHyd that allows us to calculate the clathrate's equilibrium conditions, and particularly their equilibrium pressure when the conditions of temperature and methane concentration are of the order of those prevailing on Mars. By extrapolating these data and crossing them with our data of pressure vs Martian soil depth, we can predict the most likely locations for the exploitation of clathrates and thus the best landing site for a future Martian crew.



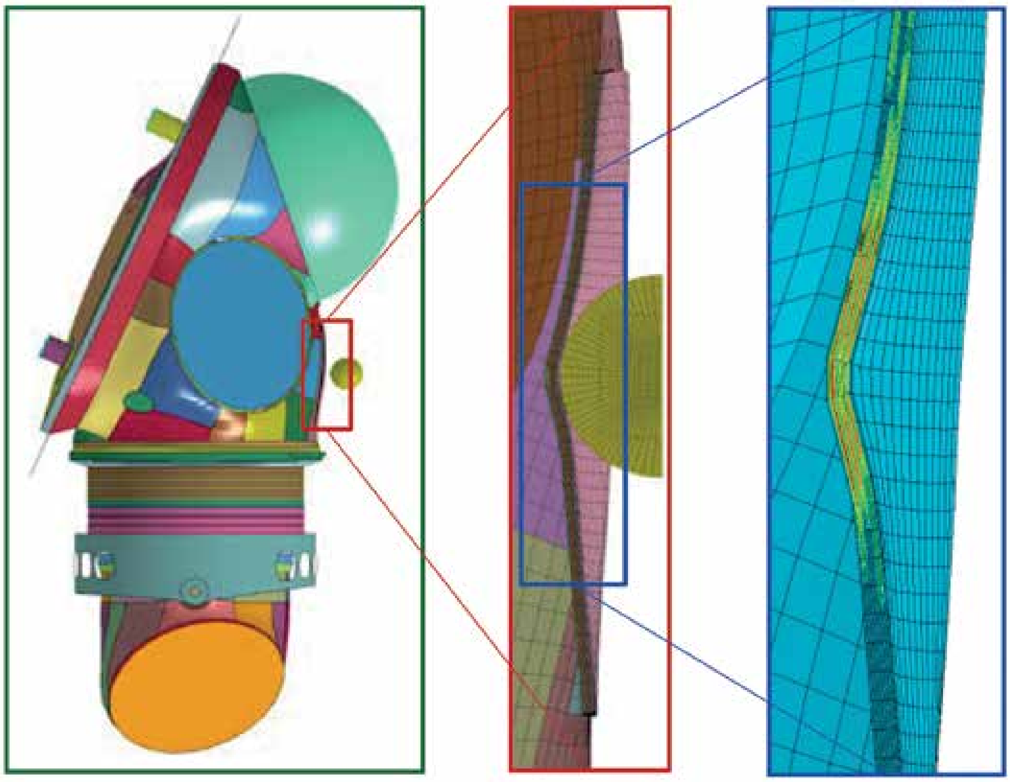
Students (left: Kendra Farnsworth and right: Ellen Czaplinski) working on the Titan environmental chamber, used to simulate cryogenic environments and study the stability and dynamics of materials under Titan's surface conditions.

View of the Andromeda simulation chamber, used to test materials under Titan surface conditions (left: Kendra Farnsworth and Vincent Chevrier, right: Ellen Czaplinski). The W.M. Keck Laboratory for Space and Planetary Simulations at the University of Arkansas hosts several simulation chambers used to study planetary environments.

Delaware RID

University of Delaware

William H. Matthaeus, PhD
Delaware NASA EPSCoR Director
University of Delaware



Impact Damage Modeling of Hybrid Composites for Space Applications

Bazle Z. Haque, Assistant Professor, Mechanical Engineering, University of Delaware

Impact Design of Composites for Space Applications:

A reverse impact modeling methodology is developed to design composite space suit with internal pressure. A global-local analysis method using local 3D solid elements and MAT162 composite damage model for the impact zone, and global shell elements have been used. The local 3D analysis can capture the transverse impact damage modes which plays a key role in satisfying the impact design criteria, however, static design with internal pressure is automatically satisfied. The concept of a skin-core sandwich composite with two different materials and through-thickness orientation is the key to mitigate the impact damage tolerance and to satisfy the no-leakage criterion. Progressive composite damage modeling capabilities of MAT162 material model in LS-DYNA enabled the impact design of space suit composite structure.

ccm.udel.edu/software/mat162/examples/example-4/

Guam RID

University of Guam

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

Seed Grants Engage New Faculty, New Departments in NASA EPSCoR

In 2019-2020, NASA Guam EPSCoR focused on expanding the research capacity for Guam jurisdiction by awarding seed grants to four faculty who were all new to NASA EPSCoR research. Three were new to the University of Guam, and two came from departments that had not previously participated directly in NASA EPSCoR activities.

- Dr. Jose Edgardo Aban: Multitemporal Change Analysis of Southern Guam's Talofofo and Ugum Watersheds Using Multi-Source Satellite Data in Support to Coastal Resource Management
- Dr. Xiangxiong Kong: Camera-based Structural Inspection of a Historic Structure in Guam
- Dr. Fenglien Lee: Designing the NASA Guam EPSCoR GEOCORE Spatial Relational Database
- Dr. Myeong-Ho Yeo: 3-D Simulation of freshwater plumes generated by groundwater discharges around the Northern Guam Lens Aquifer

The first project will utilize imagery data for assessment of watershed soil erosion for Talofofo River and Ugum River areas on Guam. The second project directly supports a larger research project, GEOCORE, by using computer science undergraduates and recent graduates to develop a geospatial relational database prototype for the GEOCORE datasets; this also provides workforce development in geospatial data and database design using ArcGIS and SQL. The third project aims to develop visual inspection methods for structural deterioration and apply them to detection of structural deterioration in historic structures on Guam. The fourth project seeks to develop a 3D regional ocean modeling system for the Tumon Bay area of Guam that would provide a 3D view of freshwater discharge plumes into Tumon Bay, and use UAS to provide validation for the model. These projects expand the research capacity in these areas, and support and inform other organizations on Guam, such as the Guam Preservation Trust and Coastal Resource Management.

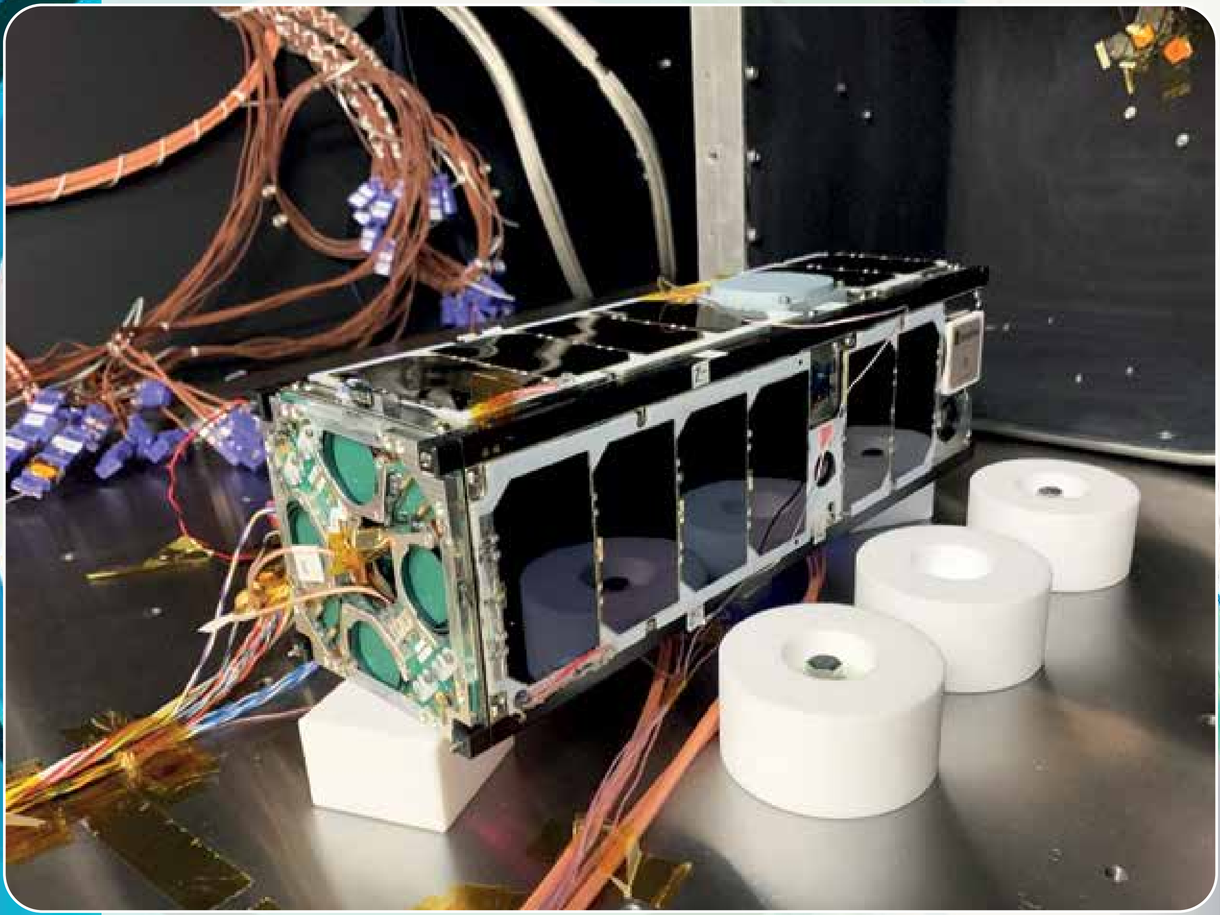
University of Guam students Manwai Nguyen, Argee Nabas, and Mary Gold Raz discuss different elements and data layers of the GEOCORE geospatial database with their project mentor Dr. Fenglien Lee.

Hawai'i RID

University of Hawai'i at Manoa

Luke Flynn, PhD
Hawai'i NASA EPSCoR Director
University of Hawai'i, Honolulu

NASA EPSCoR RID funds were used by HSFL to construct Neutron-1, a 3-U CubeSat that will test one of the neutron detectors that will be used for the NASA ASU Luna-H Map Mission. Neutron-1 will be delivered in late July, 2020 to Nanoracks in Houston in preparation for release into Low-Earth Orbit from the International Space Station. We will use NASA EPSCoR RID funds for operations support to fly Neutron-1. Neutron-1 in orbit is super important for our jurisdiction as it will give the Kauai Community College ground stations an orbital satellite to communicate with; it will exercise the COSMOS mission operations system and the HSFL Mission Ops, and it will allow us to test the CubeADCS on orbit which is also the ADCS unit for the NASA HyTI satellite.



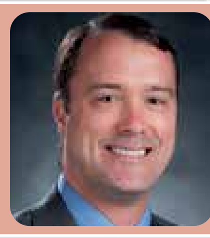
Neutron-1 is a 3-U CubeSat built by the Hawai'i Space Flight Laboratory (HSFL) that features an Arizona State University neutron detector that will be part of the Luna-H Map Mission to the Moon. Here, Neutron-1 is in HSFL's Thermal Vacuum Chamber.

RID

Idaho RID

University of Idaho

ID



Matthew Bernards, PhD
Idaho NASA EPSCoR Director
University of Idaho

Omid Mohammad Mousa was an undergraduate student researcher on Dr. Pu's Research Initiation Grant. In this picture (left), Mr. Mousa was preparing mesenchymal stem cells (MSCs) from mice for culturing. First, he seeded the cells into a flask. Then, the cells were cultured under the simulated microgravity to test its effects.

Idaho NASA EPSCoR awarded biomolecular researcher Dr. Xinzhu (Shin) Pu at Boise State University a Research Initiation Grant to explore the mechanisms involved with bone loss in astronauts during space flight. While in space, astronauts experience microgravity and weightlessness that contribute to the loss of bone mass. This could limit long-duration space missions in the future. Dr. Pu and his student researchers study autophagy, the process where cells degrade bone and their by-products get recycled. Dr. Pu and his team examined how microgravity affects autophagy, and whether manipulating the level of autophagy can encourage stem cells to become osteoblasts (which generate bone). Dr. Pu's research could result in countermeasures to help astronauts venture farther into space.

Liquid chromatography-mass spectrometry (LC-MS)-based proteomics was used in this project to quantify the global changes of protein expression levels in MSCs under simulated microgravity. Proteins were extracted from cells and processed for LC-MS analysis. In the photo, Dr. Xinzhu Pu was loading the samples on the LC-MS instruments for analysis.

Iowa RID

Iowa State University

Tomas Gonzalez-Torres
Iowa NASA EPSCoR Director
Iowa State University

The Iowa NASA EPSCoR Economic Development (INEED) RID strives to build research capacity at the nexus between NASA, researchers, and the Iowa economic development community. In the Advanced Manufacturing sector of Iowa's economy, INEED is emphasizing increased aerospace and defense product manufacturing capacities and jobs. Bioscience Development represents a fast-moving and expanding area of scientific and commercial activity. It is imperative to have an up-to-date understanding of its bioscience assets, core competencies and opportunities for ongoing development. Research to improve food production will bring the green landscape of Iowa to the surface of the moon, while research to improve energy storage will take the winds of the prairie to the depths of space.

Through the RID, the Iowa NASA EPSCoR program provides Research Building and Partnership Development Grants to researchers with capabilities in areas of interest not only to Iowa, but to the NASA Mission Directorates. Travel funds allow researchers to meet with NASA scientists involved in synergistic work. Annual research symposia allow for intra-state scholars to further increase Iowa's ability to collaborate and respond to the needs of NASA, better preparing them to compete for larger awards through both NASA EPSCoR and non-EPSCoR funding opportunities.

The Iowa Jurisdiction has renewable energy and biosciences as priorities that include wind energy and agriculture. (Photo credit Adam Sisson, Iowa State University Extension and Outreach)

Kansas RID

Wichita State University

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

The Kansas NASA EPSCoR Research Infrastructure Development (RID) Program supported twelve separate projects in the last four years. These projects covered a wide range of topics relevant to NASA goals, including the development of sensors to monitor astronaut health during spaceflight, water storage and management strategies to cope with water scarcity issues, development of a fabrication method for a more powerful next-generation battery, and investigating new material intended for noise reduction applications. The research resulted in numerous publications in international conference proceedings and journals and led to additional support from other follow-on grants from sources other than NASA EPSCoR.

Many collaborations were established with NASA and industry during the course of the RID program. This includes collaborations with twenty-one NASA researchers and eight people in industry. These collaborations were strengthened by RID grant support for trips to NASA centers and industry. One such trip was made by a Wichita State University (WSU) researcher and his team to Johnson Space Center, where the picture below was taken.

The Wichita State University research team at the NASA Johnson Space Center. Left to Right, Jerad Rogers (WSU Undergraduate Student), Jessica Aldrich (WSU Undergraduate Student), Dr. Patterson (Co-Investigator), Dr. Cluff (PI), Dr. Mahapatro (Co-Investigator), and Ryan Becker (WSU Undergraduate Student).

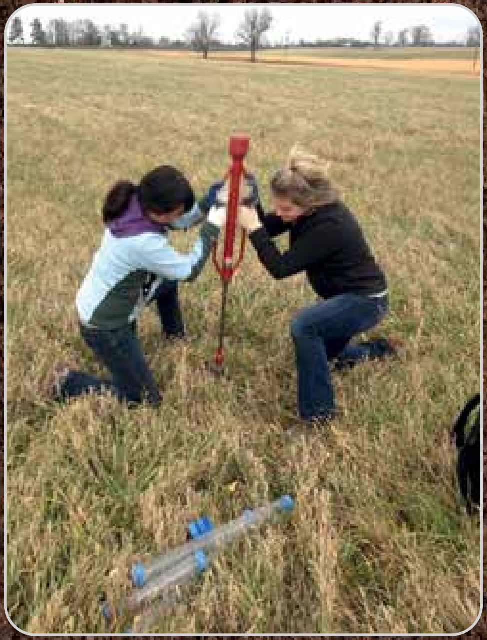
http://cusl.res.ku.edu/Research

Kentucky RID

University of Kentucky

Suzanne Weaver Smith, PhD
Kentucky NASA EPSCoR Co-Director
University of Kentucky

Alexandre Martin, PhD
Kentucky NASA EPSCoR Co-Director
University of Kentucky



The NASA Kentucky EPSCoR program supported researchers from Murray State University to conduct soil sampling at sites in western Kentucky and correlate NASA satellite observations with ground-based data to improve satellite data analysis.

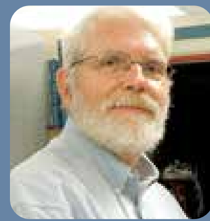
The NASA Kentucky EPSCoR Research Infrastructure Development (RID) program supports research development at Kentucky's higher education institutions with a focus on faculty in early stages of their careers. NASA KY EPSCoR RID offers complementary opportunities that fund research grants, workshops and 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, 34 RID grants along with 45 Research Faculty Travel awards to pursue collaboration with NASA researchers have focused on initiating NASA relationships and maturing collaborative research potential. In the most recent grant cycle, 15 research projects led by 22 Kentucky researchers partnered with collaborators at 5 NASA Centers and 3 industries to pursue developments in spacecraft entry/descent/landing, materials processing/additive manufacturing, energy storage, geosciences, remote sensing, adaptive sensing, astrophysics and wireless communications.

Altogether, NASA KY programs are designed to address economic and research development needs of Kentucky and the interests of NASA through strategically targeted expanded research capabilities.

Louisiana RID

Louisiana State University



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

Figure 1: The External Ammonia Coolant Loops portion of the External Active Thermal Control Subsystem (EATCS) on the ISS are circled above. Photo Credit: NASA

Evaluation of Zirconia based Sensors for NH3 Sensing

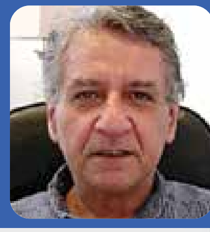
Erica P. Murray, Research Assistant Professor, Louisiana Tech University, Institute for Micromanufacturing, Ruston, LA

Exposure to anhydrous ammonia (NH3) within the cabin of the International Space Station (ISS) is considered as one of three major emergency concerns for the station. Monitoring the air quality on the ISS is not only important for the health and safety of astronauts, but also for maintaining the integrity of tools and instrumentation. The U.S. on-orbit segment of the ISS has an External Active Thermal Control Subsystem (EATCS) that circulates anhydrous ammonia through a closed loop cooling system to maintain proper temperature conditions for avionics, payloads, and electronic instruments. The EATCS, shown in Figure 1, contains the largest supply of ammonia on the ISS. The thermodynamic efficiency and light weight of ammonia makes it an attractive refrigerant. However, potential failure modes resulting in a breach in the EATCS have been identified and underscore the need for sensing capabilities that will deliver early and accurate detection of an ammonia leak. Solidstate electrochemical sensors can provide immediate feedback on toxic gases over a wide concentration range in a portable system, while offering substantial sensitivity, selectivity, and durability. Zirconia based electrochemical sensors have demonstrated high accuracy with rapid response rates for detecting low concentrations (< 5 ppm) of gases. The goal of the proposed work is to characterize the electrochemical response of zirconia-based sensors using impedance spectroscopy in order to evaluate the sensitivity, selectivity, purge response, and re-exposure behavior to NH3 for various operating conditions.

https://lanasaepscor.lsu.edu/

Maine RID

Maine Space Grant Consortium



Terry Shehata, PhD
Maine NASA EPSCoR Director
Maine Space Grant Consortium

Through our laboratory experiments, we have already improved our understanding of how lunar soil sinters under concentrated sunlight, and the temperature range between sintering and melting. We now have better targets for how to heat the material in a device that could turn lunar soil into solid construction blocks while extracting oxygen for rocket fuel. We will be using this knowledge in the second half of the project to brainstorm a prototype device which could perform the sintering/oxygen extraction process on the moon. We are sharing our knowledge with collaborators at NASA, who will use it in their own, alternative ideas, for processing lunar soil into useful products.

We have involved three undergraduate students and one graduate student. The undergraduates, in particular, view working at or with NASA as a dream goal for their careers, and this project is introducing them to a topic which they never imagined as a way to become involved with NASA.

In our laboratory at the University of Maine, we have built a test stand where we can sinter samples of simulated lunar soil using concentrated light that mimics concentrated sunlight.

This magnified photograph shows simulated lunar soil which has been sintered at a temperature of 1200°C.

Mississippi RID

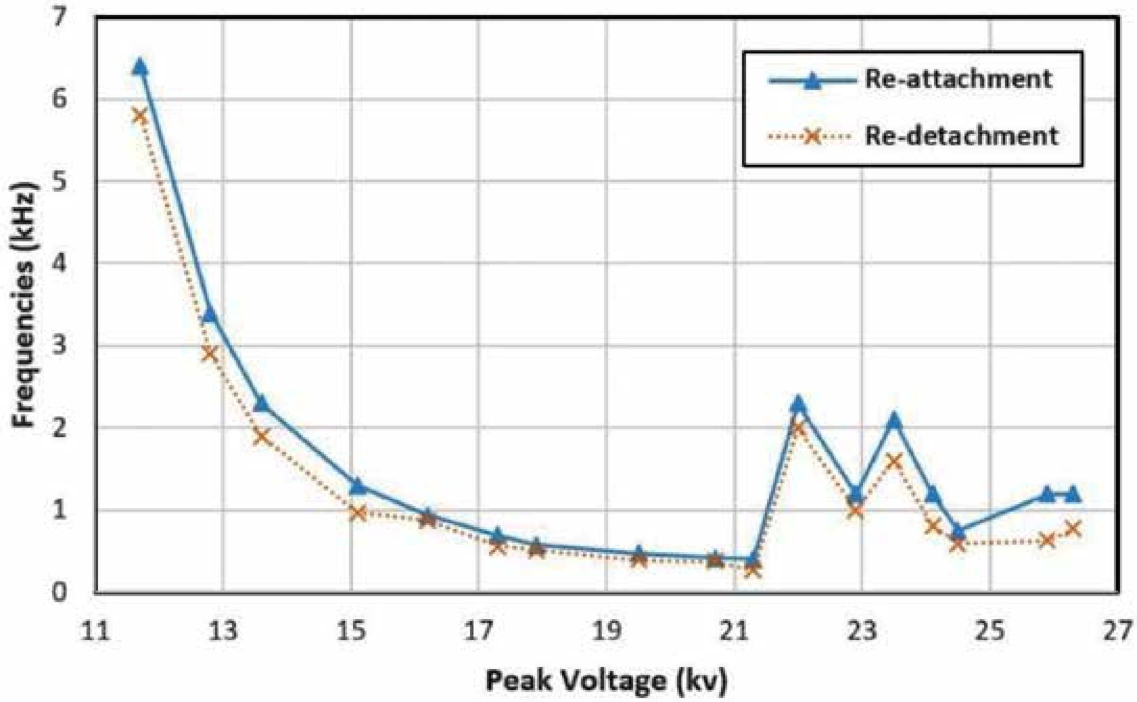
University of Mississippi

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

Understanding the Effect of Nanosecond Pulsed Discharge on Ignition and Flame Stability for Methane Engines

Dr. Omid Askari, Mississippi State University, Mechanical Engineering Department

A significant result of the project thus far has been that applying the nanosecond pulses with an adequate frequency reduces the lift-off height. If the frequency is increased further the lift-off height keep decreasing to the extent that at a certain critical frequency the flame is reattached. Increasing frequencies beyond this point didn't make a noticeable difference. An interesting phenomenon was seen at this point. If we decrease the frequency from the point that the flame is attached, the flame remains attached even in frequencies lower than the reattachment critical frequency. It is suggested to be a result of hysteresis effects.



Critical discharge frequencies at different discharge voltage for QCH4 = 14 SLM and Qair = 3 SLM

http://pcrl.msstate.edu/research/plasma-assisted-ignition-combustion/

Missouri RID

Missouri University of Science and Technology

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

"van der Waals Interaction Studies of an Important Earth and Interstellar Molecule, O_2"

Garry Grubbs, Missouri University of Science and Technology

A weakly bound complex or van der Waals (vdW) complex is made when 2 or more molecules do not necessarily undergo a chemical change upon interaction with one another, but are still held together by intermolecular forces after the interaction takes place. Understanding what happens when one of the participants is O2 is of great importance for both fundamental and atmospheric reasons. This is traditionally monitored using molecular spectroscopy and our tool of choice is microwave (rotational) spectroscopy.

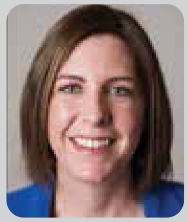
From an atmospheric standpoint, O2 is a very abundant molecule making up approximately 21% of all the molecules present. This means that although complexes with it would only account for parts per million levels in the atmosphere, this would still be more than many of the abundances of many greenhouse gases while also providing more ways by which to trap heat. Understanding the rotational spectroscopy will give insight into the structure of these molecules aiding with the understanding of the greenhouse effect contributions of these systems. From a fundamental standpoint, O2 is paramagnetic, meaning its ground electronic state has unpaired electrons. This causes it to have an electronic spin contribution. For O2 this contribution is significantly large and understanding vdW systems involving O2 from a basic Hamiltonian construction point-of-view has been problematic.

Because of the broader influence of this work and NASA JPL having the right people to help with this problem, a strengthening of the partnership between the Grubbs microwave spectroscopy team and JPL's Brian Drouin was sought. Grubbs would handle most of the groundwork like measuring, recording, and fitting spectra, while Drouin would give insight into choice of Hamiltonian parameter and why using the molecular spectroscopy gold standard of spectral assignment, Pickett's SPFIT/SPCAT software, which is distributed and maintained now by Drouin and his team. Both our science and relationship have grown as a result of this funding.

https://missouriepscor.org/nasa-epscor

Montana RID

Montana State University

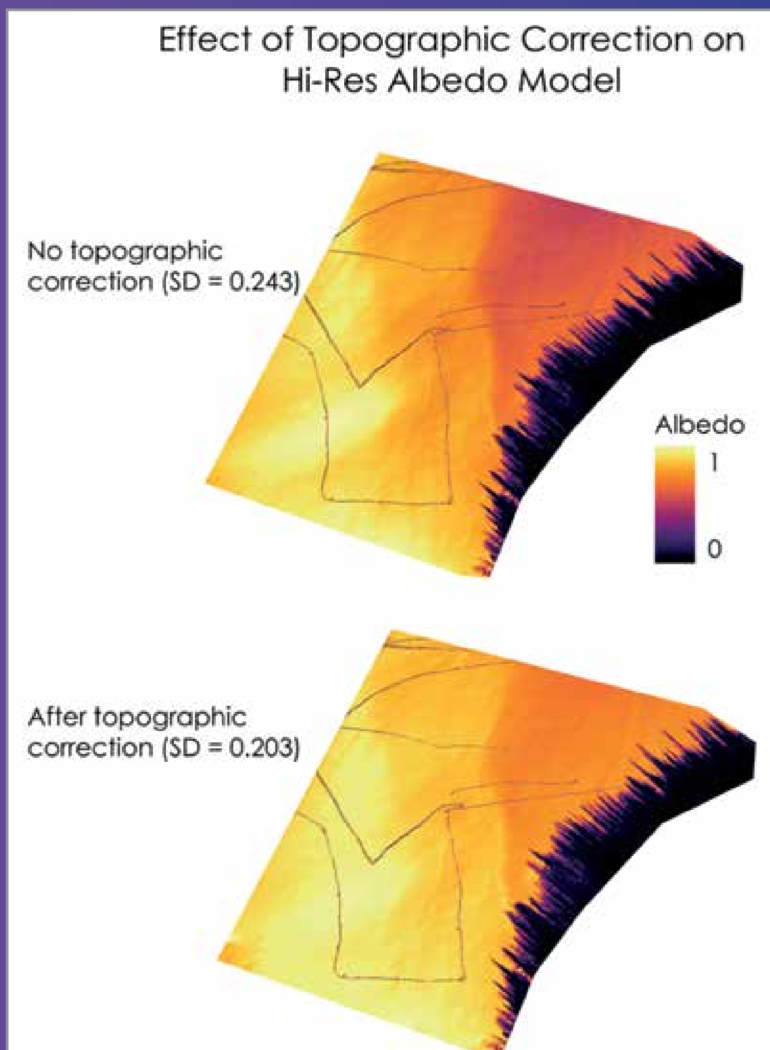


Angela C. Des Jardins, PhD
Montana NASA EPSCoR Director
Montana State University

Optimizing UAV broadband albedo survey design and quantifying uncertainties at different measurement scales

Dr. Eric Sproles

The seasonal accumulation and melt of snow represent a dramatic transformation of Earth's albedo, directly affecting water and energy cycles. Spatiotemporal estimates of albedo rely on measurements from NASA satellites, which require field data to calibrate the sensors' raw Earth Observations (EO). However, scaling issues exist between fixed-location field and satellite data. Unmanned Aerial Vehicles (UAVs) provide opportunities to bridge the scaling challenges associated with fixed-position field data. We test a framework and methodology to directly address albedo scaling issues in snowy landscapes using an integrated albedo sensor framework (ASF) deployed on a UAV. Our methods and results will be used to create high resolution data and maps of broadband albedo and topography throughout the winter to optimize survey design, data collection, and processing of albedo data from a UAV. Specifically, 1) quantifying scale-dependent factors, optimal flight altitudes, and optimal measurement scales for the UAV flights across snowy mountain headwaters and boreal forests, 2) disseminating methods and results through a no cost hands-on workshop, 3) developing a schema for archiving UAV data into NASA's databases.



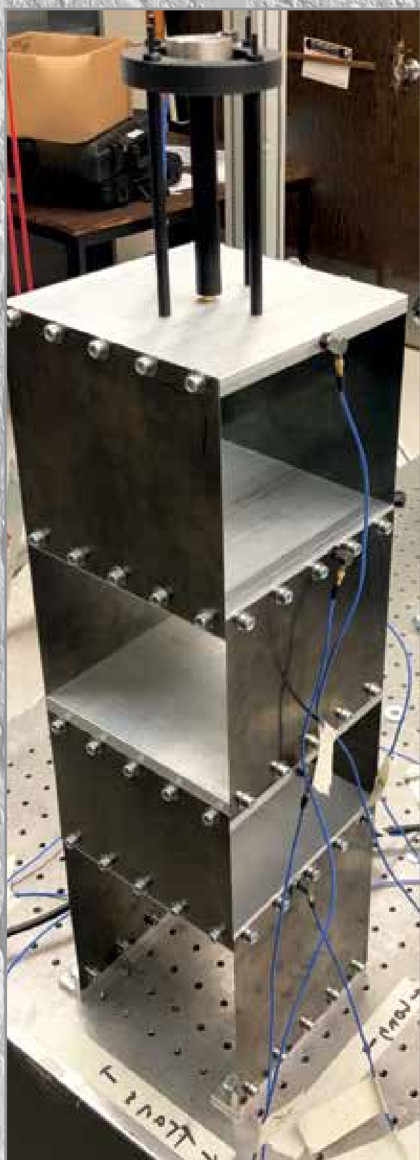
High-resolution measurements from our albedo sensor framework UAV allow for detailed measurements of topography and broadband albedo. These combined datasets allow for topographic correction of albedo from a single flight. For context, the area of the map is 150m x 210m, roughly 35 Landsat cells.

https://nasaepscor.montana.edu/

Nebraska RID

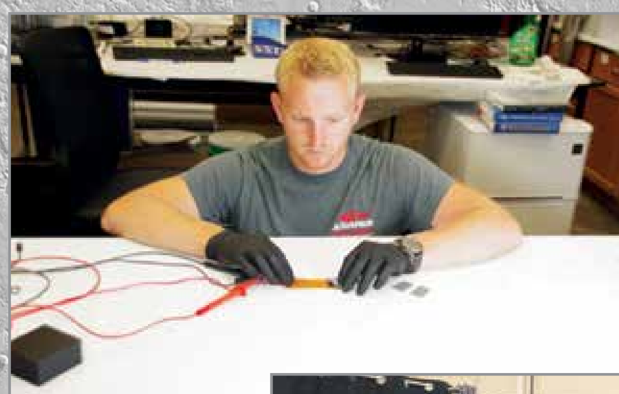
University of Nebraska at Omaha

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



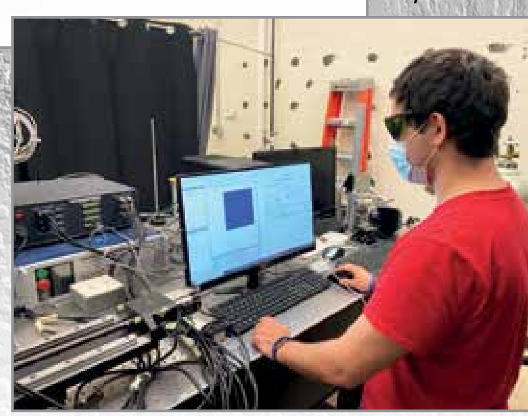
This mechanical tower mimics the motion of a high-aspect-ratio airplane wing at the Moore Dynamics and Analytics Laboratory at the University of Nebraska-Lincoln, led by Dr. Keegan Moore, a NASA Nebraska EPSCoR Research Mini-Grant recipient.

A NASA Nebraska EPSCoR Mini-Grant Research project regarding laser ablation patterning is being conducted by Dr. Bai Cui at the University of Nebraska-Lincoln, in collaboration with NASA scientist Dr. Valerie Wiesner at NASA Langley Research Center. Since the Apollo missions, the adhesion of dust from the lunar regolith to the surface of space suits, lunar rovers, and instrumentation have been reported as a major problem on the moon environment. The barbed shaped structure of lunar dusts allows them to fasten to the exposed surface, and the abrasive nature of the dust causes mechanical wear and damage on the sensitive robotics and other equipment. The novelty of this project is to develop a new laser ablation patterning technique that decreases surface energy of advanced ceramic materials, such as boron carbide and alumina, thereby reducing the potential of lunar dust adhesion. Expected outcomes include fundamental mechanisms of laser ablation patterning, and specific laser parameters for various ceramic materials to reach high lunar dust adhesion resistance. The successful development of a laser ablation patterning technique will support NASA's moon programs, such as Artemis, for the exploration of moon and building of future research stations on the moon.



Below: Graduate student Samuel Ruiz is operating a laser during the laser ablation patterning experiment.

Above: Graduate student Ethan Krings is shown measuring anisotropic thermal conductivity in the Smart Materials & Robotics Lab that is directed by Dr. Eric Markvicka, a recipient of a NASA Nebraska EPSCoR Research Mini-Grant.



http://cse.unl.edu/~netgroup/

Nevada RID

Nevada System of Higher Education

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

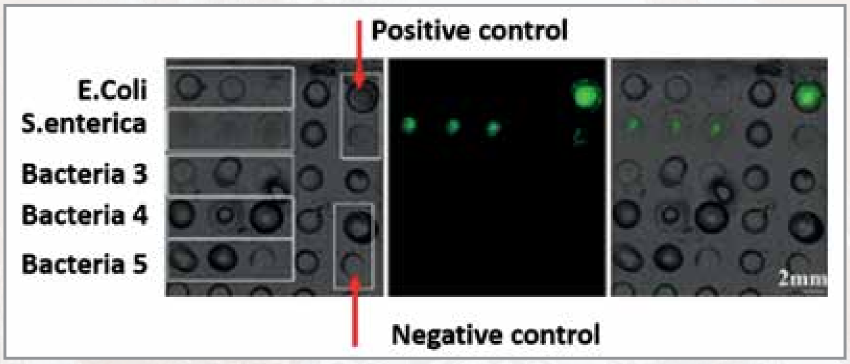
Nevada faculty made progress in enhancing research infrastructure and student training as well as developing close collaborations with scientists from five NASA Centers this past year. Major activities and significant results were achieved through three solicitations designed to meet the Nevada NASA EPSCoR RID objectives to enhance research infrastructure.

<u>Objective 1) Enhance research infrastructure by competitively awarding seed grants.</u> Two significant new seed grants were sub-awarded. The seed grants report significant research progress and results have been achieved. Research infrastructure has been enhanced in several topic areas as well as hands on training for both undergraduate and graduate students who are participating in the research efforts.

1. Dr. Monica Arienzo (DRI) received seed grant funding for a project entitled “Tahoe Rain or Snow? Leveraging Citizen Science Data to Improve Satellite Measurements of Precipitation Phase”. The goal of this work was to advance NASA’s goal of improving life on Earth by better predicting how the global water cycle will respond to a changing climate.
2. Dr. Bahram Parvin (UNR) received seed grant funding for a project entitled “Profiling Microbiome on Spacecraft Surfaces”. The project had two aims of synthesizing nucleic acid probes for identifying three International Space Station (ISS) specific bacteria and designing an initial microfluidic system to simplify space-based application.

<u>Objective 2) Promote planning workshops to enhance proposal development.</u> No applications were submitted for workshop planning this past year. The annual NV NASA EPSCoR and NV Space Grant Statewide Annual Meeting that was planned for this year was cancelled due to the Coronavirus outbreak. A virtual student poster was the only activity held as a substitute for the statewide meeting.

<u>Objective 3) Build new NASA collaborations by funding travel awards.</u> Five travel sub-awards were made to one faculty member from UNLV and four from UNR; two female and two male faculty. Three traveled to the National NASA EPSCoR Technical Interchange Meeting at the Jet Propulsion Laboratory and two traveled to the 2019 NASA-International Space Station (ISS) U.S. National Laboratory Materials Science for the ISS Workshop July 29 in Atlanta, Georgia.



Dr. Bahram Parvin’s (UNR) Seed Grant results to date: A microwell chip was designed, fabricated and recently patented to demonstrate the simultaneous identification of multiple bacteria with a single fluorophore. S.enterica (a bacterium found on the International Space Station) probe complexes were printed and spatially registered in a specific row of the chip, as seen in the figure. S.enterica were identified by its corresponding probe complexes printed in microwells in the second row of the microchip.

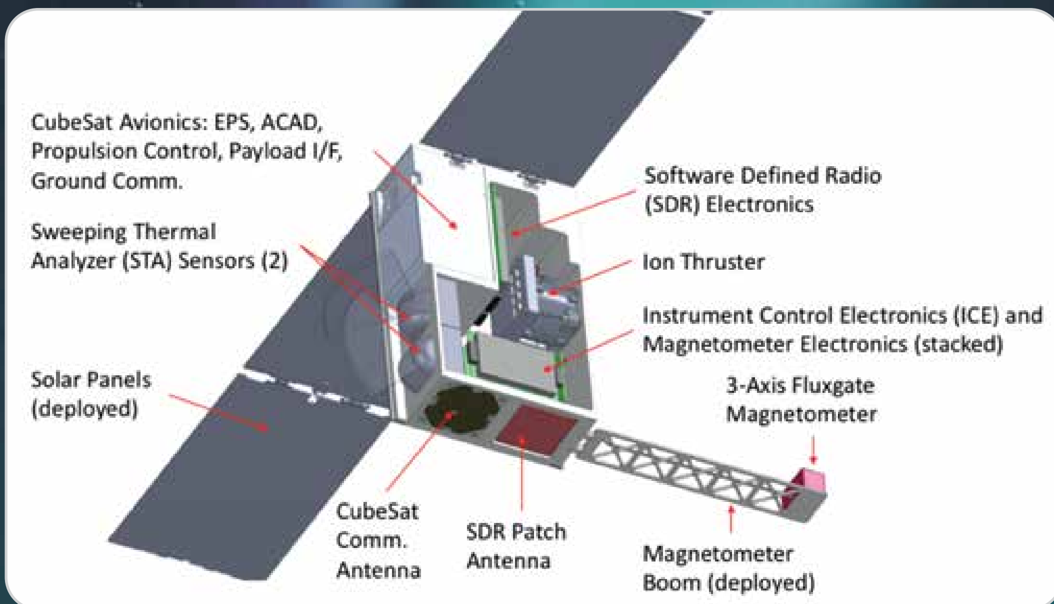
https://nasa.epscorspo.nevada.edu

New Hampshire RID

University of New Hampshire

NH

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



Advanced ion detection instruments are mounted on multiple CubeSats to allow for inexpensive deployment of complex instrumentation in swarms. Spacecraft concept above was rendered by UNH Mechanical Engineer Colin Frost.

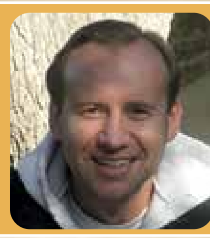
Development of CubeSat Swarm Mission Concept to Study Auroral Characteristics

Nano-satellite CubeSats, built from palm-sized modular units, offer the scientific community massive cost savings and flexibility compared with traditional satellites. When deployed in swarms, those benefits are multiplied, and arrays of multiple CubeSats can be used to answer scientific questions that cannot be answered by larger, more expensive single satellite missions. For example, single-point measurements to date of the plasma environment of the auroral zone have not been able to answer some of the basic questions about how the aurora functions. Researchers at the University of New Hampshire (Lead Prof. Lynn Kistler), in cooperation with Dartmouth College (Lead Prof. Kristina Lynch), are performing a study to determine the feasibility of launching 32 CubeSats to provide multiple, simultaneous plasma measurements over the aurora. This concept mission, called the Auroral Reconstruction CubeSwarm (ARCS), would place an array of identical CubeSats in a polar orbit to study the aurora over the state of Alaska. UNH Mechanical Engineer Colin Frost developed the mechanical layout of the satellite and its miniaturized payload, shown in the above figure. UNH Electrical Engineer Mark Widholm worked with Prof. Kistler on designing the Sweeping Thermal Analyzer (STA) instrument that will measure the velocity of the cold plasma. The design of the STA instrument must meet the science requirements as developed through simulations of the instrument response to the expected range of auroral conditions, that has been modeled by UNH Staff Scientist Dr. Christopher Mouikis. This mission design and payload concept study is a major new collaborative effort between UNH and Dartmouth College, expanding the competitive and cooperative capabilities of both institutions.

https://www.dartmouth.edu/~aurora/

New Mexico RID

New Mexico State University

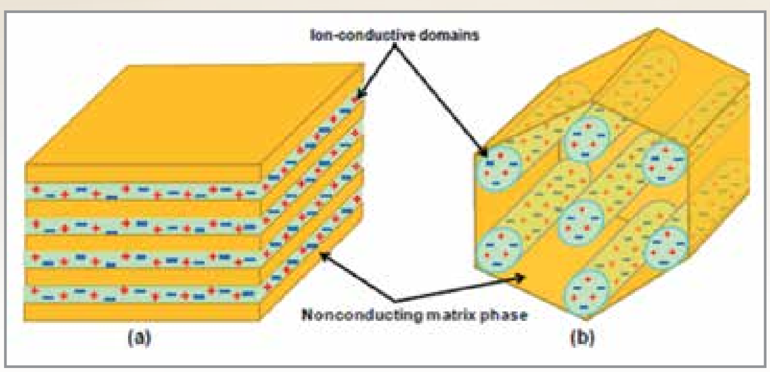


Paulo Oemig, PhD
New Mexico NASA EPSCoR Director
New Mexico State University

Dr. Reza Foudazi in front of lab equipment designed to test the properties of different membrane compositions

Room Temperature Solid Polymer Electrolytes for Oxygen Generation on Mars

Reza Foudazi



Schematic of heterogeneous solid polymer electrolyte (SPE) with different shapes of nanoscale channels: a) lamellar b) hexagonal

The atmosphere of Mars contains 95.3 % carbon dioxide (CO_2) and can be mined to produce propellant and life support consumables, such as oxygen, fuel, and water for long-term human exploration. NASA has developed two technologies, solid oxide electrolysis (SOE) and Sabatier process, to convert Mars CO_2 into oxygen and fuel, respectively. However, disadvantages of the current state of the art for CO_2 reduction are high temperature and power usage. In this project, we prepare a gel polymer electrolyte (GPE) membrane from lyotropic liquid crystal mesophases with high ionic conductivity and mechanical strength for application in direct generation of O_2 and the reduction of CO_2 in electrochemical cells at low temperatures. While this work will advance technology that can improve upon the current state of the art for CO_2 reduction and O_2 generation in a spacecraft, it can also be beneficial to the environment and energy production industry. This project also creates research and mentorship opportunities for undergraduate and graduate students from New Mexico State University (minority-serving institution), particularly students from under-represented minorities in STEM.

https://www.nmepscor.org/

North Dakota RID

University of North Dakota

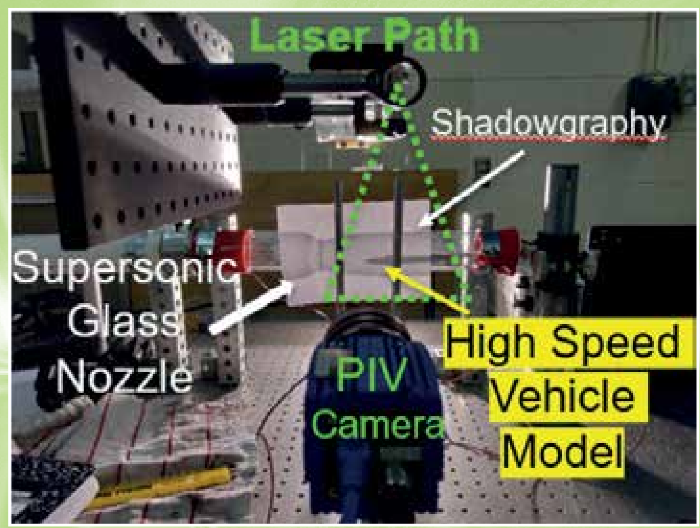
Caitlin Nolby
North Dakota NASA EPSCoR Director
University of North Dakota

Advanced Optical Diagnostics for Hypersonic Wind Tunnel Research at NASA

Jordi Estevadeordal

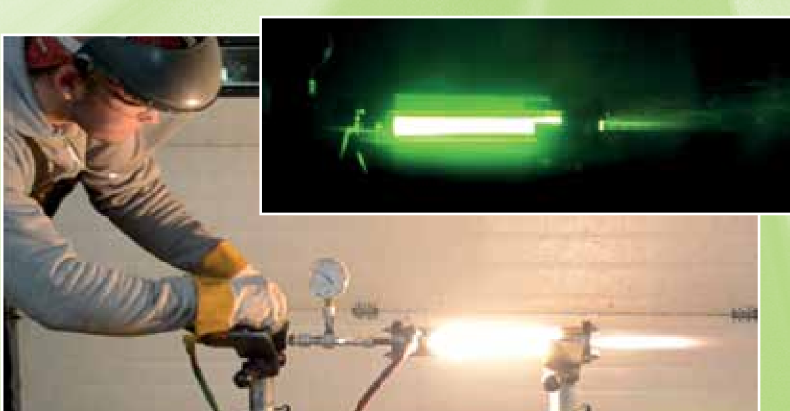
NASA research on hypersonic flight is crucial for space exploration with applications including launching of planetary solid rockets and booster separation, planetary landing and re-entry, etc. Aircraft operating in these regimes include the Space Shuttle and space vehicles such as the XPLANE, ORION, SATURN, etc.

NASA conducts experimental research testing in their wind tunnels to study these high speed flows. A variety of velocimetry methods are used and NASA is pursuing most of them in their wind tunnels. NDSU Faculty and students have been performing research in developing strategies for performing and improving various velocimetry measurement techniques, including particle image velocimetry (PIV) in the harsh environments encountered during supersonic and hypersonic flight. They have also developed numerical codes for high speed flow simulations and nozzle designs.



Photography of NDSU Supersonic Nozzles with Advanced Optical Diagnostics setup

The PI wrote a book Chapter with NASA collaborators during the program and he gave a presentation at NASA Langley. NDSU Mechanical Engineering is generating graduate Masters and Ph.D. degrees thesis related to the program, has several undergraduates involved in the research, and has ongoing senior design projects to demonstrate these techniques in high speed flows and rockets for planetary and space applications.



Photography of supersonic flow test from NDSU Rocket Propulsion Design Team prototype (student David Arstein depicted)

Science PI Jordi Estevadeordal with student

https://www.ndepscor.ndus.edu/

Oklahoma RID

Oklahoma State University

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

The purpose of the project is to improve the sensitivity of solid-state magnetometry instruments for space applications. Magnetic field measurements have been vital in space exploration. Many chemical and physical properties of planets have consequences on their complex magnetic fields, which has been used to understand these properties. For instance, sensitive magnetic field measurements of Jupiter's moon Europa and Saturn's moon Enceladus allowed NASA scientists to identify a liquid ocean on these moons.

In these space missions, magnetometry measurements have been mostly performed by fluxgates and optically pumped atomic gases, which are bulky. Although such massive sensors have appreciably served for an extended period, there is a need to develop robust and miniaturized magnetometer probes with superior sensitivity and speed for the future planetary and other space missions with miniature satellites.

Alternatively, a solid-state magnetometer method based on isolated atomic defects in crystal lattices has been developed. This isolated nature of a defect makes the electronic and spin states of these defects extremely sensitive to the external magnetic field. These states then can be probed electrically at their spin resonances for magnetic sensing. The first prototype of the magnetic sensor based on atomic defects at JPL has a sensitivity on the order of 100 nT/Hz. The current goal is to demonstrate sensitivity on the order of 1 nT/Hz and test these sensors to develop its technology for flying on a mission. Our group at OSU will focus on the testing of the sensor at low temperatures with better temperature stability and a vacuum environment.

Here we use a SiC diode with naturally existing Si defects and construct the Helmholtz coils in our cryo-stat to cycle temperature below room temperature down to 10 K and test the sensitivity of the sensor.

Helmholtz coils to apply precise magnetic field and calibrate with room temperature magnetic sensor.

Connecting magnetic field coils on the cold-head of the cryo-stat.

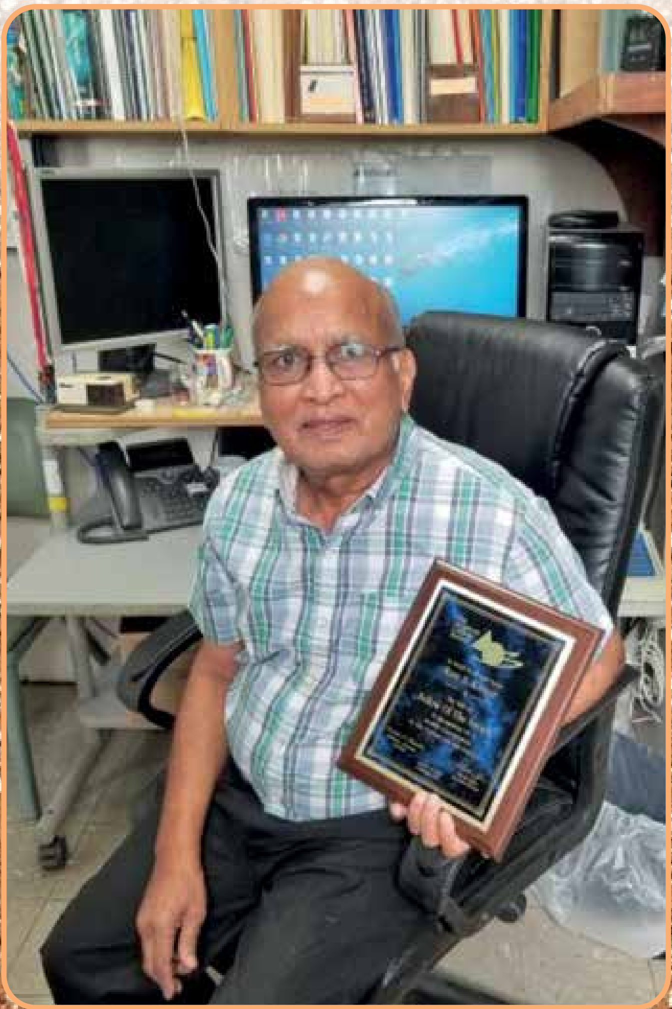
Science Investigator:
Emrah Turgut, PhD, Department of Physics, Oklahoma State University

https://okpvri.okstate.edu/

Puerto Rico RID

University of Puerto Rico

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



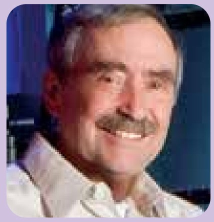
Prof. Ram S. Katiyar in his office holding the plaque naming him Fellow of the American Ceramic Society, Class of 2018.

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.

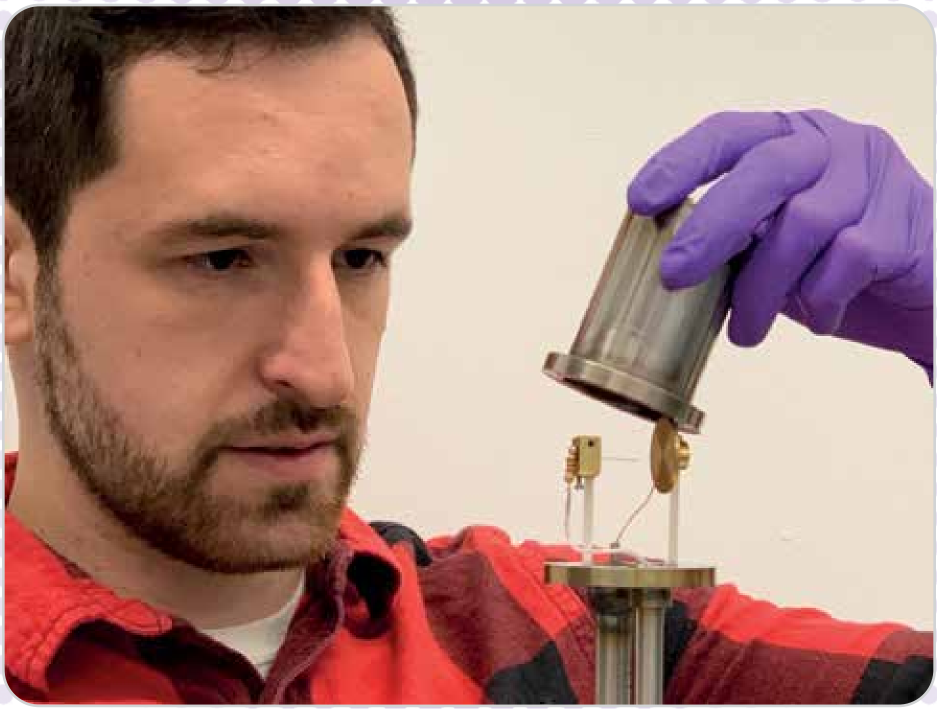
Rhode Island RID

Brown University

RID



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



David Osterman examines the instrument he developed for detecting free helium atoms, which is a crucial step in a scheme for measuring energy deposits with unprecedented sensitivity.

This project is developing a technology for measuring stimuli that are two orders of magnitude smaller in energy than can be measured at present. If successful, this project will not only advance the search for dark matter, it will enable giant improvements in imaging and spectroscopy, which could in turn lead to revolutionary biomedical or defense applications. The instrumentation and knowledge that were developed with support from the NASA EPSCoR RID program are therefore seeds from which technological innovations can grow. Rhode Island is fertile ground for developing and commercializing new technologies, thanks to its strong research institutions, industrial legacy, and investments in the infrastructure of innovation and entrepreneurship.

South Carolina RID

College of Charleston

Cassandra Runyon, PhD
South Carolina NASA EPSCoR Director
College of Charleston

SC NASA EPSCoR RID funds a minimum of three innovative projects a year insupport of NASA's mission. An example of one such project is:

Evaluation of Polyphenol Antioxidants to Lower Redox & Active Iron Levels and Prevent Cellular Oxidative Damage

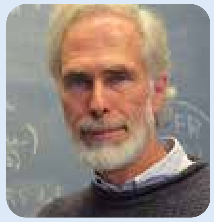
Dr. Julia Baumgartner, Clemson University

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.

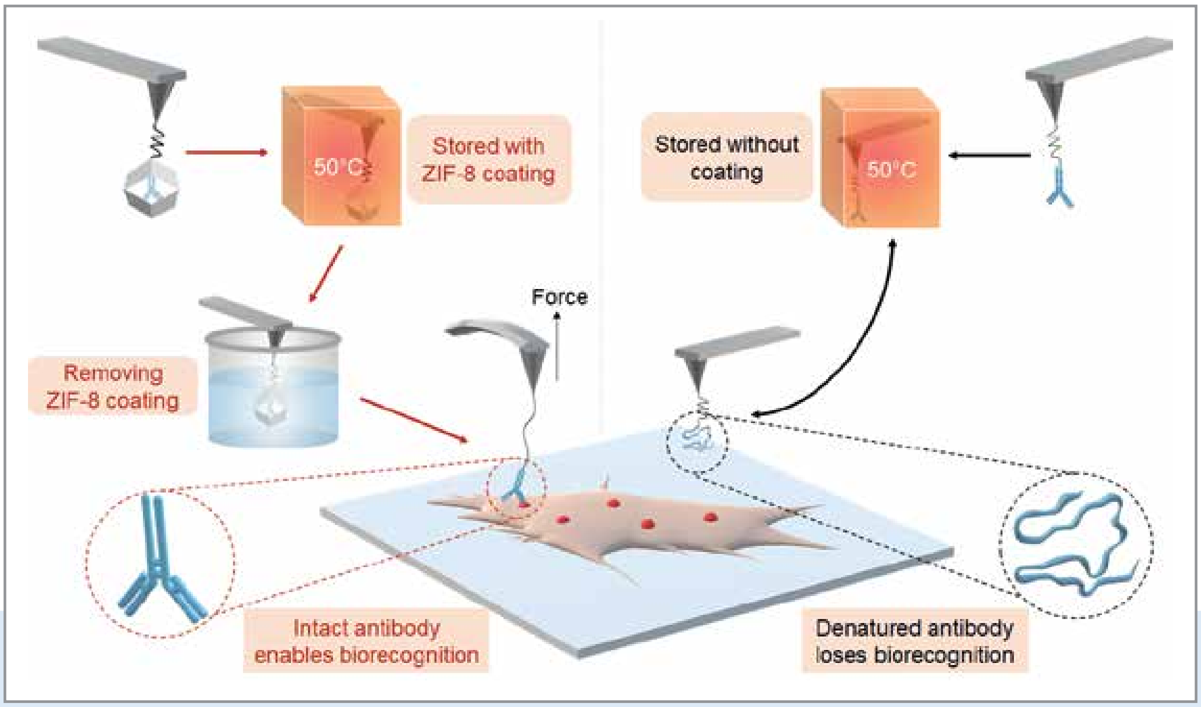
Clemson University Principal Investigator, Dr. Julia Brumaghim, and graduate students: top - removing cells from cryogenic storage; middle - setting up the chemistry tissue culturing facility; and right - working in the biosafety cabinet for mammalian cell culturing.

South Dakota RID

South Dakota School of Mines & Technology



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



Atomic force microscopy-based force spectroscopy validating the concept of using a protective and removable film for preservation of recognition capabilities of antibodies.

Bone loss is an essential problem for astronauts during extended stays in space and there is a clear need to develop a rapid, miniaturized, and ultra-robust sensor platform for monitoring astronaut's bone loss noninvasively (e.g., through detection of urinary biomarkers). The overall goal of this project is to develop novel plasmonic biosensors with enhanced environmental stability and shelf-life for detection of bone loss biomarkers in astronaut's urine.

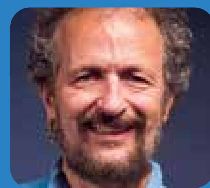
Most biosensors relying on antibodies as the recognition elements perform poorly in extreme environments because of antibody denaturation, strict storage conditions required, and short shelf-life, thus limiting their applications in point-of-care and resource-limited settings (e.g., in space). To tackle this challenge, especially for adapting to extreme space environments, this project has developed a protective and removable film for preservation of recognition capabilities of antibodies on the biosensor surface, therefore enabling the use of biosensors in long-duration, manned space missions. The preliminary results (image above) have been recently published in ACS Appl. Mater. Interfaces 2020, 12, 2, 3011-3020, https://doi.org/10.1021/acsami.9b19551.

The project also supported a materials chemistry outreach workshop at Nebraska Indian Community College, stimulating STEM education in the Native American population.

https://www.sdsmt.edu/Research/Research@Mines/Wang-Researches-Osteoporosis-Screenings/#.XkGkT6bsYuU

Vermont RID

Vermont Technical College



Carl Brandon, PhD
Professor and CubeSat Lab Director
Vermont Technical College

Deep Space Weak Signal Hardware and Software for CubeSats

For communication from far beyond low Earth orbit, current plans for CubeSats involve the NASA Deep Space Network (DSN). DSN has large dishes, allowing for high data rate communications from deep space. However, use of DSN is expensive and availability is limited. This pilot study seeks to address the current lack of deep space communication capability for small satellites without using DSN. This research builds on the existing weak-signal protocol software, known as JT-65, and the CubedOS flight-control software developed at the VTC CubeSat Lab. The specific research objectives are:

- Modify the JT-65 software so it can be controlled autonomously by CubedOS.
- Rewrite the critical portions of JT-65 in SPARK/Ada to improve reliability.
- Test the new software using a portable ground station and the VTC CubeSat Lab ground station by bouncing signals off the Moon.

This research is synergistic with topics outlined in the NASA Technology Roadmap, especially in areas of communications, navigation, and orbital debris tracking and characterization. The anticipated developments are of high value to the current emphasis at NASA on CubeSats and SmallSats for deep space and interplanetary missions. Drs. Brandon and Jeremy Ouellette will be assisted by 2-3 undergraduate students, who will gain valuable research experience from this project.

Vermont Lunar CubeSat developed at the VTC CubeSat Lab

Launch of the Vermont Lunar CubeSat from Wallops Island

Virgin Islands RID

University of the Virgin Islands

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

During the COVID19 pandemic, USVI EPSCoR director Dr. David Morris coordinated with another UVI faculty member, Dr. Tim Faley, and a UVI student, Ms. Kedisha Charles, to voluntarily produce personal protection equipment (PPE) using 3D printing technology to help safeguard medical personnel and other front-line workers in the USVI from the spread of the COVID19 virus. Dr. Morris' work in UVI's aerospace engineering lab commonly uses 3D printing technology to prototype new cubesat and other instrumentation flight platforms, but during the pandemic, Dr. Morris and others recognized that these 3D printing resources could be used to quickly provide badly needed PPE while supply chains to the USVI were severely limited due to the spread of the disease across the globe. Due to the USVI's own stay-at-home orders, Dr. Morris and his colleagues moved their 3D printing operations to their personal residences, setting up PPE printing operations in makeshift "labs" in their bathrooms or elsewhere in their homes. Over the course of approximately 30 days, with resource support from NASA EPSCoR funding, Dr. Morris and his colleagues produced and distributed more than 200 facemasks and 100 faceshields to doctors and nurses at local hospitals, essential workers at UVI and across the USVI community. In recognition of their efforts, Dr. Morris and his colleagues were presented with a UVI Presidential Appreciation Award at the June 2020 UVI Board of Trustees Meeting.

West Virginia RID

West Virginia University

Majid Jaridi, PhD
West Virginia NASA EPSCoR Director
West Virginia University

Transpiration and water use of several hardwood species in Appalachian forest

The Appalachian forest is one of the most diverse and productive ecosystems in the northeastern United States. It has been the subject of numerous research studies on watershed management, biodiversity conservation, logging and other silvicultural practices. However, only a few limited studies have attempted to quantify water consumption of mixed hardwood trees and their contribution to forest water balance. Understanding the ability to compete for water resources and the differential utilization of water by plants without the destructive excavation of roots needs to be explored in this ecosystem. The use of sap flow gauges to quantify water use can therefore be indispensable tool in further exploration of the impacts of vegetation communities on the productivity of Appalachian forest. The main objective of this study was to estimate daily, and seasonal water use by several mature oak species in a mixed hardwood forest. The study is important in characterizing the contribution of the mixed hardwood trees on the hydrology or water balance of Appalachian forest.

This research project was conducted by Dr. Rico M. Gazal, Professor and Chair, Department of Land Resources, Glenville State College under a RID grant from NASA WV EPSCoR.

http://nasawvepscor.org

The probe is inserted into the sapwood at a depth of 30 mm using a drill bit and covered with a reflective bubble wrap for insulation.

Wyoming RID

University of Wyoming

RID

Shawna McBride, PhD
Wyoming NASA EPSCoR Director
University of Wyoming

The focus of the Wyoming NASA EPSCoR RID project is to develop a strong Materials Science and Engineering (MSE) program at the University of Wyoming (UW) aimed at furthering NASA research goals in materials science, as well as jurisdiction priorities. Materials science is a multidisciplinary field involving collaborations across many traditional academic programs and the MSE program at UW provides a rich, collaborative research environment for graduate students, research scientists, and faculty to interact across departments. This is facilitated through an MSE seminar course, speaker series, and annual research symposium sponsored by Wyoming NASA EPSCoR. Over the past year, Wyoming NASA EPSCoR also supported three research projects: one examining perchlorate production via photoelectrochemistry and semiconducting minerals and the implications for Mars exploration led by Alero Gure; one focused on developing spintronic devices to benefit semiconductor and memory storage technologies led by Dr. Jifa Tian, which resulted in several publications, a course in Spintronics, and a collaborative research grant from the Department of Energy EPSCoR program; and a third project to develop a method for characterizing and modeling non-stationary materials in the environment using 2D/3D images led by Dr. Pejman Tahmasebi. Dr. Tahmasebi, an Assistant Professor in Civil and Petroleum Engineering, was subsequently awarded Wyoming's first NASA EPSCoR Rapid Response Research grant, in collaboration with NASA Goddard Space Flight Center's Earth Science Technology Division. Dr. Tahmasebi's R3 grant will focus on machine learning for environmental feature recognition. Artificial intelligence and machine learning will also be the focus of a NASA EPSCoR research award given to Dr. Patrick Johnson, Dr. Lars Kotthoff, and Dr. DP Aidhy at UW, as well. This interdisciplinary project, incorporating computer science, chemical engineering, and mechanical engineering, will develop faster, autonomous methods to design new materials, which could have significant applications for in-space manufacturing. The efforts of the Wyoming NASA EPSCoR RID project are yielding results by creating a cohesive, collaborative group in materials science at UW; through supporting early career faculty in making connections with NASA and in securing extramural funding; and by facilitating interdisciplinary research.

Artificially Intelligent Manufacturing workshop group at the 2019 Materials Science and Engineering Symposium, University of Wyoming. Invited speakers included David Estrada from Boise State University (front row, far right) and Kamal Choudhary from NIST (front row, second to right).

Research

NASA EPSCoR Research awards provide seed funding to enable qualifying state and territory university systems (referred to as Jurisdictions within EPSCoR) to develop an academic research enterprise directed toward long-term, self-sustaining, nationally competitive capabilities in aerospace and aerospace-related research high-priority to NASA. This capability promotes partnerships among NASA research assets, academic institutions, and industry; and contribute to the overall research infrastructure, science and technology capabilities of higher education institutions, and economic development of the jurisdiction. New awards are granted annually, each up to $750,000 for a three-year performance period. Awardees are required to provide a 50 percent cost-share (cash or in-kind).

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92	AL	Micro-Magnetic Driven Design of Multi-Component Magnetic Alloys for Advanced Electric Propulsion
93	ND	Derive Phytoplankton Size Classes, Detrital Matter, Particulaste Organic Matter and Particulate Inorganic Matter from Ocean Color Observation
94	MT	Satellite-Guided Hydro-Economic Analysis for Integrated Management and Prediction of the Impact of Droughts on Agricultural Regions
95	WY	Igniting a New Era of Planet Discovery with FHiRE: A Precision Spectrograph at the WIRO Telescope
96	NV	Life in Salts: a Multidisciplinary Investigation of Microorganisms and Biosignatures in the Death Valley Salt Pan
97	LA	Understanding and Quantifying Carbon Export to Coastal Oceans Through Deltaic Systems
98	KS	Efficient and Compact Thermal and Water Management Systems using Novel Capillary Structure for Space Technology
99	VT	Critical Gas-Surface Interaction Problems for Atmospheric Entry
100	OK	Space-Borne Antennas and Circuits for Condensed Radars and STEM (SPACERS)
101	SC	Nanomaterials-Based Hybrid Energy Storage Devices and Systems for Space Applications
102	NH	Application of Antifreeze Proteins and Mimetic Peptides in Anti-Icing Surface Coating
103	LA	Production of Fuels and Other Life Support Products Using Wastewaters as a Feed into a Space-Based Biochemical Conversion System (BIOSYS)
104	NE	MORS: Modular Robotic Suit as an Exercise System for Maintenance of Muscle Strength of Astronauts During Long-Term Space Missions

SMD

Research

Tectonic Influences on High Temperature Biosphere Hability

Montana State University, Bozeman, Goddard Space Flight Center, Glenn Research Center, Jet Propulsion Laboratory, Ames Research Center

A hot spring in Yellowstone National Park, Wyoming, USA, that harbors microbial organisms that provide insight into some of the earliest known types of life on Earth. Photo: Daniel Colman

Science PI
Daniel Colman
Assistant Research Professor
Montana State University

NASA Technical Monitor
Ali Shaykhian, PhD
Kennedy Space Center

Despite their apparent inhospitable nature, hot springs harbor highly diverse communities of unusual microorganisms. These organisms are of incredible importance for informing our understanding of the limits to life on Earth, understanding the nature of the earliest life on Earth, evaluating the possibility for life on other planetary bodies, and providing new targets for bio-prospecting of industrially useful organisms or enzymes. The spring shown above was the focus of a recently published study by Colman et al. that provides new insights into how geologic processes alter water chemistry in hydrothermal fields, and how these processes can support the presence of organisms previously unknown to science. In particular, the organisms within this spring may be uniquely important for understanding the biodiversity and evolution of sulfate-reducing microorganisms which are responsible for important components of sulfur and carbon-cycling on Earth both on contemporary Earth, as well as early on after life's emergence on ancient Earth.

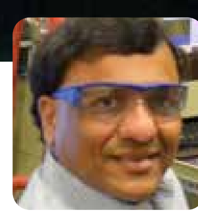
Experimental Investigation of Noise and Thermo-Acoustic Instabilities in Low-Emission, High-Efficiency Combustion Systems for Aviation

The University of Alabama, Glenn Research Center, Langley Research Center, Marshall Space Flight Center

This research in the Department of Mechanical Engineering (ME) at the University of Alabama produced 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. The LDI combustion is prone to thermoacoustic instabilities or large-amplitude pressure oscillation that can severely damage the engine. UA team developed a porous insert concept to address these problems. We explored methods to create highly functional porous inserts from aviation grade materials using 3D additive manufacturing techniques. We worked with NASA Glenn Research Center (GRC), where LDI combustion research has been extensively investigated. Key accomplishments of the project are: (1) record enrollment of students in Mechanical Engineering undergraduate, Masters' and PhD programs. The project partially supported four PhD students, (2) STEM course "Introduction to Combustion" was revised and led to record enrollment of undergraduate and graduate students, who are interested in fuels, energy and environment, (3) several competitive multi-year research awards on related combustion/engine projects, (4) a high-level delegation from a well-known US company visited our laboratory to develop plans for collaborative research and educational opportunities, and (5) project has created opportunity to collaborate with three different federal laboratories (NASA, DOE, and NRL). In future, we expect to transition the UA technology to the gas turbine, power generation, and industrial burner sectors.

Background Image:
Low-Emission Combustor Setup in Engine and Combustion Laboratory at University of Alabama

UA Thermo-Acoustics Group



Science PI
Ajay K. Agrawal, PhD
The University of Alabama

NASA Technical Monitor
Kathy Tacina, PhD
Glenn Research Center

Advanced Electroactive Polymer Actuators and Sensors for Aerospace Robotic Applications

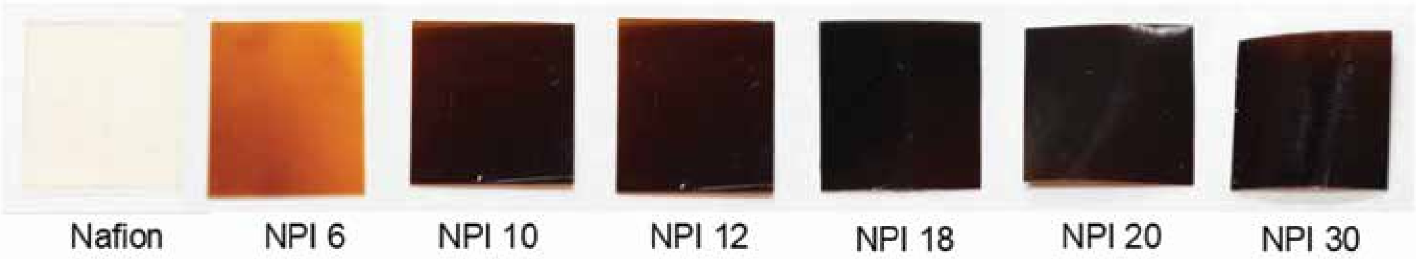
University of Nevada, Las Vegas, Johnson Space Center, Langley Research Center

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.

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

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.

NASA Technical Monitor
Kumar Krishen, PhD
Johnson Space Center



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

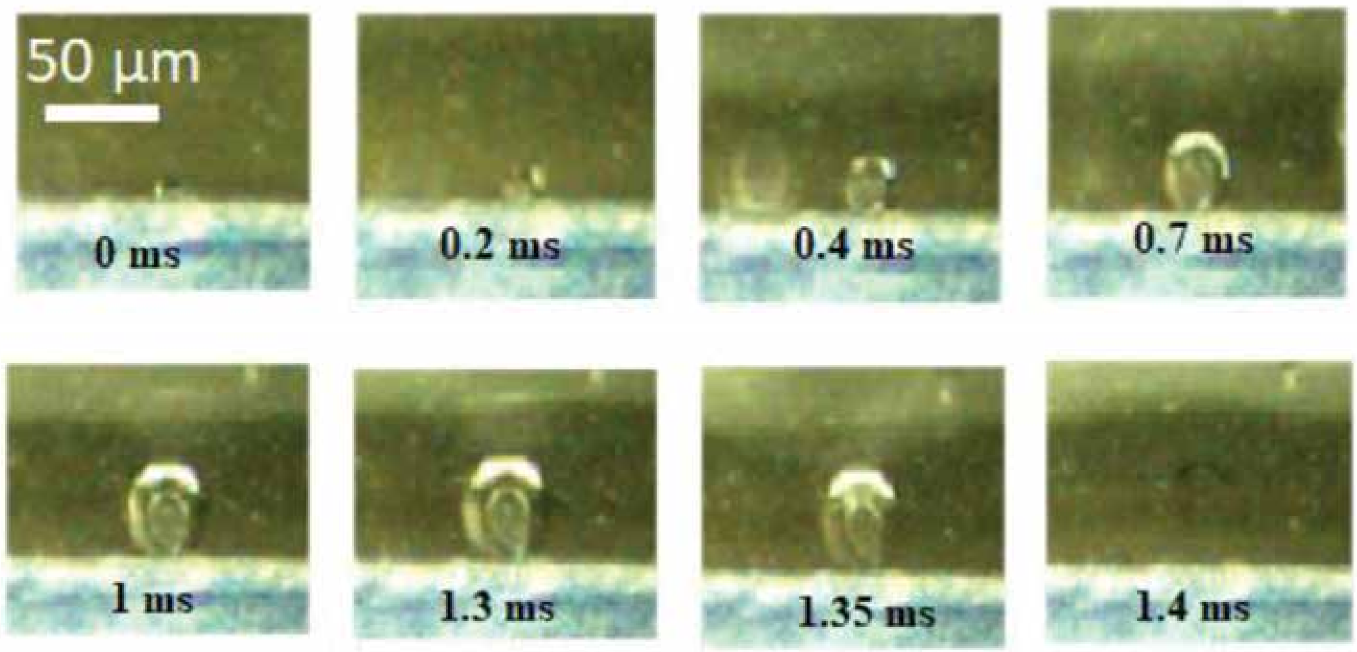
Return on Investment (ROI) to Date

New proposals/scholarships awarded: 11 with 8:1 ROI
Patent: 1
PI induction into National Academy of Investors
Publications/presentations: 24 pubs and 34 presentations
Students impacted, research experience: 11

www.kwangjinkim.org

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

University of South Carolina, Jet Propulsion Laboratory, Goddard Space Flight Center



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

- 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 two-phase heat sinks for space applications.

http://www.me.sc.edu/Research/MNT/

Science PI
Chen Li, PhD
University of South Carolina

NASA Technical Monitor
Ted Swanson, PhD
Goddard Space Flight Center

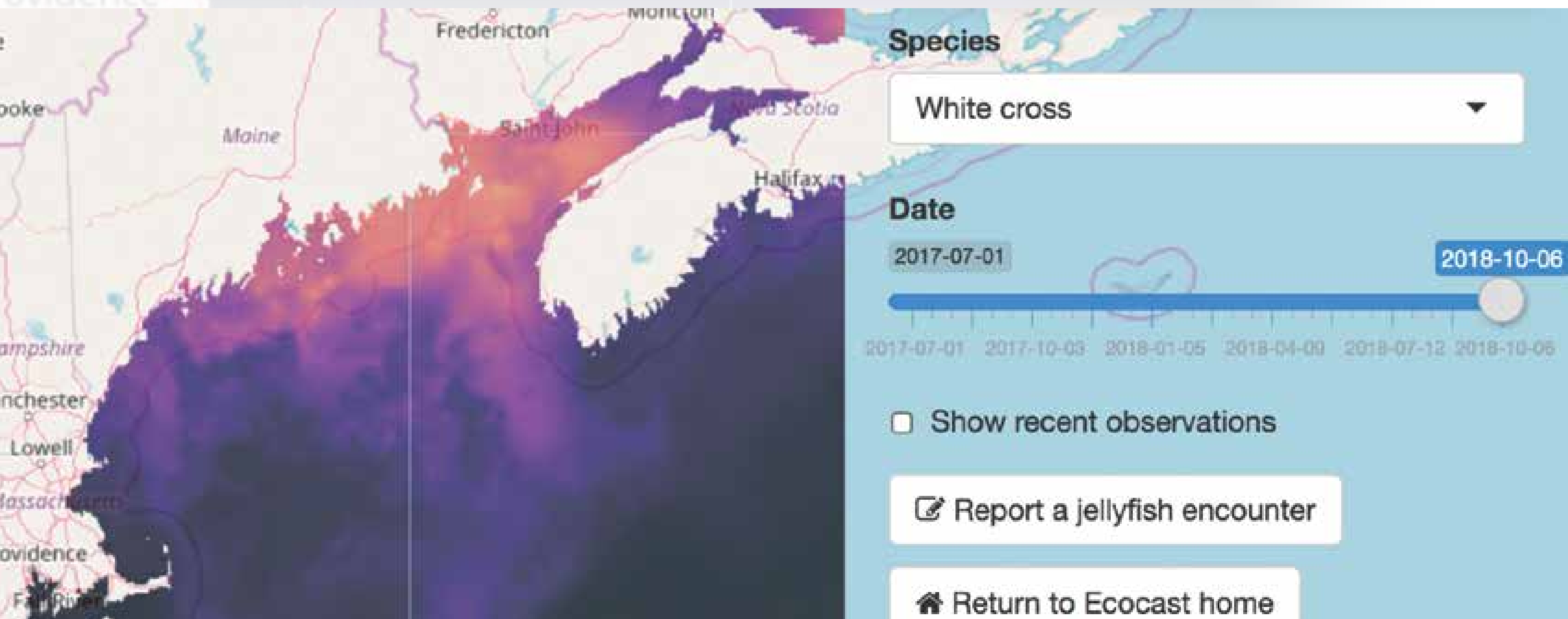
Earth System Data Solutions for Detecting and Adapting to Climate Change in the Gulf of Maine

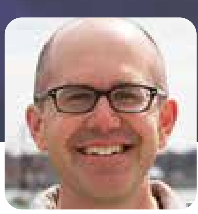
Gulf of Maine Research Institute, Jet Propulsion Laboratory

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 at eco.bigelow.org (ecocast at Bigelow - Laboratory for Ocean Sciences), 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.





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

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

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

http://seascapemodeling.org/tickcast.html

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

Hawai'i Institute of Geophysics and Planetology, University of Hawai'i, Ames Research Center

Dr Casey Honniball deploying her EPSCoR-funded MIDAS (Mid-Infrared Detector of Atmospheric Species) instrument to measure the composition of the volcanic gas plume at Kilauea volcano, Hawaii, in January 2018, in support of the HyspIRI ER-2 overflights.

Improved technology and emerging interferometric techniques have allowed the use of uncooled microbolometers in the long-wave infrared (LWIR; 8 to 14 ˚m) for hyperspectral imaging. The mid-wave infrared (MWIR; 3 to 5 ˚m) presents several advantages with respect to the LWIR for Earth and planetary science. For example, important atmospheric trace gases such as CO2 and CH4 are not masked by other atmospheric constituents in the MWIR. However, hyperspectral imaging in the MWIR is more challenging at ambient Earth temperatures because less radiance is available to measure. We built an instrument for acquiring hyperspectral images in the MWIR which uses an uncooled microbolometer married to a Sagnac interferometer. At a spectral resolution of 100 cm-1 (17 bands between 3 and 5 ˚m), we measured an SNR of 100 at 30˚C with the microbolometer instrument, and an SNR of 50 at 50 cm-1 (33 bands). Results from this work show that coupling microbolometers with interferometers allows for quality measurements with adequate SNR for high temperature science applications.

Science PI
Brendan Hermalyn, PhD
University of Hawai'i

NASA Technical Monitor
Ali Shaykhian, PhD
Kennedy Space Center

Development of Turbulence Models, Uncertainty Quantification and Optimization Tools for Aircraft and Turbomachinery Analysis and Design

Washington University in St. Louis, NASA Glenn Research Center, Langley Research Center, Ames Research Center

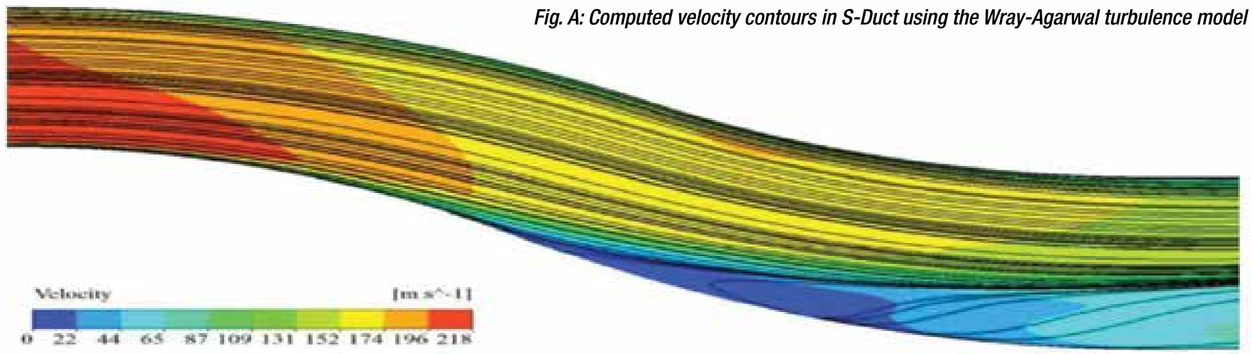


Fig. A: Computed velocity contours in S-Duct using the Wray-Agarwal turbulence model

Detached Eddy Simulation (DES) of Turbulent Flow in a S-Duct Based on Wray-Agarwal Turbulence Model

S-duct is widely used in an aircraft propulsion system. Fig. A shows the geometry of the NASA Glenn S-duct [D-1] which was designed to study the complex three-dimensional flow phenomena such as the boundary layer separation and secondary flows. The flow is separated at the lower surface of the duct creating a separation bubble. It has been very difficult to predict this flow field using CFD; one of the primary reason being the inability of the existing turbulence models to accurately compute this flow using the RANS equations. Fig. A shows the velocity contours depicting the separation bubble. Fig. B shows the comparison of the measured pressure distribution and the computed pressure distribution for flow in the NASA Glenn S-duct using the Wray-Agarwal (WA) model and its DES version developed as a result of this grant [D-2]. WA- DES model shows much improved prediction compared to industry standard turbulence models such as the Spalart-Allmaras (SA) turbulence model.

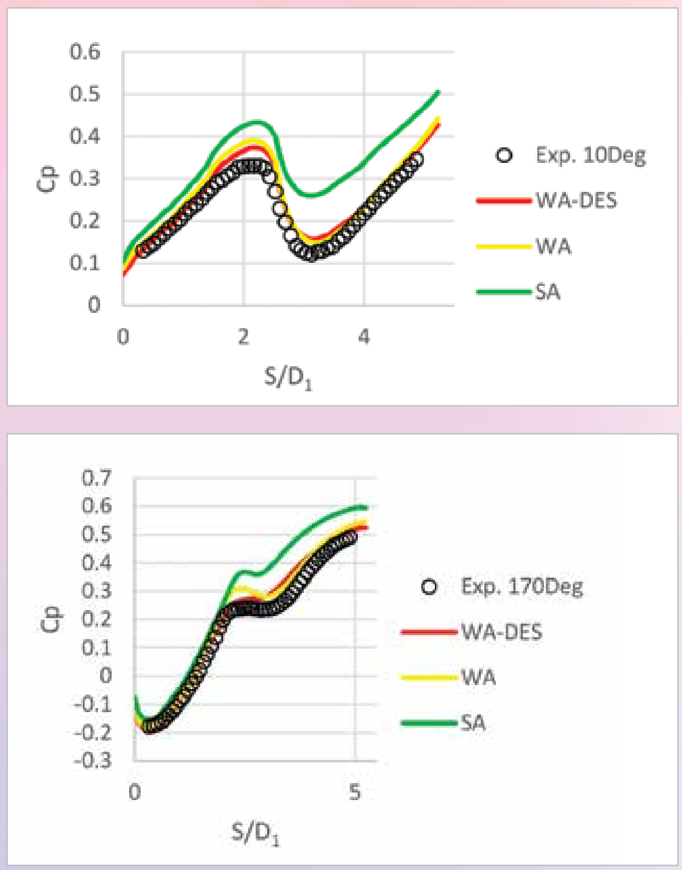


Fig. B: Comparison of pressure distribution along the NASA Glenn S-Duct at two angular locations of 10 and 170 degrees.

NASA Technical Monitor
Mujeeb Malik, PhD
Langley Research Center

Science PI
Ramesh K. Agarwal, PhD
Washington University in St. Louis

https://github.com/xuhanwustl/WrayAgarwalModels

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

University of Puerto Rico, Río Piedras, Ames Research Center

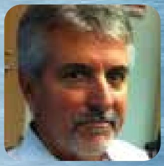
Prof. E. Nicolau and a graduate student working on next-generation water purification membranes for NASA exploration missions at UPR's Molecular Sciences Research Center.

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.

Science PI
Eduardo Nicolau, PhD
University of Puerto Rico

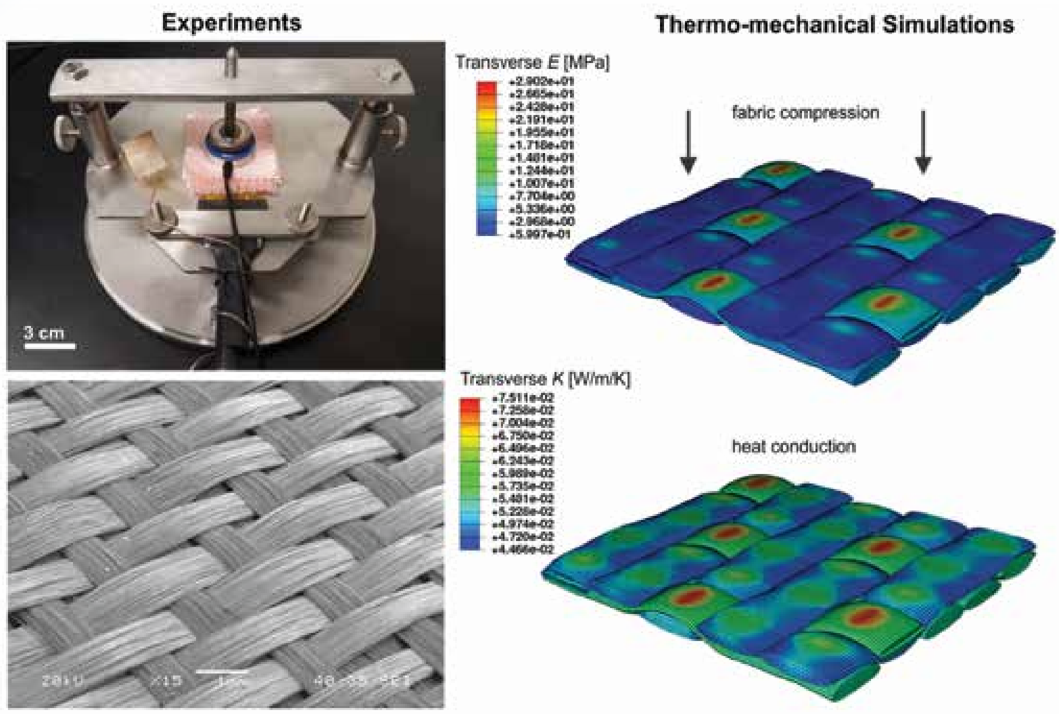


NASA Technical Monitor
Michael Flynn, PhD
Ames Research Center

https://nicolaulab.weebly.com/

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

University of Vermont, Burlington, Langley Research Center



Experimental and computational studies of anisotropic heat conduction through two-dimensional woven ceramic fibers for inflatable aerospace structures

Science PI
Frederic Sansoz, PhD
University of Vermont

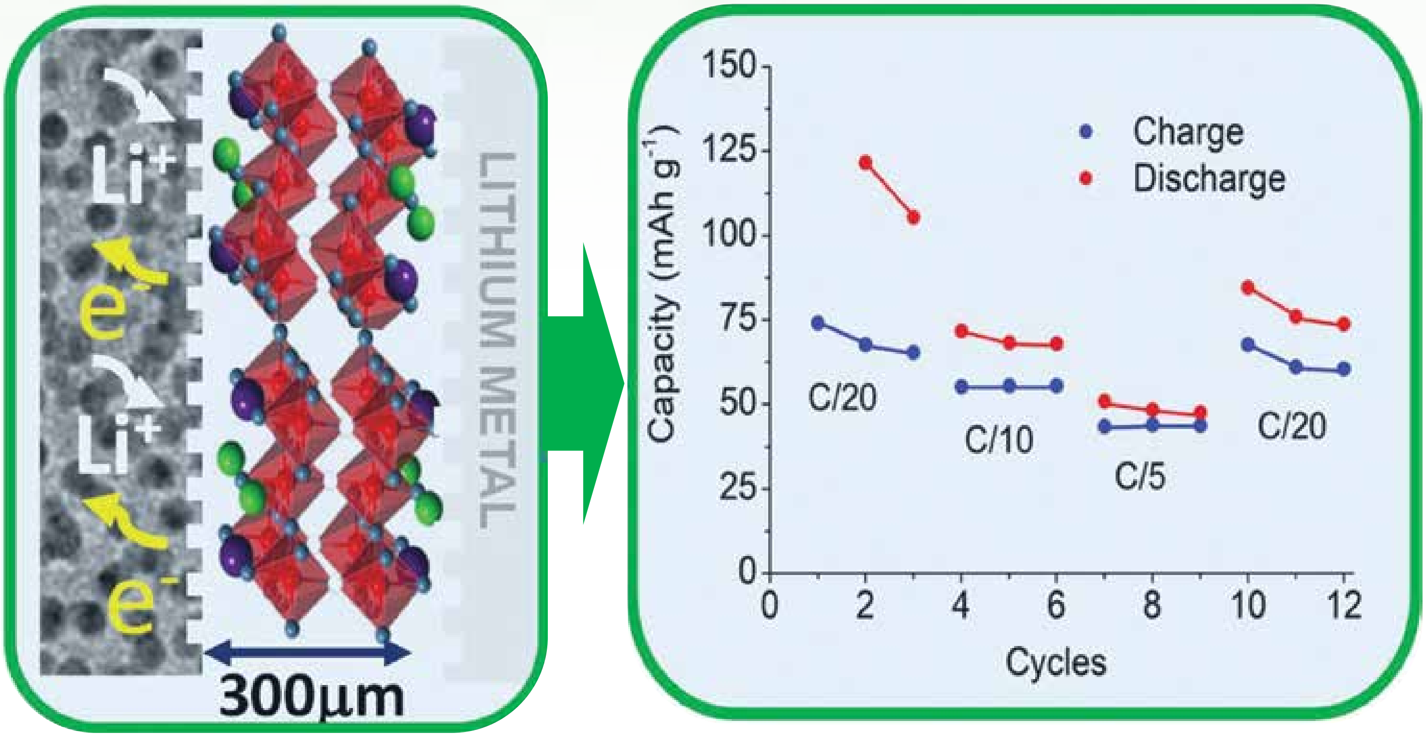
NASA Technical Monitor
Anthony Calomino, PhD
Langley Research Center

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.

High Performance and Durable Lithium-Ion Battery for NASA Space Applications

South Dakota School of Mines and Technology, Glenn Research Center

Conventional lithium ion batteries with liquid electrolytes are flammable, have limited lifetime due to electrolyte decomposition and formation of non-conductive solid electrolyte interphase (SEI) layers, and cannot be used with highly efficient lithium metal as the anode due to lithium dendrite formation. In this project, a solid-state superionic antiperovskite electrolyte has been used to replace the flammable liquid electrolyte. It has been tested in an eco-friendly and non-flammable solid state lithium-ion half-cell with a graphite anode and solid-state antiperovskite electrolyte.



Schematic diagram showing performance of the eco-friendly and non-flammable solid state lithium-ion half-cell with graphite anode and solid-state antiperovskite electrolyte.

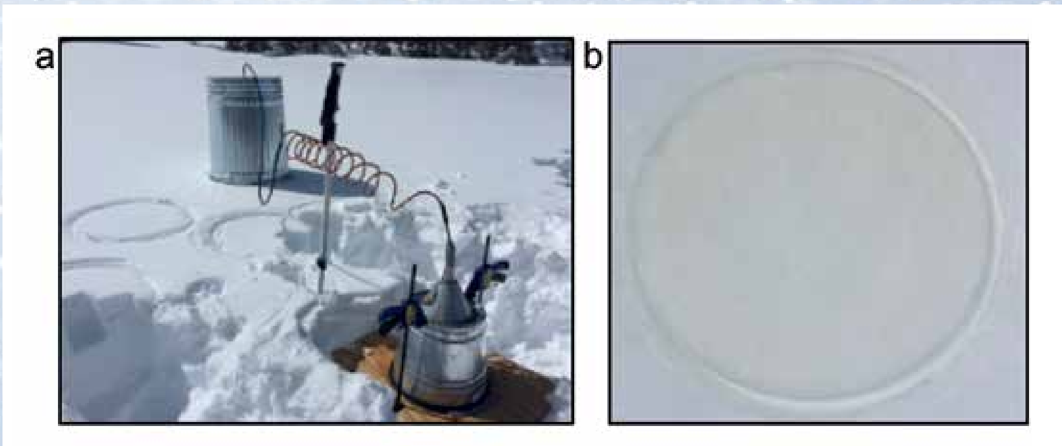
Science PI
Alevtina Smirnova, PhD
South Dakota School of Mines & Technology

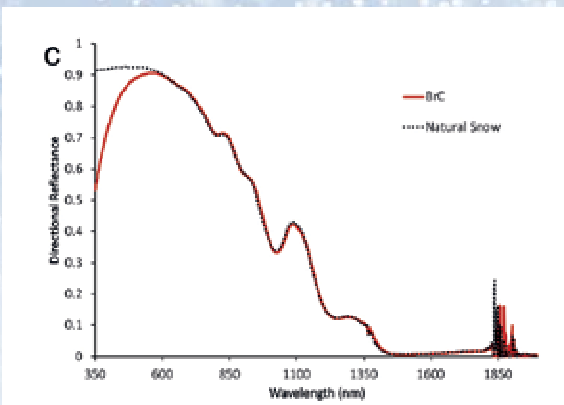
NASA Technical Monitor
James J. Wu, PhD
Glenn Research Center

https://www.sdsmt.edu/Research/Profiles/Smirnova/Research/Lithium-Ion-Battery-for-Space-Applications/

Building Capacity in Interdisciplinary Snow Sciences for a Changing World

Desert Research Institute, Goddard Space Flight Center

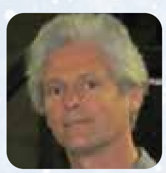




Deposition apparatus consisting of (a) a smaller volume for aerosol generation and a larger volume for aerosol deposition. Air is pumped into the smaller volume pushing the generated aerosol into the larger volume and depositing it onto the snowpack. (b) Brown carbon (BrC) aerosol was deposited onto the snow surface, creating a yellowish appearance that significantly affects the radiative properties of snow in the ultra-violet and at shorter visible wavelengths (C).

We have developed and tested a field deployable apparatus for the dry deposition of aerosols onto snow surfaces (Beres and Moosmüller 2018). This apparatus (above figure A) is capable of generating combustion aerosols including light absorbing black carbon (BC) and brown carbon (BrC) through in situ combustion of biomass or fossil fuels (smaller volume) or through entrainment of mineral dust. The aerosol generated is pumped into a second larger volume standing on the snow surface and open to it; here the generated aerosol is deposited onto the snow surface and into the top few cm of the snowpack. This apparatus has been tested and used at Tamarack Lake in the Carson Range of the Sierra Nevada (to characterize changes in snow spectral albedo after deposition of light absorbing aerosols (shown in figure C) and to relate these albedo changes to the optical properties of the deposited aerosols (Beres et al. 2019; Chakrabarty et al. 2016; Sengupta et al. 2018). This information is critical for understanding and quantifying the role of aerosol deposition on snow energy balance, actinic flux, photochemistry, and snowmelt.

Science PI
Alison Murray, PhD
Desert Research Institute



NASA Technical Monitor
Brian Cairns, PhD
Goddard Space Flight Center

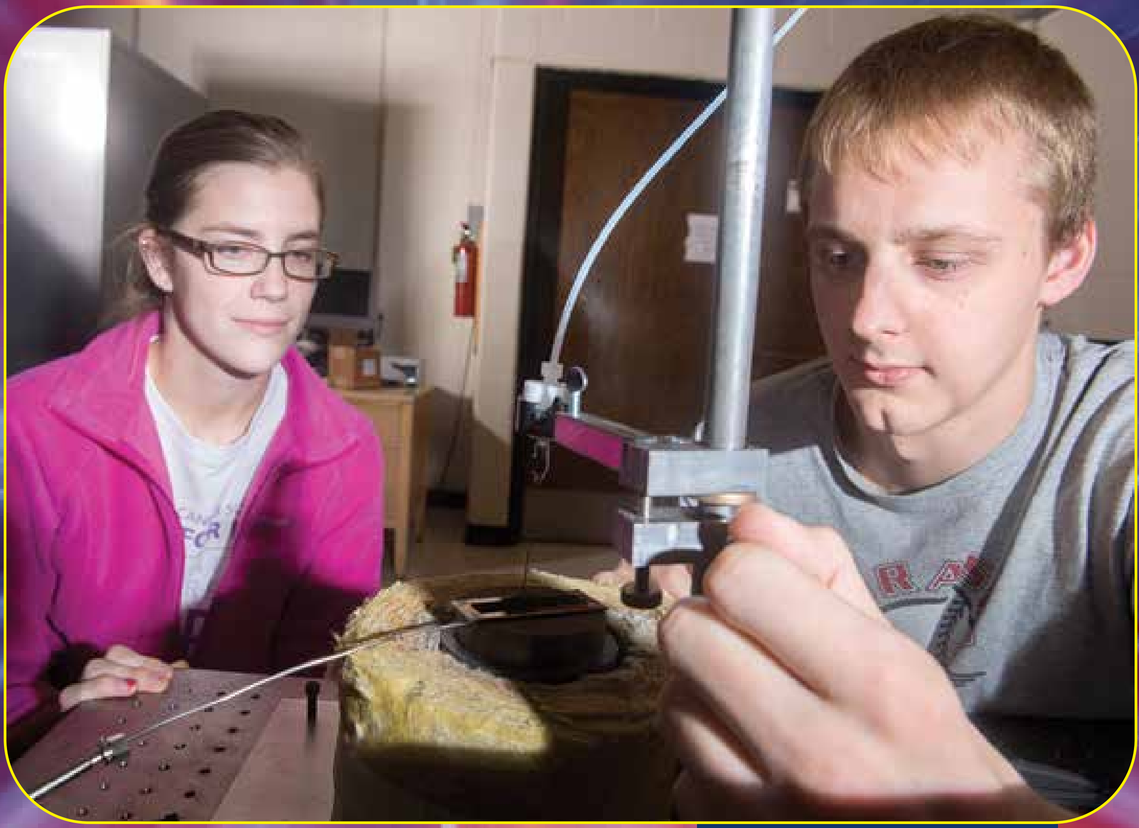
Return on Investment (ROI) to Date

New proposals funded: 13 for total of $3,312,270 (a 3:1 return)
Peer-reviewed publications: 38   Presentations: 250
Students impacted, research experience and expertise: 24

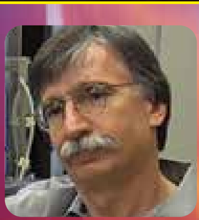
Highly Permanent Biomimetic Micro/Nanostructured Surfaces by Femtosecond Laser Surface Processing for Thermal Management Systems

University of Nebraska-Lincoln, Glenn Research Center

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.



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



Science PI
George Gogos, PhD
University of Nebraska-Lincoln

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

http://CEFS.unl.edu

A New Paradigm for Efficient Space Communications: Rateless Coding with Unequal Error Control and Data Fusion

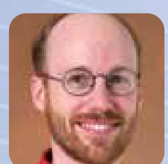
The University of Mississippi, Jet Propulsion Laboratory, Goddard Space Flight Center

This project focuses on technologies to improve both the quantity and quality of information obtained through deep space exploration. We have developed new fountain codes and a fountain codes-based protocol that may result in substantial improvements in data transmission from space to earth. We have also developed efficient algorithms of fusing data to improve the quality of information derived from both uncorrelated and correlated observations. Technical outcomes have been documented in both journal and conference publications.

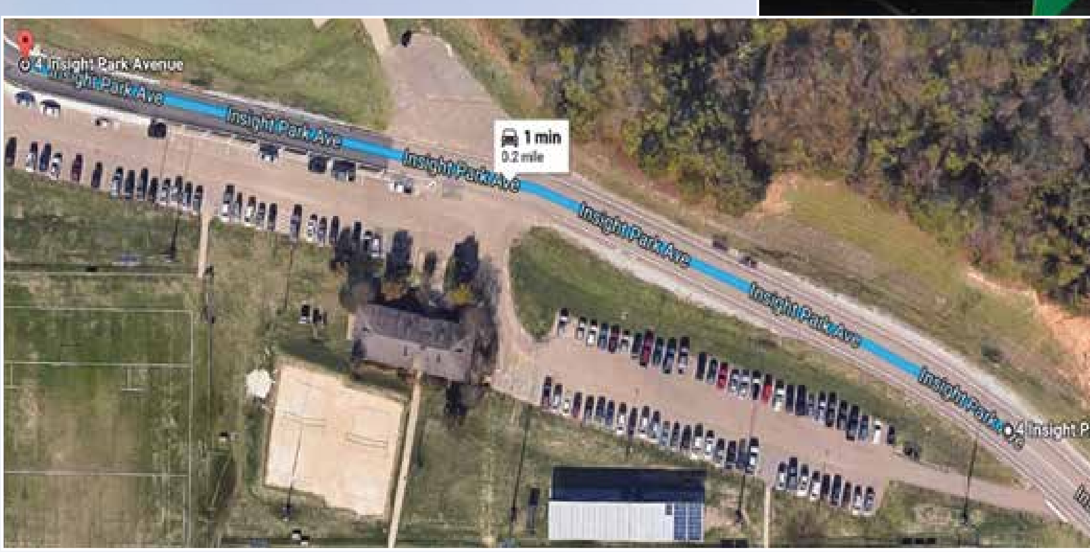
This grant has formed an energetic research group, including faculty and graduate students from University of Mississippi (UM) and Jackson State University and collaborating with scientists in Jet Propulsion Laboratory. As a consequence, we have successfully established a UM site of Broadband Wireless Access and Applications Center sponsored by NSF, and have collaborated with companies including Intel, Qualcomm, Raytheon, C-Spire and Fedex in various wireless communications projects.

About 20 graduate and undergraduate students have been educated through this grant with hands-on research experience. Using USRP and GNU radio, wireless projects developed by citizen undergraduate students at UM have resulted in oral presentation in the National Conference on Undergraduate Research and publication with University of Mississippi Undergraduate Research Journal.

Science PI
Lei Cao, PhD
The University of Mississippi



NASA Technical Monitor
Jon Hamkins, PhD
Jet Propulsion Laboratory



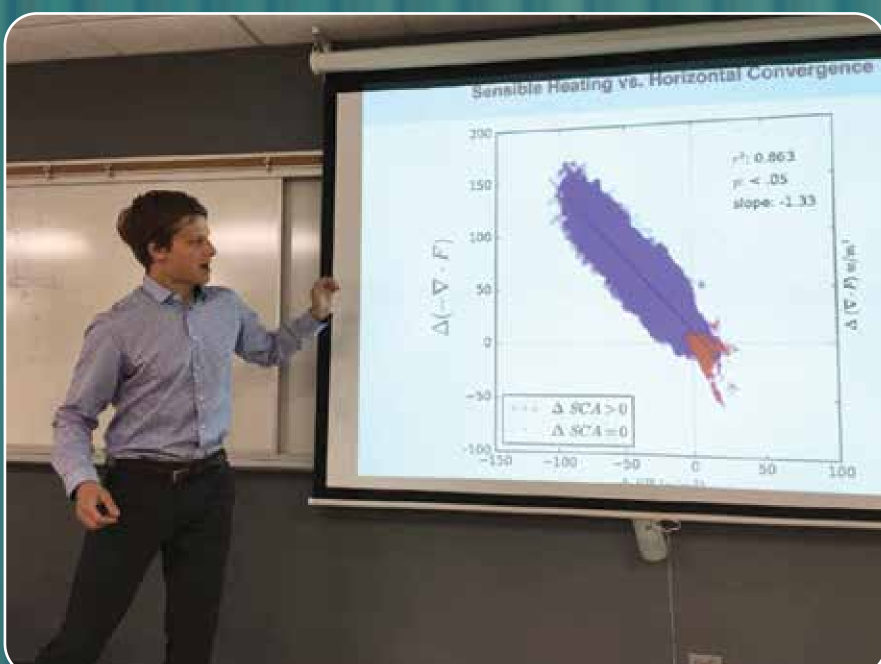
A stand-alone mobile communication network built by undergraduate students using OpenBTS and USRP, and tested in the field.

http://pcrl.msstate.edu/research/plasma-assisted-ignition-combustion/

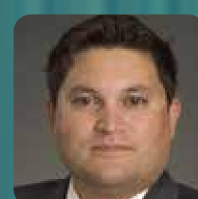
Monitoring Earth's Hydrosphere: Integrating Remote Sensing, Modeling, and Verification

Boise State University, Goddard Space Flight Center, Jet Propulsion Laboratory

Water derived from the mountains of Idaho plays an important role in sustaining the economy, ecosystems, and cultural of the state. Water from mountain snowpacks is used to irrigate fields across the state, especially the Snake River Plain, that grow crops that wind up in food that is valued across the US and the world. The water stored in that snow is ultimately derived from evaporation in the Pacific Ocean in the warm belt of water near the equator, between the Philippines and Hawaii. Flows of moisture in the atmosphere, known as atmospheric rivers, can move significant amounts of water from equatorial regions to the Western US in very short periods of time. These atmospheric rivers are called such because the water vapor, when viewed in satellite imagery, in the atmosphere visibly resembles long and thin riverine features and because they are known to transport volumes of water that approach those of the largest rivers in the world, albeit for short periods of time. For this reason, they are also known to pose risks of flooding and can threaten flood control infrastructure. While the importance of atmospheric rivers to precipitation along the mountains of the West Coast is well known and received significant press coverage in 2017, there remain significant uncertainties about the degree to which they are important in inland watersheds like the Snake River Basin. This NASA EPSCoR project supported research that explored how atmospheric rivers interact with mountain watersheds that are covered with snow to varying extents. Snow acts as a potential absorber of thermal energy transported in these atmospheric rivers and sufficient snow cover could serve to buffer large watersheds against flooding risks by dissipating the energy they bring from equatorial regions. In a series of numerical simulations, Will Rudisill of Boise State University, explored how changes in snow cover could lead to alternative outcomes in the presence of atmospheric river conditions. In particular, Will's MS research found that snow-covered areas act to draw energy away from non-snow-covered areas during these atmospheric river events, serving to suppress surface temperatures in those non-snow-covered areas. This change in energy balance in the atmosphere also influenced the phase of precipitation (i.e., rain vs snow) during these atmospheric river events. Will's work highlights how these atmospheric rivers may ultimately interact with the land surface in future decades where snow cover is less extensive due to climate change. It also highlights the need for continuing to dedicate science and satellite resources for monitoring the water status of difficult-to-access mountain regions, as they serve as the "water towers of the world." Will is currently preparing a manuscript to submit to the American Meteorological Society's Journal of Hydrometeorology, and is continuing his education at Boise State as a student in the PhD Geophysics program. His PhD research will continue to focus on the hydrometeorology of mountain watersheds and is funded by the Department of Energy's Subsurface Biogeochemical Research Program, an award catalyzed by this NASA EPSCoR project.



As part of his MS Hydrologic Sciences thesis defense, which was supported by this award, Will Rudisill presents results from modeling experiments performed to understand how snow-covered landscapes interact with atmospheric rivers.



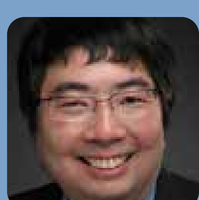
Science PI
Alejandro N. Flores, PhD
Boise State University

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

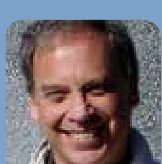
Nanostructured Polarization Optics for Atmospheric Remote Sensing

Montana State University, Jet Propulsion Laboratory, Goddard Space Flight Center, Ames Research Center

Professor Joseph Shaw (2nd from left) and his group of graduate and undergraduate students are shown here with a suite of optical instruments used in research conducted at Montana State University to develop new remote sensing instruments for testing and refining theoretical predictions made by NASA colleagues for the use of polarization in determining properties of clouds that are critical in climate and weather research on Earth and other planets.



Science PI
Wataru Nakagawa, PhD
Montana State Untiversity

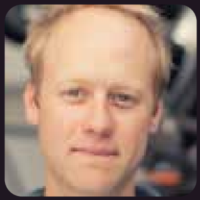


NASA Technical Monitor
David J. Diner, PhD
Jet Propulsion Laboratory

The overall purpose of this project is to develop new nano-structured optical devices for use in remote sensing instruments to determine the properties of clouds in the atmosphere. These are critical properties for studies of the climate and weather on Earth and other planets. This research also has importance in determining atmospheric effects on high-speed data links using laser beams to communicate between Earth and space, as well as on military sensing. One of the major components of this project was developing and applying methods for experimentally testing and refining theoretical predictions published recently by NASA colleagues. These theories indicate that polarization of sunlight scattered by clouds can be used to remotely determine whether the clouds contain liquid water droplets or ice crystals. The instruments that have been developed and used for these experiments measure the polarization scattered sunlight – similar to viewing the world through polarized sunglasses, but with very sophisticated glasses. The students who have worked on this and related projects are in high demand in industry and research organizations worldwide.

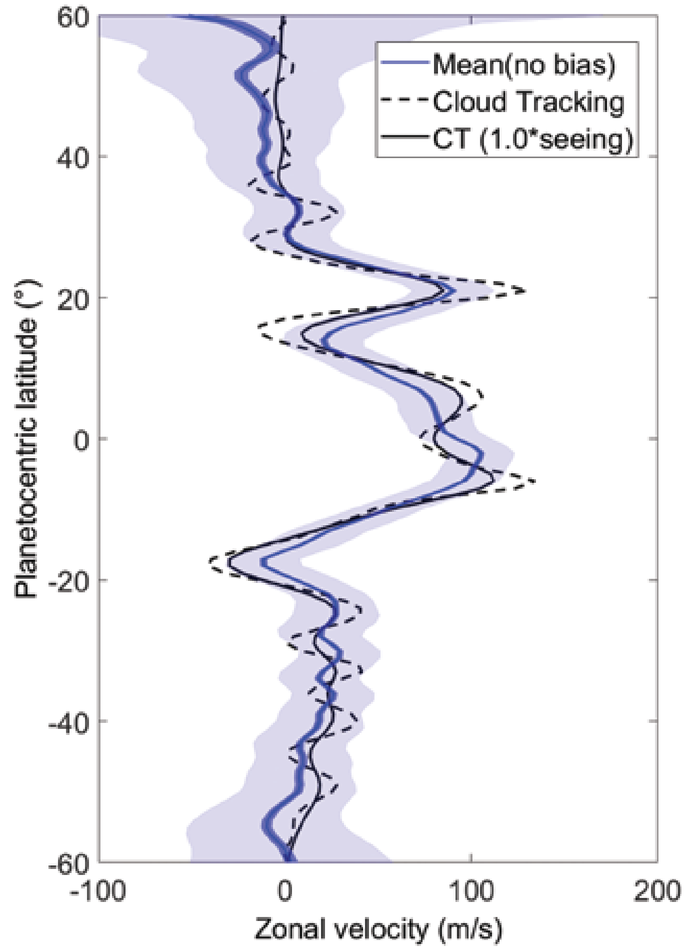
Jovian Interiors from Velocimetry Experiment in New Mexico (JIVE in NM)

New Mexico State University, Ames Research Center, Jet Propulsion Laboratory, Glenn Space Flight Center



Science PI
Jason Jackiewicz, PhD
New Mexico State University

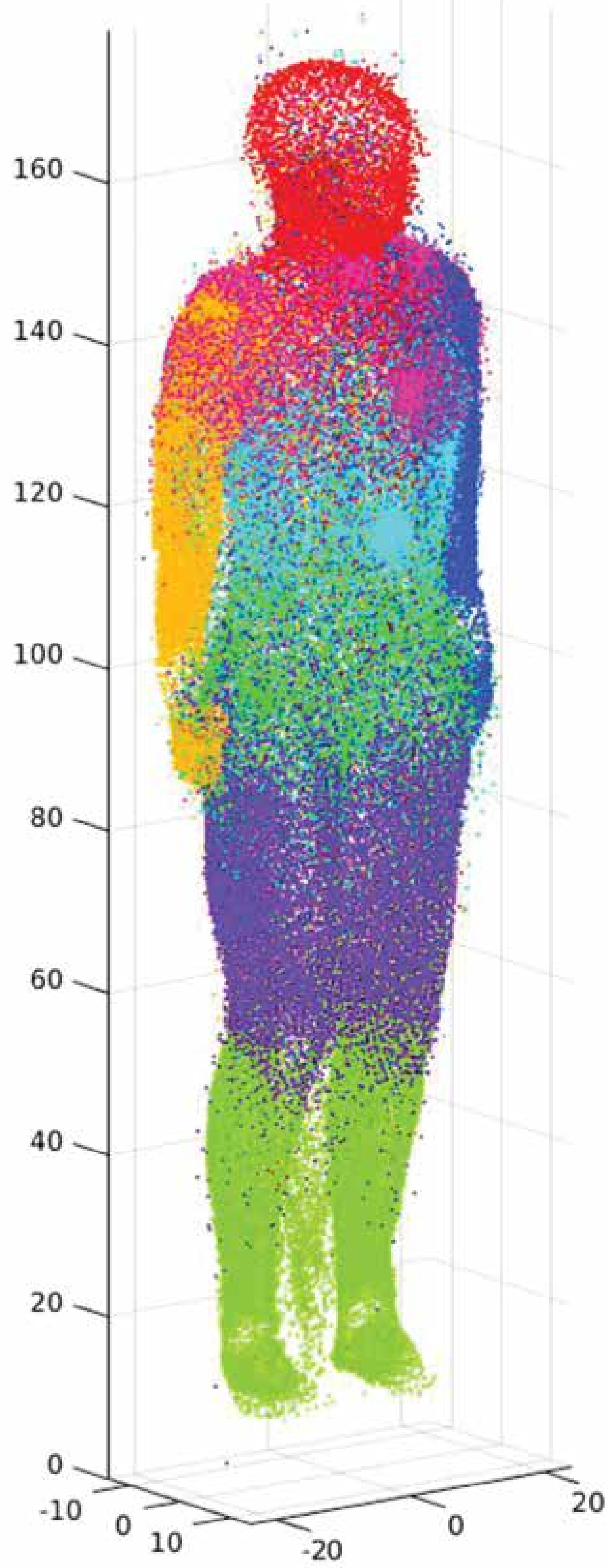
NASA Technical Monitor
Mark S. Marley, PhD
Ames Research Center



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 spectroscopic instrument for such a task has been designed, tested, and installed at the Dunn Solar Telescope in southern New Mexico. In addition to discovering Jovian pulsations, the instrument can measure the complex and puzzling atmospheric wind structures seen on Jupiter. The figure shows the wind speed as a function of latitude and averaged over all longitudes. One sees the alternating prograde and retrograde zones and jets. The figure also compares to results obtained from tracking cloud motions using images from the Hubble Space Telescope. The agreement is very encouraging, showing that accurate measurements from the ground are possible.

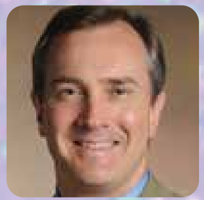
GEANT4 Simulations for Astronaut Risk Calculations

University of Southern Mississippi, Marshall Space Flight Center



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

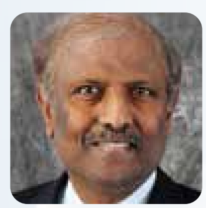
Learning Algorithms for Preserving Safe Flight Envelope Under Adverse Aircraft Conditions

Missouri University of Science and Technology, Ames Research Center

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

Single-Large-Surface Flight Simulator at WSU GAFL

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
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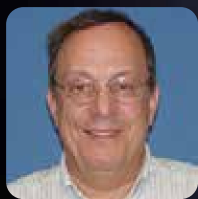
Missouri University of Science and Technology

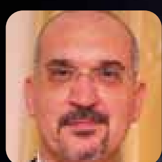
NASA Technical Monitor
Susan Frost, PhD
Ames Research Center

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

Louisiana State University, Glenn Research Center



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 groundbased measurements have 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 three locations – at Utuado in the mountains of central Puerto Rico, at the National Metrology Centre of Panama (CENAMEP) in Panama City, and at Louisiana State University in Baton Rouge – is designed to provide detailed and close-up information about nearby (< 5 km) thunderstorms producing bursts of energetic radiation.

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 locations of two of the detectors are marked by the yellow arrows.

Vertical Comet Assay for Measuring DNA Damage to Radiation

University of Alaska Fairbanks, Glenn Research Center

Photo 1: Miniaturized Vertical Comet Assay device in testing. Only 0.1 V is necessary to perform electrophoresis in this device for about 90 minutes to extract detectable broken DNA strands, as compared to the traditional electrophoresis at the tens voltage level for a few hours.

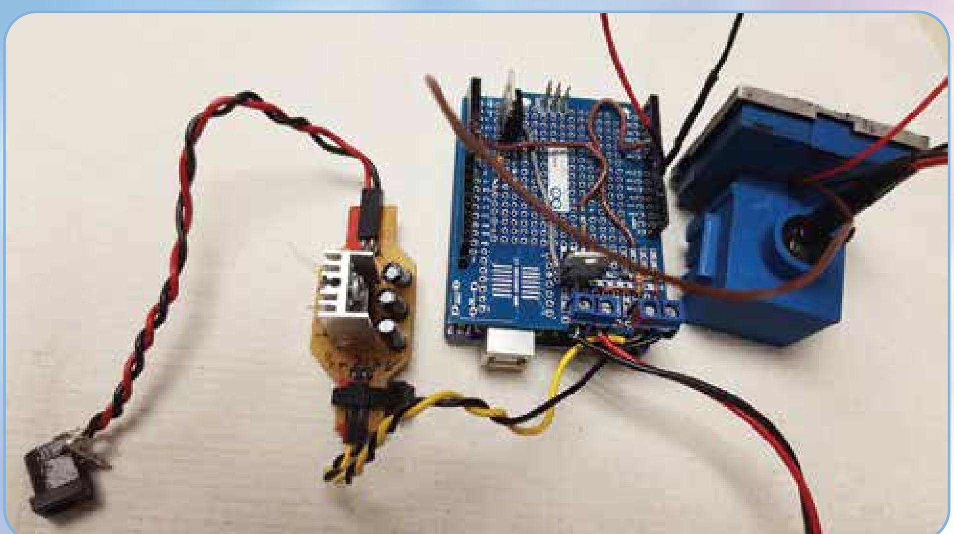
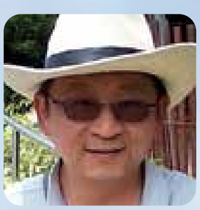
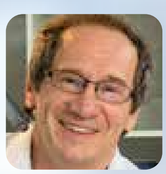


Photo 2: High-sensitivity portable fluorometer (encapsulated in the blue case on the right). When operated by a standard 9V battery with an equivalent energy 4.94Wh, the lifetime of operation falls in 2~5 hours depends on the number of total measurements.



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



NASA Technical Monitor
Yuri Griko, PhD
Ames Research Center

https://sites.google.com/a/alaska.edu/sites/system/errors/WebspaceNotFound?path=%2Fc

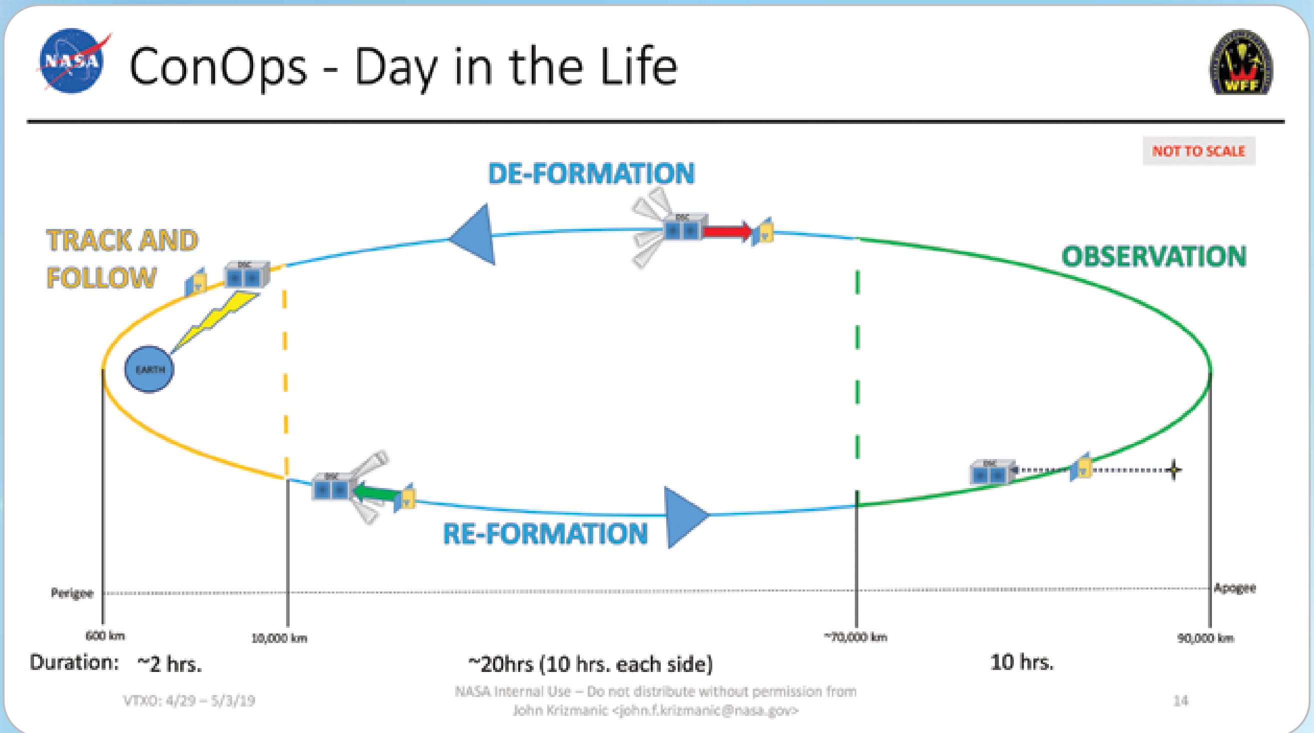
Vertical Comet Assay: The Prospect for Measuring DNA Damage from Space Radiation

NASA has a keen interest in mitigating the human health and performance risks associated with exposure to cosmic radiation during human spaceflight missions. To date, a scientifically sound estimation of the associated risk of chronic exposure to cosmic radiation is still problematic. Data for humans under such exposure is lacking. The existing animal models are inadequate. These issues are originated from the limitation of the current techniques for quantifying DNA damage from radiation, which are configured for operation in a ground-based laboratory. The limitation—the lack of portable apparatus for sampling and detection of damaged DNA in space—restrains any attempt to measure the level of DNA damage in space.

A team at the University of Alaska Fairbanks has developed a portable sampling and detection technique for measuring broken DNA strands. In a four-year research project, the researchers have developed a miniaturized electrophoresis technique, the *Vertical Comet Assay*, named by the researchers. The Vertical Comet Assay, as small as a soda cracker, is proven to be able to extract broken DNA strands from a cell model at a relatively low voltage setting (e.g., 0.1V, see photo 1). To measure the existence of extracted DNA strands in a small-amount of solution, the team has also prototyped and tested a few high-sensitivity portable fluorescence detectors (see photo 2). Palm-sized, light-weighed, and battery-driven, the portable fluorometer has been tested in the laboratory with an ability to detect the existence of fluorescence-labeled DNA strands at a concentration as low as 0.0064 ng/μl. This portable prototype of fluorescence detector is suitable to field applications such as space trips.

Virtual Telescope for X-Ray Observations

New Mexico State University, Goddard Space Flight Center



The VTXO project was one of nine missions selected under the Astrophysics Science SmallSat Studies program (J. Krizmanic, PI). This figure, from the Wallops Missions Planning Lab., shows the Concept of Operations for the VTXO Mission. The spacecraft fly in close formation through perigee and then separate and align for observations taken around apogee. These maneuvers are repeated for each orbit with a different X-ray source targeted during each observational period. Figure used with the permission of J. Krizmanic – PI

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

NASA Co-Technical Monitor
Neerav Shah
Goddard Space Flight Center

Teamwork in Space

New Mexico State University, the University of New Mexico and NASA's Goddard Space Flight Center are teaming to find a way for two small satellites 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 astrophysicists 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.

Using NASA's Ocean Color Sensors to Identify Effects of Watershed Development and Climate Change on Coastal Marine Ecosystems of the US Virgin Islands

University of the Virgin Islands, Ames Research Center

Ongoing issues stemming from the two catastrophic category 5 hurricanes continue to delay some progress on this grant. M. Brandt and T. Smith remain in temporary offices, and the scheduled reconstruction of the MacLean Marine Science Center (MMSC) has been delayed three times which has made scheduling of coordinated field work and analysis with A. Ali and J. Ortiz difficult. Scheduled commencement of demolition was originally for Nov 1, 2018, then June 1, 2019, and now October 1, 2019, but upon submission of this report no demolition activity has been observed.

Reconstruction of the upper floor and stabilization of the entire structure of the Environmental Analysis Laboratory (EAL) was also scheduled to begin October 1, but no activity has been observed. The bottom floor of the MMSC has been used as temporary laboratory space since the passages of Hurricanes Irma and Maria in September 2017. A temporary roof structure was put in place on the upper floor that allowed this use. On August 28, 2019, category 1 Hurricane Dorian hit St. Thomas island directly (the eye of the storm went over the UVI campus). This storm blew the temporary roof off of the MMSC and onto the outer row of seawater tables (photo below). This allowed rain to get to the bottom floor which resulted in standing water and damaged equipment. The storm also damaged the seawater pump at the end of the dock taking the seawater system offline. Another temporary roof was installed within 10 days of the storm's passage and the seawater system was brought back online within one week. M. Brandt and T. Smith have committed significant time to the planning and design of the new MMSC and the movement of laboratory space to trailers and containers stationed in the upper parking lot. This has also hindered their ability to plan for coordinated field sampling and analysis with A. Ali and J. Ortiz. In the additional no-cost extension year, the science team intends to focus on accomplishing Objective 3 which is to compare products produced under Objectives 1 and 2.

Science PI
Marilyn Brandt, PhD
University of the Virgin Islands

NASA Technical Monitor
Liane Guild, PhD
Ames Research Center

http://scepscor.org/

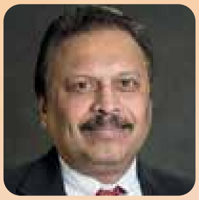
MacLean Marine Science Center after the passage of Hurricane Dorian. The temporary roof installed after the storms of 2017 was blown off when Hurricane Dorian passed directly over St. Thomas.

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, Glenn Research Center

The main goals of this study were achieved by developing a new biologically based life support system, capable of increasing microorganism production by converting unused wavelengths of sunlight into useful 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. A prototype bioreactor with three specific components was designed and fabricated. This first component of the proposed technique is the algae growth layer, where cultures of edible microalgae are grown using wavelengths that are either supplied directly from the sun or have been converted to useful ones by the other subsystems. The second component is a thin film of photonic up/down converting nanoparticles, which take wavelengths in the near ultraviolet and infrared ranges, and converts them into wavelengths useful for the algae layer. The third component is a development of a nanostructured photovoltaic (PV) thin film, which allows for power cogeneration for the other subsystems. We have demonstrated that by carefully filtering light, algae growth of 14% or above can be achieved. In addition, a conversion efficiency of 2.44% was achieved in the nanostructured PV system.

TU graduate students work on the fabrication and testing of novel solar cells.



Science PI
Parameswar Hari, PhD
University of Tulsa

NASA Technical Monitor
Jeremiah "Jay" McNatt
Glenn Research Center

https://okpvri.okstate.edu/

Advanced Transport Technologies for NASA Thermal Management/Control Systems

University of Nevada, Reno, Glenn Research Center

Mr. Blake Naccarato of UNLV with the PC-HEX apparatus he developed.

Science PI
Miles Greiner, PhD
University of Nevada, Reno

NASA Technical Monitor
Vikram Shyam, PhD
Glenn Research Center

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.

https://www.youtube.com/watch?v=Ww_FfdzOJJc

Responsive Autonomous Rovers to Enable Polar Science

Dartmouth College, Goddard Space Flight Center

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.

Frosty Boy during a 2018 field season at Summit,Greenland (courtesy of Austin Lines)

Science PI
Laura Ray, PhD
Dartmouth College

NASA Technical Monitor
Brooke Medley, PhD
Goddard Space Flight Center

Frosty Boy during a 2019 field season in southern Greenland (courtesy of Austin Lines)

https://sites.dartmouth.edu/polarregionsrobotics/

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

University of North Dakota, Grand Forks, Kennedy Space Center

Above: Mission Specialist Jared Peick completes step down microbial culture and analysis of collected soil samples with incubator, petri dishes and other equipment.

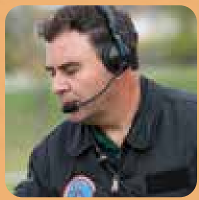
Below: Winter 2018 overview of the completed Lunar Martian Analog Habitat at the University of North Dakota.

http://human.space.edu

The University of North Dakota (UND) Human Spaceflight Laboratory has developed a Multipurpose Research Station in North Dakota in order to expand NASA-relevant research within the state. During the fourth year of the current NASA EPSCoR grant, UND finalized and integrated two additional dedicated modules: an Exercise and Human Performance Module and performed research in exercise regimes for long-duration crews spending time on planetary habitats, and a Geology/Microbiology Module to sample and process geological and biologicalrelevant samples without the risk of contamination by or to the crew. During previous years of the current grant, a Plant Production Module to perform research on the production of edible plants for the crew and an Extravehicular Activities Module were also developed, completed, and tested.

This research includes a collaborative effort among numerous organizations and several NASA Centers. A total of eight analog missions have been performed to date, ranging from 7 to 30 days with crews of three to four crewmembers. Longer duration missions are being planned for the upcoming year of operation.

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 on the Moon and onward to Mars.



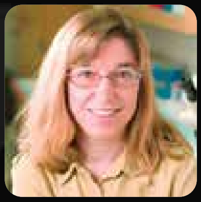
Science PI
Pablo de León, PhD
University of North Dakota

NASA Technical Monitor
Douglas Gruendel
Kennedy Space Center

Large Volume Crystal Growth of Superoxide Dismutase Complexes in Microgravity for Neutron Diffraction Studies

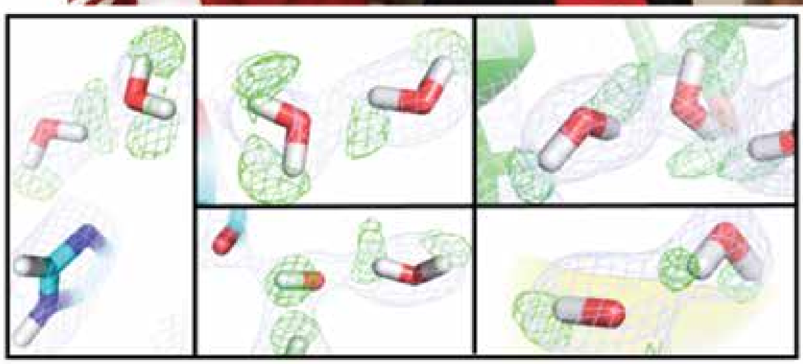
University of Nebraska Medical Center, Johnson Space Center

Space radiation is a health hazard to astronauts and is deadly during a prolonged time in space such as travel to Mars. Every day people on Earth are also susceptible to radiation, with casual exposure causing major health problems such as cancer, neurological disorders, and heart disease. The harm from radiation comes from the formation of reactive oxygen species (ROS), creating oxidative stress and leading to damage to crucial cellular components. Human manganese superoxide dismutase (MnSOD) is a significant enzyme in combating ROS and is essential in combating radiation-induced diseases that astronauts are prone to manifest. The inner workings of human MnSOD are unknown. The catalytic mechanism of MnSOD is unclear owing to limitations in detecting protons, which MnSOD is reliant on to prevent radiation damage. We aim to detect protons using recent technological developments in neutron crystallography, where a neutron beam diffracts off crystallized MnSOD molecules. Neutron crystallography requires large, perfect crystals to obtain high-quality data. After four publications on earth-grown crystals involving a team of students and research staff, the team has now grown crystals of MnSOD on the International Space Station. These microgravity-grown crystals are of superior quality compared to the Earth-grown counterparts and will yield the higher quality data needed for revealing the workings of the radio-protective MnSOD.



Science PI
Gloria Borgstahl, PhD
University of Nebraska Medical Center

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



Neutron diffraction reveals orientations of water molecules in human manganese superoxide dismutase.

Earth-grown cystals (left) vs. microgravity-grown crystals (right) from the same crystallization conditions.

https://sbl.unmc.edu/

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

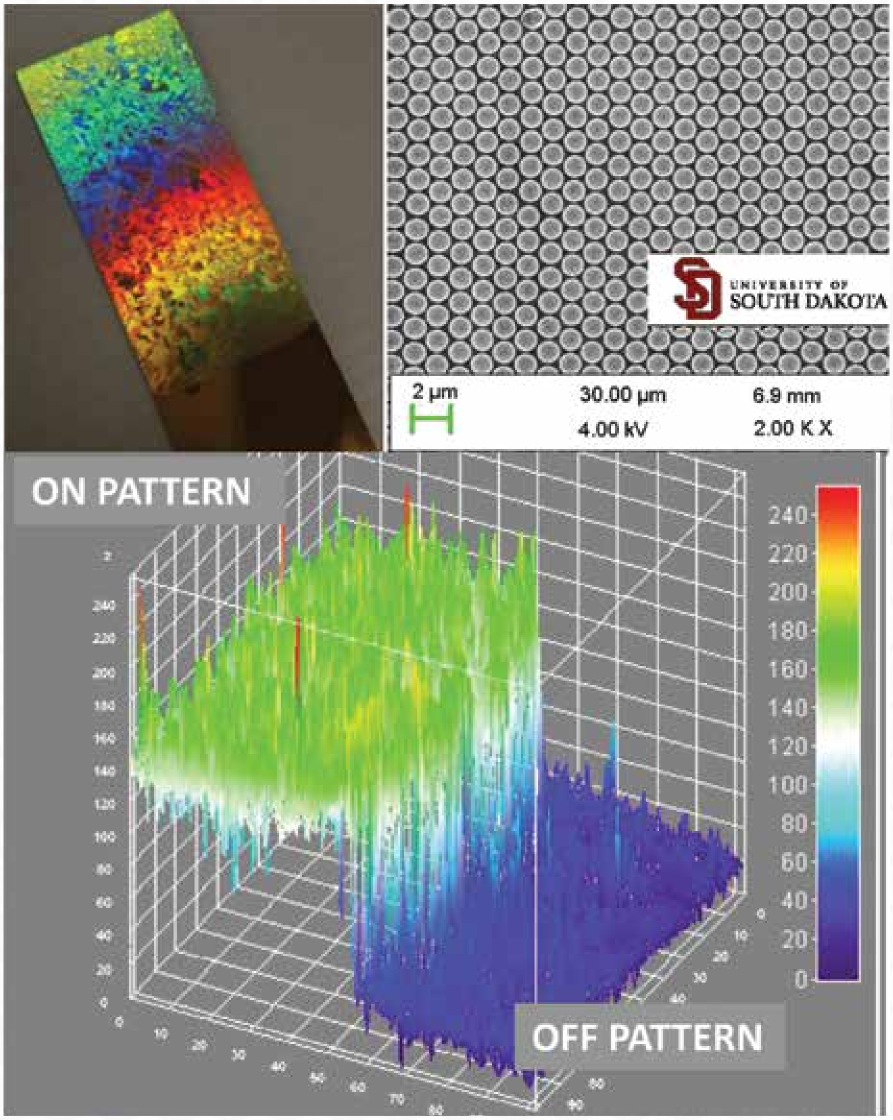
South Dakota School of Mines and Technology, Jet Propulsion Laboratory

Gold Microcavity Arrays as Enhancing Substrates for NIR-to-Visible Upconversion for Solar Energy Applications

A significant fraction of solar radiation is in the near-infrared (NIR) and cannot be directly captured by conventional solar cells. Upconversion phosphors can convert NIR light to useable visible light, but the intrinsic efficiency of the NIR-to-visible upconversion is low. We have designed and fabricated large areas of gold-cavity arrays which can be used as substrates for dramatically enhancing the efficiency of NIR-to-visible upconversion. This work could lead to solar photovoltaic devices that capture a larger fraction of the solar spectrum. Andre Schaum, an undergraduate student working at the University of South Dakota, played a pivotal role in overcoming a key technological challenge; his work enabled us to move from small-sized test arrays to high-quality, large-area arrays suitable for practical applications. Andre won a Barry Goldwater Scholarship based partly on his undergraduate research achievements.

Science PI
Grant A. Crawford, PhD
South Dakota School of Mines & Technology

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



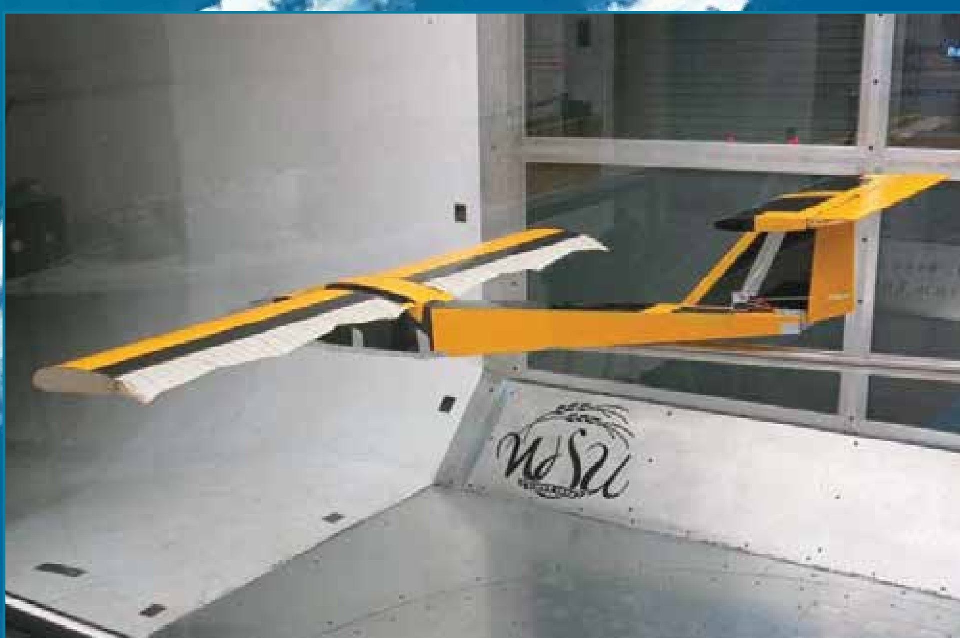
(Upper left) Gold cavity array created using a Langmuir-Blodgett templating method which produces large areas of highly structured hexagonal close packed arrays of 600nm-diameter cavities and shown in the SEM image (Upper right). (Lower Image) Upconversion films coated onto these patterned arrays show dramatic increase in NIR-to-visible upconversion luminescence relative to the same films that are deposited off-pattern.

Active Wing Shaping Control for Morphing Aircraft

Wichita State University, Ames Research Center

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.

WSU's wind tunnel test of the SANSEC sensor for wing shape sensing.



WSU's wind tunnel test of a Variable Camber Continuous Trailing Edge and Flaps (VCCTEF) aircraft.

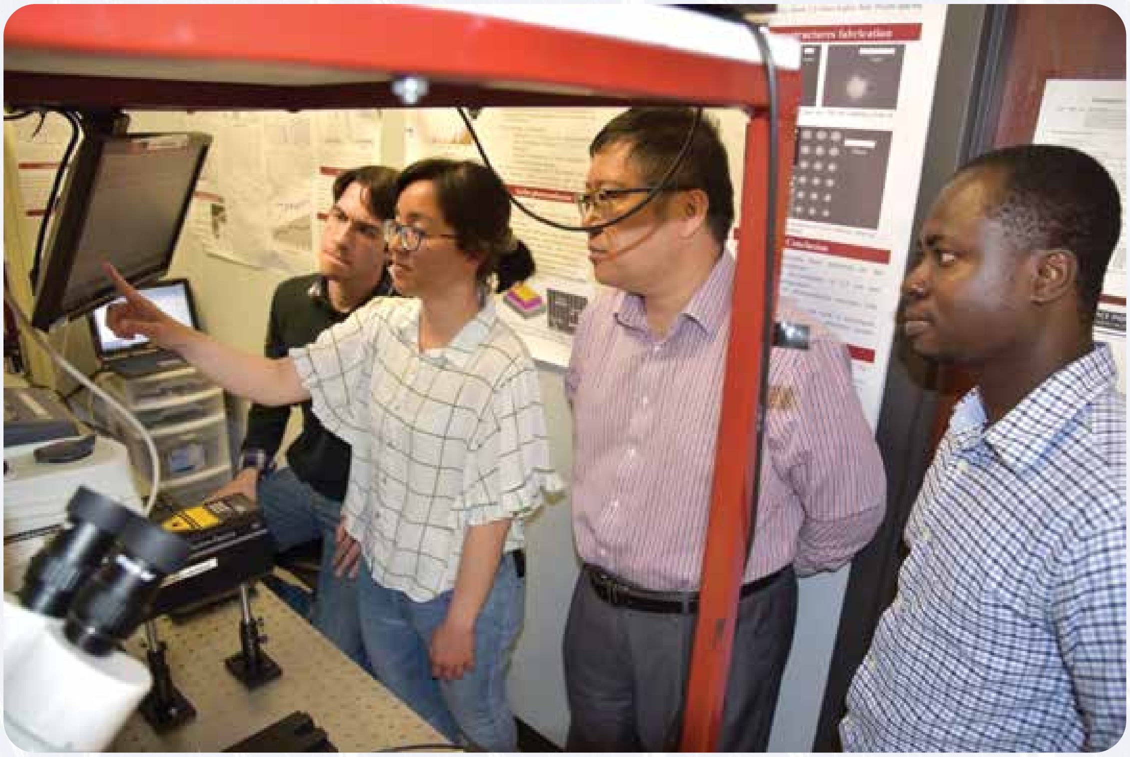
Science PI
James Steck, PhD
Wichita State University

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

https://www.wichita.edu/academics/engineering/aerospace/gafl/research.php

SiGeSn Based Photovoltaic Devices for Space Applications

University of Arkansas at Fayetteville, Glenn Research Center



Yu (second from the right) is analyzing results with his Ph.D. graduate students

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

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

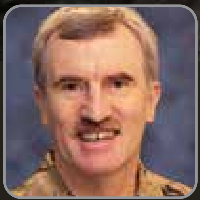
NASA Co-Technical Monitor
Geoffrey A. Landis, PhD
Glenn Research Center

Researchers at the University of Arkansas Fayetteville in collaboration with other universities in Arkansas (UA Little Rock and UA Pine Bluff) have studied silicon-germanium-tin (SiGeSn) PN junctions and photonic devices to be utilized in the future of photovoltaics and multijunction solar cells. Efforts toward a systematic study of SiGeSn materials and devices in this NASA project resulted in a thorough understanding of that powerful semiconductor alloy. A significant material analysis was developed for the growth of high-quality SiGeSn crystalline films using different CVD (UHV-CVD and RP-CVD) mechanisms. This NASA project has contributed significantly to explore different aspects of the SiGeSn materials and devices. Consequently, the team at UA Fayetteville, supervised by Prof. Shui-Qing (Fisher) Yu, received the prestigious "Multidisciplinary University Research Initiative", or MURI award in 2019. A total of $7.5 M funding is provided by the Air Force Office of Scientific Research. This is the first time that the University of Arkansas is the leading institution for the MURI project. A team of other researchers from universities, including Arizona State University, Dartmouth College, University of Massachusetts – Boston and George Washington University will collaborate with Prof. Yu in that project to study high-efficient and cost-effective night vision and infrared imaging systems. In that MURI project, the SiGeSn infrared imaging platform will be designed, fabricated, and tested. The goal is to investigate the capability of the SiGeSn alloys to demonstrate lighter, faster, higher signal-to-noise, and more energy-efficient infrared imaging devices at significantly lower cost compare to the existing systems in the market. Besides its military applications, the SiGeSn-based infrared imaging could be used in healthcare, metrology, surveillance, and autonomous systems.

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

Hawai'i Institute of Geophysics and Planetology, University of Hawai'i, Jet Propulsion Laboratory

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.



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

NASA Technical Monitor
Matthew Fladeland, PhD
Ames Research Center

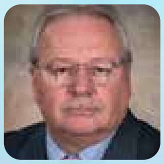
Ocean debris is becoming a significant problem in the Hawaiian Islands, as well as around the Pacific Basin. So tracking the distribution of such debris becomes both an environmental as well as an oceanographic research issue. Above is an example of debris which has washed up on the shores of Oahu within the past year. These mats of old fishing nets can cross the entire Pacific Ocean, and so provide information not only on their source, but also the currents and eddies which brought them here.

Damage Healing of Polymer Composite Structures Under Service Conditions

Louisiana State University, Langley Research Center

Dr. Isiah Warner working with a student and post-doc from his research team in his Chemistry lab at LSU.

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 (2WSMPs), 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 third year of this project, we synthesized a new thermoset shape memory polymer which has mechanical properties comparable to those of conventional thermoset polymers such as epoxy, but is self-healable, recyclable, and 3D printable. We also synthesized a new two-way shape memory polymer, which shows giant expansion upon cooling and contraction upon heating at frozen temperatures, and in particular, expansion under external compressive load. This polymer has the potential to help close cracks at frozen temperatures if it is embedded into a selfhealing polymer matrix. We have also developed a new thermoset epoxy, which is integrated with high mechanical strength, high stiffness, perfect shape memory, self-healable and recyclable, and fire tolerance. In particular, this is the first polymer exhibiting fire triggered shape recovery.



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

Science PI
Isiah Warner, PhD
Louisiana State University

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

University of Maine, Goddard Space Flight Center

The hyperspectral ocean optical sampling instrument HyperSAS mounted on the bow of the ferry "The Cat" crossing the Gulf of Maine in summer 2018.

Each year, harmful algal blooms in waters of the Gulf of Maine necessitate closure of sections of the coast to shellfish harvesting, costing New England coastal states money in both management monitoring and lost revenue. Three marine research institutions in Maine are collaborating to investigate the extent to which NASA's present and future satellite ocean color data can provide information on the types of surface water these blooms preferentially develop in. Using a combination of bio-optical field work done from cross-Gulf ferries, data analysis using neural network algorithms, numerical circulation modeling and GIS mapping, the project is developing tools that quantify the utility of NASA satellite ocean color data to assist in bloom management. Assessment of 17 years of archived satellite color data shows strong interannual variability and trends in the types of water color present in the Gulf of Maine, and the locations where these are found over the season. Work is presently underway to investigate their linkage to the blooms and coastal toxicity events, as well as to provide useful GIS maps showcasing impacted regions to the community.

Science PI
Andrew J. Thomas, PhD
University of Maine

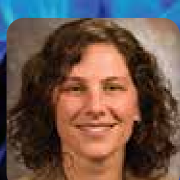
NASA Technical Monitor
P. Jeremy Werdell, PhD
Goddard Space Flight Center

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

University of Wyoming, Glenn Research Center

Low temperature (or "cool") flames have an important role in advanced combustor designs, such as Homogeneous Charge Compression Ignition (HCCI) engines, as well as 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). In this work to-date, cool flames have been extensively characterized for heptane, which is a single component liquid fuel surrogate for logistical fuels of widespread importance. Modeling techniques have been developed to simulate the propagation speeds of these flames, which are a fundamental characteristic that can be used as a validation target for chemical kinetics mechanisms. These techniques have been extended to decane, which is another fuel of logistical importance and for which cool flames have also been observed aboard the ISS. Droplet modeling has been undertaken, using experimentally derived propagation speed data to modify chemical kinetics mechanisms for improved droplet modeling results. 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.

University of Wyoming graduate students conduct formaldehyde planar laser induced fluorescence experiments to visualize cool flame structures

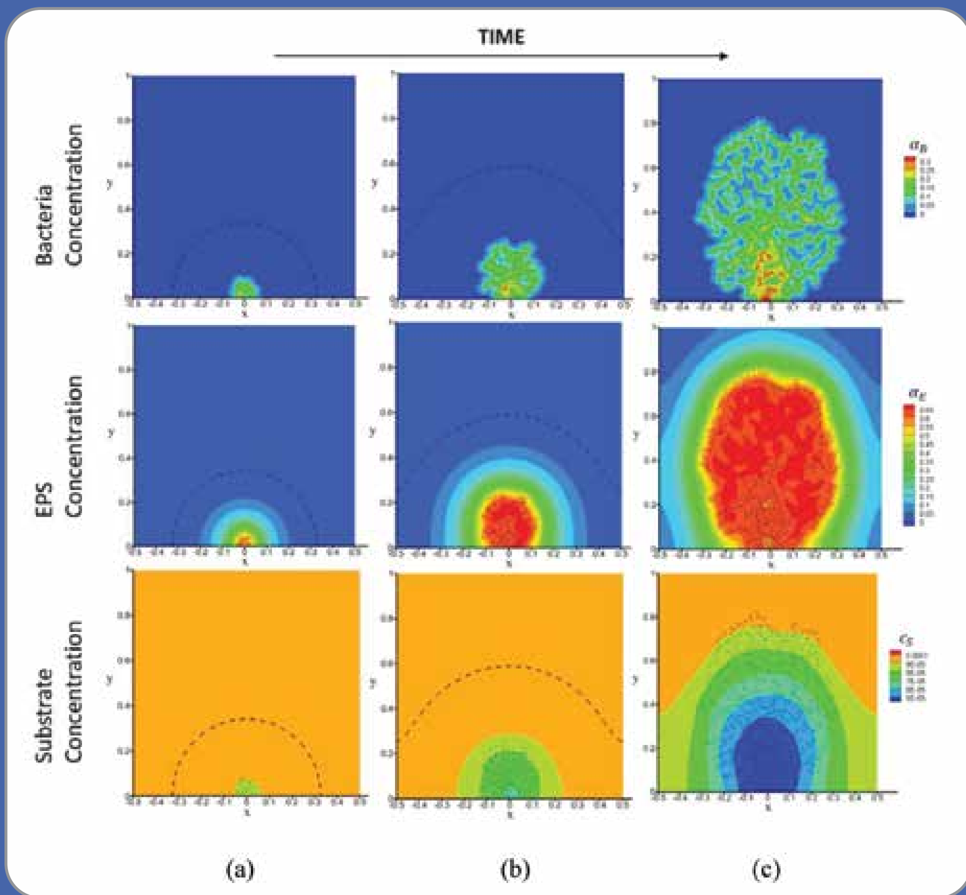


Science PI
Erica Belmont, PhD
University of Wyoming

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

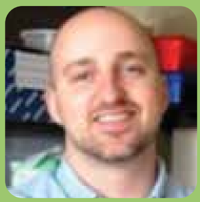
Characterization and Modeling of Biofilm Development by a Model Multi-Species ISS Bacterial Community

University of Vermont, Johnson Space Center

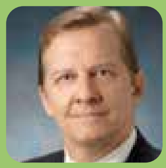


Development of bacteria, EPS and substrate (nutrient) concentration fields for over a series of three time steps, as simulated by the biofilm model

Bacterial biofilms play a critical role in environmental processes, water treatment, human health, biofouling, and in the food processing industry. Biofilms consist of microorganisms embedded in a self-secreted mixed polymer matrix known as Extracellular Polymeric Substances (EPS). Development of biofilms, including generation of spatial organization, is governed by complex interactions between the component cells, EPS, water, nutrients, and non-nutrient signals generated by the bacterial community. There currently exists limited ability to accurately simulate biofilm development in a manner that accounts for the roles of the different components that compose the biofilm system. We have developed a hybrid model that includes the dynamics of the four principal biofilm components – bacteria, EPS, water and nutrients – in which the individual bacterial cells are modeled as discrete agents and the EPS, water and nutrients are modeled as interacting continua. The simulated bacterial cells grow, divide, collide and adhere to each other and to the bottom surface, all while absorbing water and nutrients and generating EPS. The cells can be of spherical, ellipsoidal or sphero-cylindrical shape, representing a wide range of bacteria species.



Science PI
Matthew Wargo, PhD
University of Vermont



NASA Technical Monitor
Mark Ott, PhD
Johnson Space Center

High Efficiency Dilute Nitrides Solar Cells for Space Applications

The University of Oklahoma, Glenn Research Center

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 sun's energy equally across its emission spectrum, which is a perquisite for high power conversion. A method proposed to accomplish this is to add a 4th junction that will more equally "break up" the sun's energy to further improve the performance of the MJSC. The dilute nitrides material - GaInNAs - has a number of practical properties that make it a candidate for this 4thJ 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, along with testing the stability of this process in spacelike conditions. If successful, this project will produce a new generation of solar cells that push the power conversion of MJSCs close to 50%.

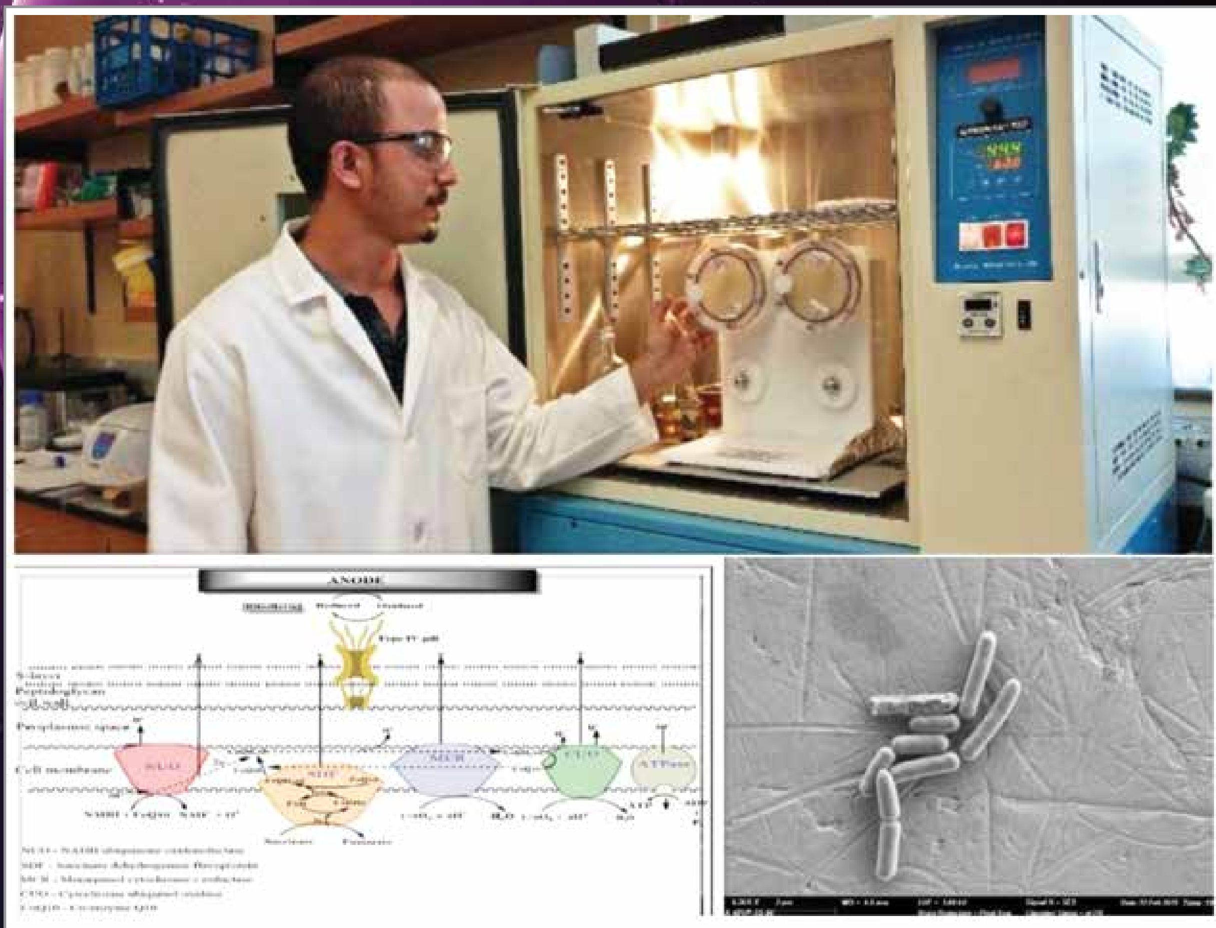
Graduate student probing the electrical properties of solar cells prior to analysis under space conditions

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

NASA Technical Monitor
Jeremiah "Jay" McNatt
Glenn Research Center

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

South Dakota School of Mines & Technology, Jet Propulsion Laboratory, Ames Research Center, Kennedy Space Center



Growing thermophilic microbes in Rotatory Cell Culture System (simulated microgravity condition)

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. This research uses unique microorganisms isolated from the deep levels of the Sanford Underground Research Facility (SURF) as test subjects to develop an advanced biological module that 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 South Dakota School of Mines & Technology, South Dakota State University, University of South Dakota, and several industrial partners.

The research team originally received a 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

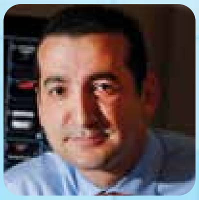
NASA Technical Monitor
Ali Shaykhian, PhD
Kennedy Space Center

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

Wichita State University, Johnson Space Center, Langley Research Center

The long-term impact of this NASA funding is significant for the high school students involved, undergraduate research assistants, graduate students, and faculty here in Kansas. The student involvement in this work is inspiring them about science and biomedical engineering and motivating them to pursue STEM fields and graduate school. This research is providing a foundation for our students and faculty researchers to excel in scholarship, contribute to solving real world problems. Publications with the undergraduate student researchers and graduate students will have long-term effects in helping them to be competitive for graduate school and obtain scholarships. As a result of this NASA funding, Jacob Griffith, a first generation college student and an undergraduate research assistant in this work, was able to successfully compete for the prestigious NSF Graduate Research Fellowship Program (GRFP) award. This NASA research increased the competitiveness of Jacob and in part allowed him to successfully compete for the prestigious NSF Graduate Research Fellowship. Reviewers acknowledged Jacob's involvement in this NASA funded research as a strength to his application. The NSF fellowship will provide a $34K stipend for three years and pay for his graduate school tuition $12K for 3 years. This fellowship will allow Jacob to continue as Dr. Cluff's (Sc-PI) Master's student here at WSU. Additionally, Ryan Becker, (graduate student research assistant in this project) was able to have entrepreneurial experience in trying to commercialize this research. The student entrepreneurs successfully competed for the Red Bull Innovation Summit. Ryan Becker is a first generation college graduate. 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.

NASA research to develop a new wearable sensor to detect multiple physiological parameters.



Science PI
Kim Cluff, PhD
Wichita State University

NASA Technical Monitor
Ali Shaykhian, PhD
Kennedy Space Center

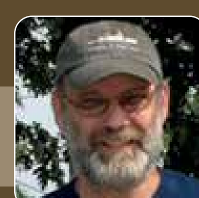
https://www.wichita.edu/research/bioe/Lab_Homepage.php

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

University of Rhode Island, Goddard Space Flight Center

Upper left: URI personnel waiting for SGS drillers to extract the latest drill core section from the core barrel. Lower left: URI and UMN personnel transporting a drill core section to the core processing table. SGS drill rig is in the background. Right: Bottom-most section of drill core, showing contact between loessoid sediments at top and quartzite bedrock below.

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 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 CDSCO at University of Minnesota and their contracting with the drilling team of SGS Argentina, our project recovered an 81m sedimentary sequence that extends into bedrock and completely the previously inaccessible depths of Pliocene and Miocene sediments of Argentina. In doing so, the recovered sequence will provide unique teaching and research opportunities by providing the first samples recovered from a time period that spans warmer periods in Earth's history, a major change in the South American fossil record, and at least one significant meteorite impact event.



Science PI
John King, PhD
University of Rhode Island

NASA Technical Monitor
Cynthia Evans, PhD
Johnson Space Center

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

University of South Carolina, Goddard Space Flight Center

Students from a graduate level course were tasked with surveying a floodplain channel.

This project has supported new and exciting opportunities for two PhD students and several undergraduate research projects in the USC-C and USC-A. For instance, over the grant period, a total of 16 undergraduate students were able to participate in the project through independent undergraduate research contracts, and through paid and voluntary research assistant positions. Moreover, 30% of the students participating in NASA funded research were underrepresented minorities and women. This project has also enhanced learning outcomes at USCA by increasing the number and quality of opportunities to integrate research and teaching through field-based learning experiences and unique opportunities for Dr. Sullivan and USCA undergraduate students to collaborate with faculty and students from other institutions, and across a range of disciplines. Overall, this project has provided Dr. Sullivan with a dramatic boost in her research program during the first years of her tenure-track at USCA.

Science PI
Raymond Torres, PhD
University of South Carolina

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

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

University of Alaska Fairbanks, Kennedy Space Center

Aluminum alloys are a preferred material for aircraft structure. In particular, Al 2024, with copper as the primary allying element for high-strength-to-weight ratios applications, has been used extensively for decades. Yet, there are unsolved issues concerning stress corrosion cracking (SCC) testing of aerospace vehicle structural alloys. Stress corrosion cracking testing is about knowing and predicting ricks of a material in service under synergic harming factors such as humidity, corrosive environments, and various types of mechanical loads.

A team at the University of Alaska Fairbanks has developed and tested an innovate recipe for coating Al 2024 to increase its corrosion resistance for a longer lifetime in service. This technique is based on polymer nanocomposite coatings (PNCCs), developed by project PI Prof. L. Zhang.

Now in the third year, the team has characterized the corrosion properties of the PNCC-coated Al 2024 alloy. Not done yet, the team is about to conduct SCC testing, a very challenging task as it is involved with corrosion and fracture of materials, two very distant disciplines that can only be tackled with specific apparatus and highly trained personnel. During the third year, co-PI Prof. C.-f. Chen has designed, prototyped, and tested 7 sets of portable test rigs for conducting the SCC testing. Each rig is able to perform various loading patterns, such as a constant loading rate as slow as 10-8 strain per second, required for SCC testing. The team was thrilled that the innovation of the test rigs were disclosed to the University of Alaska Fairbanks for a patenting consideration. Prof. Chen will next test PNCC-coated specimens, to know the superiority of the coating in mitigating SCC susceptibility and to understand the related SCC failure mechanisms.

This impact of this project can be evidenced by the innovations of techniques and machines developed by the team, to answer some unsolved issues in SCC testing of coated Al 2024 alloys. The outcomes could potentially advance the use of aluminum alloys in more harsh environments.

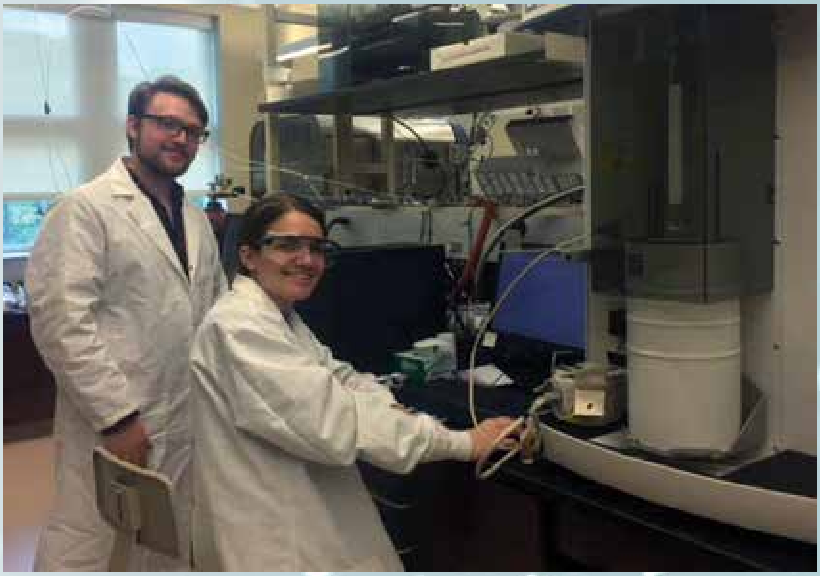
Research assistants with the portable test rigs developed at the University of Alaska Fairbanks by Prof. C.-f. Chen

Science PI
Lei Zhang, PhD
University of Alaska Fairbanks

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

Development of Dust Free Binders for Spacecraft Air Revitalization Systems

University of South Alabama, Johnson Space Center, Marshall Space Flight Center



Graduate students in Dr. Glover's Research Group each authored, and were awarded, competitive fellowships to support their work related to this NASA grant.

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 is now employed as an engineer at AM/NS Calvert and another by Malvern Panalytical. The student now employed by AM/NS Calvert is 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. The other undergraduate student completed a Research Experience for Undergraduates program at Harvard in the Summer of 2019.

This program has contributed to the development of research at the University of South Alabama through research infrastructure. Specifically, the University of South Alabama now has current research adsorption equipment that, to the best of our knowledge, cannot be found anywhere in the State, which has positioned the University to compete for research funding that was simply not previously possible.

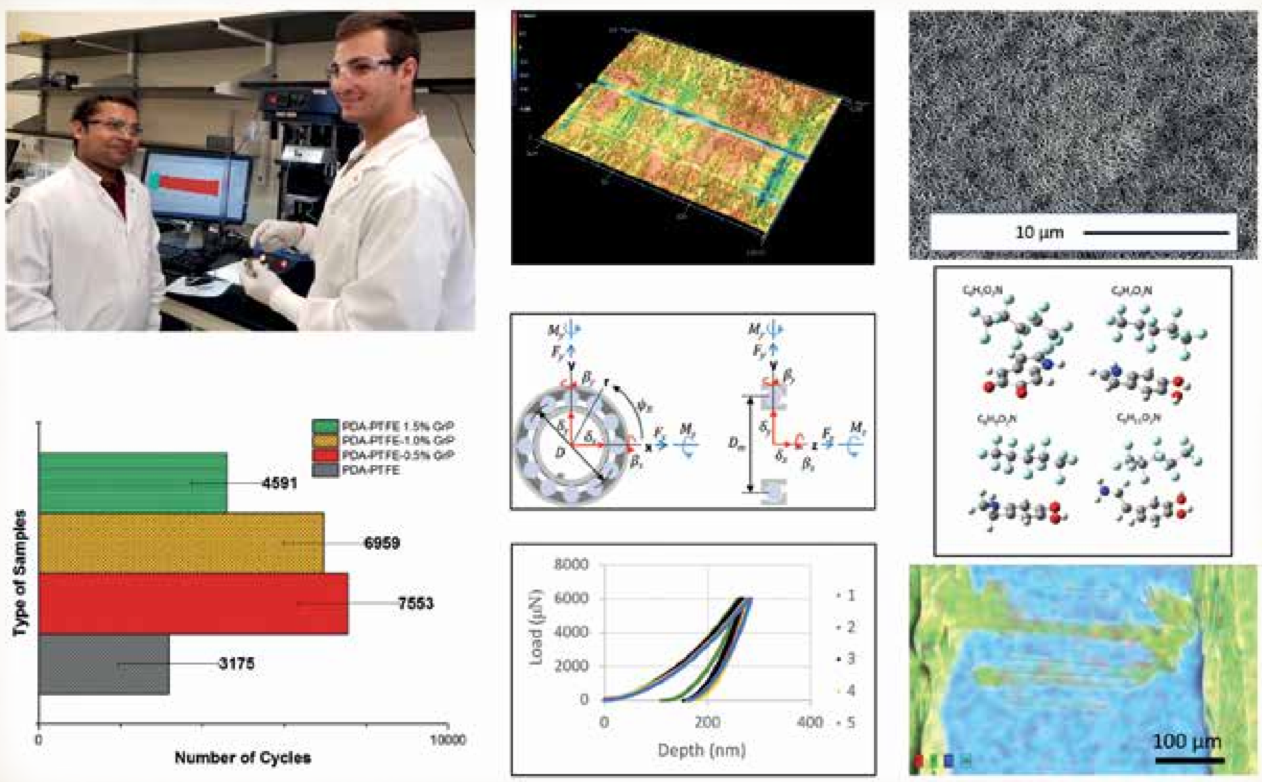
Science PI
T. Grant Glover, PhD
University of South Alabama

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

Research

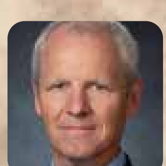
Bio-Inspired PTFE-Based Solid Lubricant Coatings on Nickel-Titanium for Space Mechanisms and Aerospace Applications

University of Arkansas at Fayetteville, Glenn Research Center



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 at Fayetteville



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.

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

Delaware State University, Goddard Space Flight Center

Science PI
Renu Tripathi, PhD
Delaware State University

NASA Co-Technical Monitor
Michael A. Krainak, PhD
Retired from Goddard Space Flight Center; Currently Chief Tech. Officer at Relative Dynamics Inc.

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

The research performed under this project has brought quite a few opportunities to disseminate the results in various conferences and other platforms. This has brought the Optics research at Delaware State University to forefront and has positively impacted the public awareness. Some of the main impacts are as follows:

1. The Sc-PI and Co-I, Drs. Tripathi and Pati attended the NASA Fundamental Physics & Quantum Technology Workshop in Washington DC during April 08-10, 2019. They presented a poster based on the work done in this EPSCoR project. As a result, they received communication from the Executive Director of the White House Initiative on Historically Black Colleges and Universities, White House Domestic Policy Council, U.S. Department of Education to take the initiative to connect Delaware State University to the office of Assistant Director for Quantum Information Science at the White House Office of Science and Technology Policy to participate in the National Quantum Initiative (NQI).

2. Graduate student Ms. Christiane Ebongue participated in the SPIE Student leadership workshop during Photonics West Conference 2019. She was chosen as one of the Faces of Photonics by SPIE: https://photonicsforabetterworld.blogspot.com/2019/04/facesofphotonics-applied-optics-masters.html

3. We participate in various outreach activities in the Delaware region, including at Optics outreach at William Henry Middle School in Dover, Delaware.

4. Ms. Christiane Ebongue attended the Congressional Day Visits (CVD) organized by SPIE and OSA to celebrate the National Photonics Initiative (NPI) on April 03, 2019. During the visit, the group met with Rep. Sheila Jackson Lee (D-TX). Picture below shows

Rep. Sheila Jackson Lee (center) and Christiane Ebongue on her right

Sodium magnetometer setup in Tripathi Lab. From L to R: Dr. Tripathi, Kevin Heesh and Dr. Grewal

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

University of Hawai'i at Manoa, Ames Research Center

Research

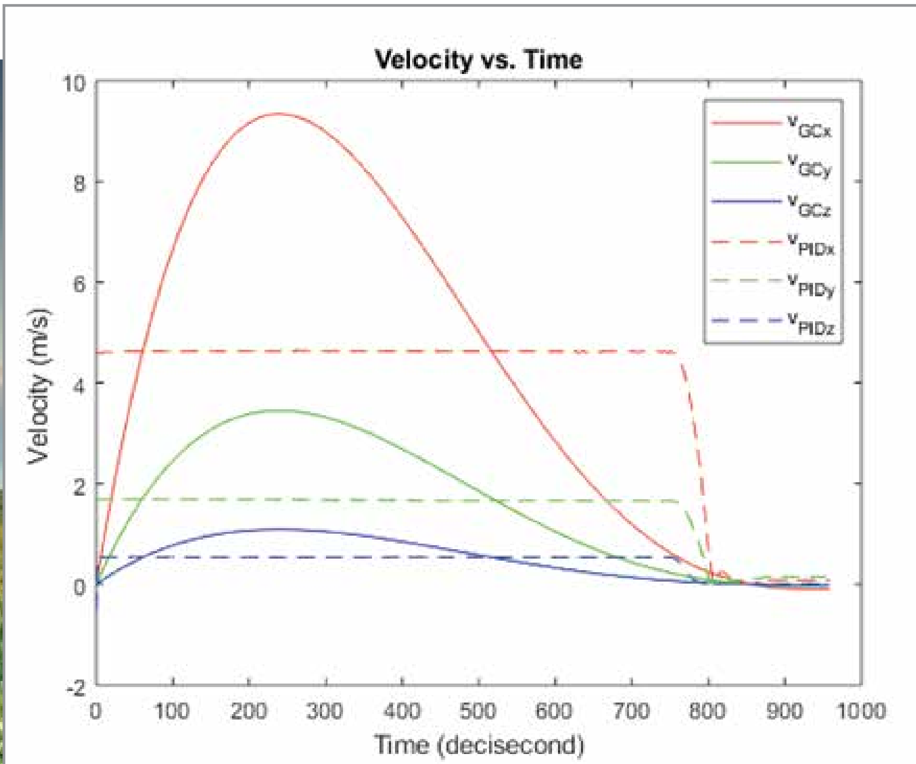


Figure 1. Velocities integrated from the accelerations computed via the proposed E-guidance technique.

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

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

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. As part of the project, the targeting and GNC (TGNC) platform with appropriate guidance and control functions has been developed and implemented for various maneuvers for fixedwing aircraft and quadcopters (Figure 1). The proposed research paves the way to leveraging the autonomy and enables UAVs with various capabilities, including sense and avoid, collision avoidance, beyond line-of-sight, utility of maps to find safe areas for landing, etc. Development of UAV technologies allows us to further disseminate educational curricula, extend the utility and applications of UAV in Central Pacific and Micronesian Islands. The UAV technology and applications resulting from the project contribute to the fulfillment of the NASA strategic plans as well as the NASA Earth Science missions.

Discussion of research results with the project team and collaborators

http://www.hawaii.edu/actuas

Space-Grade Flexible Hybrid Electronics

Boise State University, Ames Research Center, Johnson Space Center, Marshall Space Flight Center

Science PI
David Estrada, PhD
Boise State University

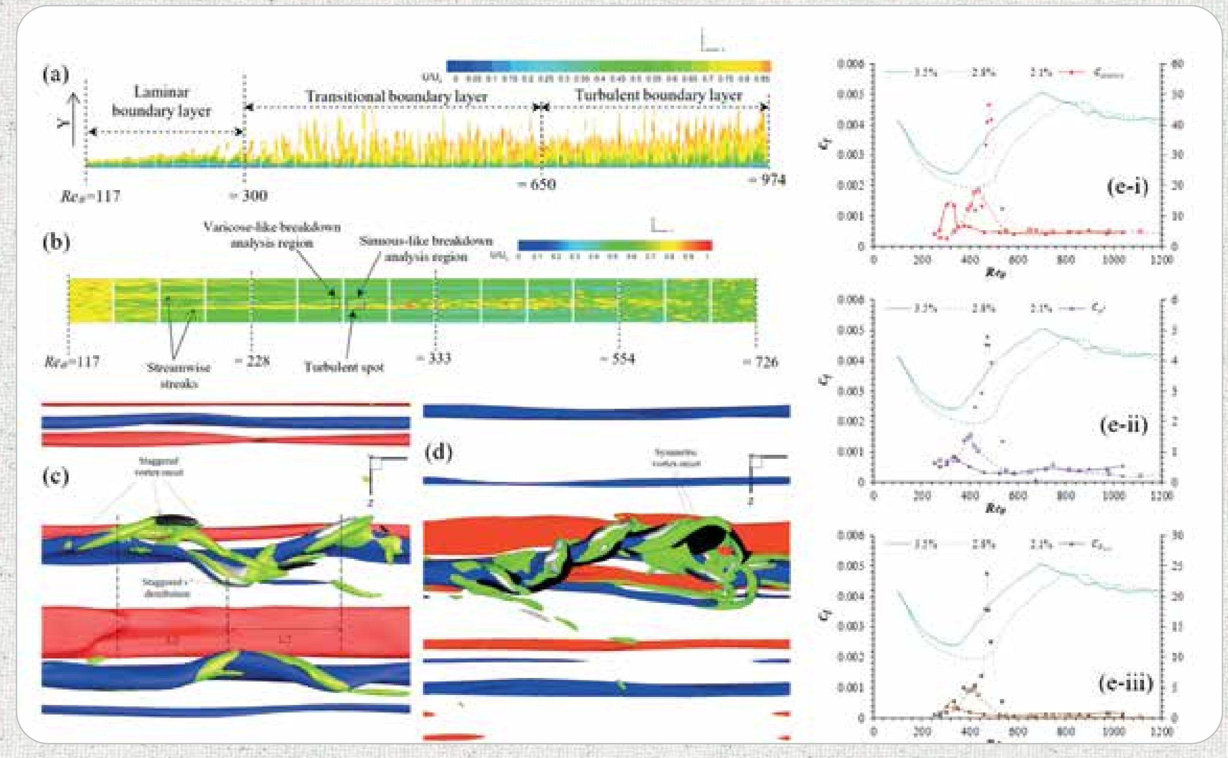
NASA Technical Monitor
Jessica Koehne, PhD
Ames Research Center

Boise Idaho is becoming a hotbed for flexible electronics. A team of researchers in the State of Idaho are advancing the field of flexible electronics with support from NASA. Boise State University, American Semiconductor, and the University of Idaho have partnered to investigate the possibility of manufacturing specialized sensors in space, using a flexible hybrid electronics (FHE) approach. Flexible hybrid electronics are an innovative approach to combining flexible silicon integrated circuits with printed nanomaterials in order to develop a completely flexible electronic system. American Semiconductor, Inc. (ASI), headquartered in Boise, is the global leader in physically flexible integrated circuits called Semiconductor-on-Polymer (SoP). The team was recognized with awards at this year's FlexTech Conference. Boise State's Tony Varghese received was recognized as an outstanding early career researcher in flexible electronics with a best poster award for his work on "Additive Manufacturing and Photonic Sintering of Flexible Thermoelectric Generators for Wearable Applications. ASI was awarded the 2019 FLEXI award for Product Innovation for their new FleX-NFC™ flexible near field communication technology. This technology allows wireless communication between sensors and your phone for a variety of Internet of Things applications. This year American Semiconductor released a flexible Bluetooth Low Energy chip, FleX-BLETM which is a game changer in the field of flexible and wearable electronics. The team is of researchers is now working on solving fundamental challenges in FHE technologies, e.g. power dissipation of electronics, die attachment strategies, and device reliability to advance FHE technology for in-space manufacturing of custom sensors and electronics, positioning the Idaho EPSCoR jurisdiction to become a global leader in this technology.

Dr. Courtney Hollar (left) and Twinkle Pandhi (right) inspect an array of flexible carbon nanotube sensors printed on polyimide substrate

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

Mississippi State University, Glenn Research Center, Marshall Space Flight Center

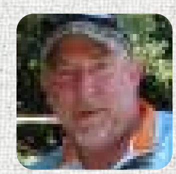


Direct numerical simulation of bypass transition over flat-plate boundary layer. (a) Contours of instantaneous streamwise velocity at the spanwise center plane. (b) Contours of streamwise velocity shown in x-z plane close to the wall. (c) Sinuous-like and (d) varicose-like breakdown of streamwise streak 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

Coordinated Position and Attitude Control for Formations of Small Satellites

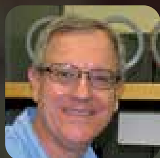
University of Kentucky, Ames Research Center, Kennedy Space Center, Marshall Space Flight Center

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.

Electromagnetic formation-flying satellite experiment: Electromagnetic actuators (experimental setup pictured) are used to control the relative position and attitude of small satellite swarms

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.

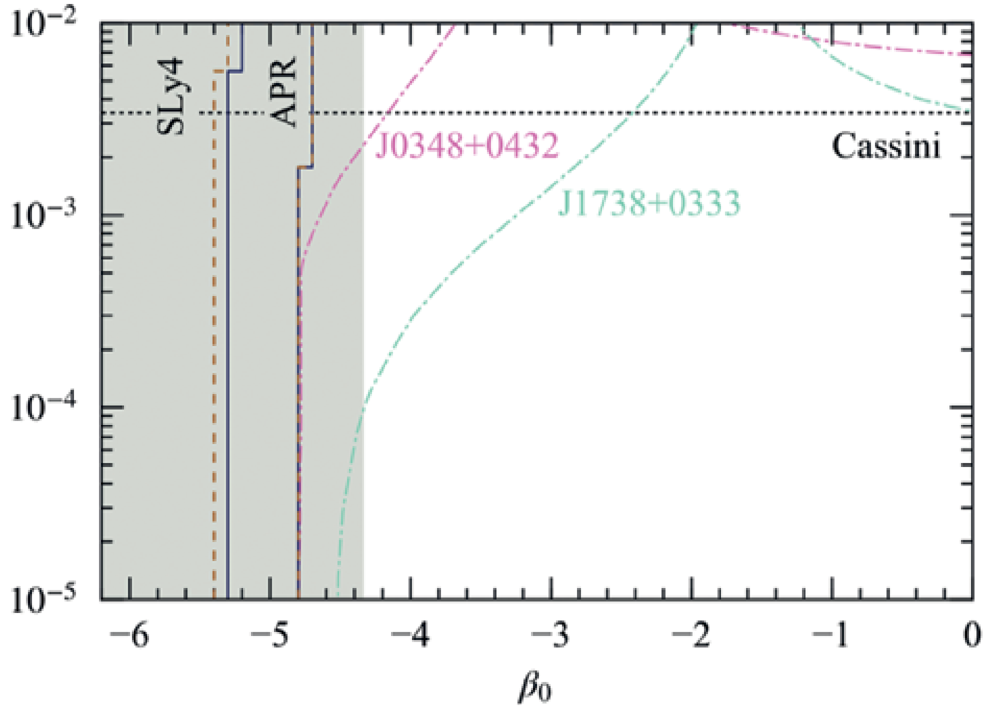
Science PI
T. Michael Seigler, PhD
University of Kentucky



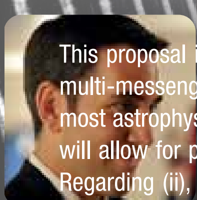
NASA Technical Monitor
Robert C. Youngquist, PhD
Kennedy Space Center

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

Montana State University, Goddard Space Flight Center, Marshall Space Flight Center, Jet Propulsion Laboratory

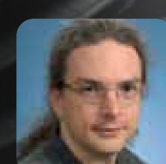


Projected 1σ-constraints on scalar-tensor theory parameters from pulse profile observations with NICER. In this plane, general relativity is pushed infinitely down the ordinate. The shaded region covers the portion of the parameter space in which spontaneous scalarization happens. The solid (dashed) lines delimits the 68% credible regions for stars rotating with f = 600 (200) Hz, and different equations of state. For comparison, we also included the 68% credible regions from the Cassini mission (dotted line) and the binary-pulsar systems J1738-0333 and J0348-0432 (dot-dashed lines). The left-most part of our constraints lays on β0 = −4.8 (for the APR equation of state), indicating that pulse profile observations have the potential to marginally exclude strong-gravity phenomena as spontaneous scalarization.
Image from Neutron star x-ray burst oscillations as extreme gravity probes (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 model independent 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.

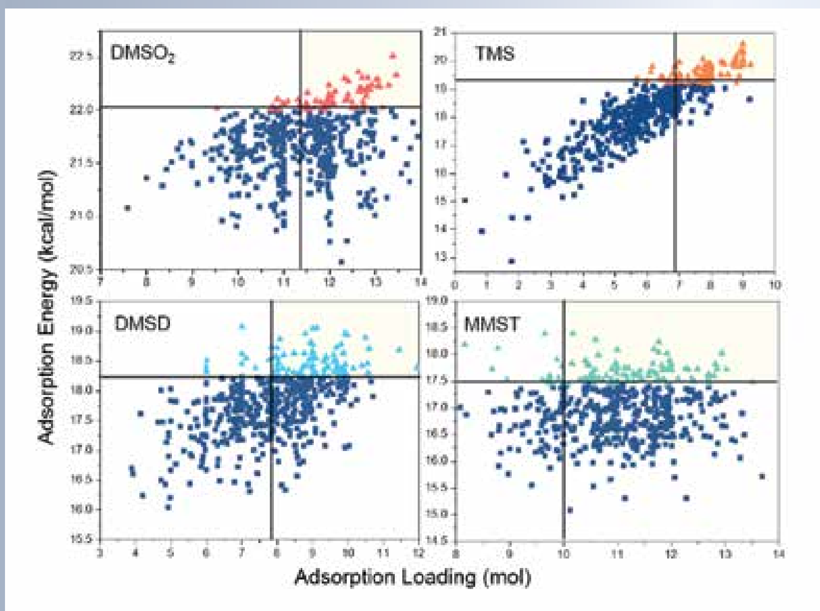


NASA Technical Monitor
John G. Baker, PhD
Goddard Space Flight Center

During year 2, 24 papers were published (with a subset submitted but awaiting referee reports). In addition, we have established several new collaborations that have included MSU graduate and undergraduate students. The papers published report on work related to all research focus areas.

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

University of Puerto Rico, Goddard Space Flight Center



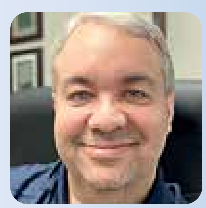
Experimental evidence of the superior adsorbent materials developed to remove problematic compounds from reclaimed water, including dimethylsulfone (DMSO2), trimethylsilanol (TMS), dimethylsilanediol (DMSD), and monomethylsilanetriol (MMST).

ISS water reclamation assembly unit duplicate at MSFC.

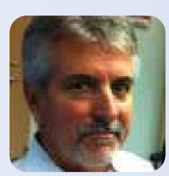
https://academic.uprm.edu/arturojh/

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. To overcome these challenges, scientists from the University of Puerto Rico are developing nanoporous adsorbent materials to be used as filters for onboard treatment of water. The design strategy involves the use of machine learning based computational and materials synthesis methods to elucidate the features and properties of adsorbents capable of effectively removing problematic compounds (i.e., siloxanes) from water during space missions. The products of this project are also expected to pave the way for the development of new terrestrial wastewater treatment technology based on adsorption to remove persistent contaminants, particularly for remote areas with limited resources.

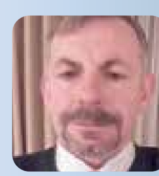
The site visit by the project's Technical Monitor, Andrew Trunek (NASA Glenn Research Center), took place on October 19th, 2018. Michael Flynn (NASA ARC) was also present during the visit. As part of the agenda, the PD, Science-I and Co-Is offered presentations with an overview PR NASA EPSCoR and the details about the progress attained during the first year of the project. The students affiliated to this project participated in a poster presentations session and also met with Mr. Trunek. The site visit also included a tour of the project's laboratory infrastructure located at UPR Mayaguez.



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

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

University of the Virgin Islands, Goddard Space Flight Center

UVI refurbishes Etelman Observatory and Virgin Islands Robotic Telescope after effects of hurricanes Irma and Maria – better than ever!

The impacts of hurricanes Irma and Maria in the USVI were felt acutely in the immediate aftermath of the September 2017 storms and chronically as the recovery dragged on for some 2+ years. The USVI's Etelman Observatory and UVI's physics team, however, was one of the first groups in the territory to take matters into its own hands to recover, repair, and restart. In the weeks after the storms, when most in the territory were struggling just to find food, water, and shelter, the UVI physics team was organizing education and outreach activities at UVI's library using a generator-powered inflatable planetarium. "Thank you - for 30 minutes I completely forgot my house has no roof." remarked one grateful patron after their visit. Carrying on, the crew went to work patching the observatory back together, diagnosing failed components, and repairing critical items needed to get back to the business of doing science. Over the past 30 months, the facility has been repaired back to a better state than it was in before the storms and the Virgin Islands Robotic Telescope is, today, operating at 10x greater efficiency than it did before the storms, thanks to new personnel and new collaborations. While no one is eager to revisit the storms of 2017, it is true in this case, that which did not kill the facility has made it stronger.

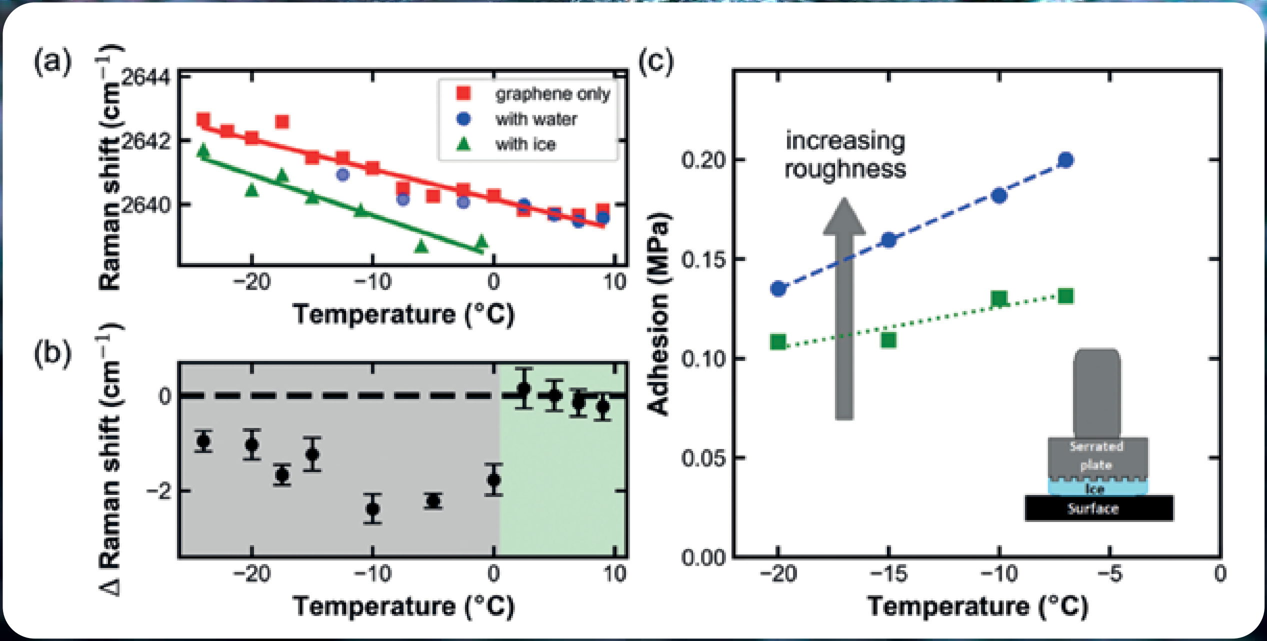
PHOTO UNAVAILABLE

Science PI
Hien Vo Bich, PhD
University of the Virgin Islands

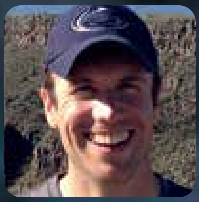
NASA Technical Monitor
Georgia A. De Nolfo, PhD
Goddard Space Flight Center

Advanced Optical Measurements of Ice Adhesion on Icephobic Aircraft Surfaces

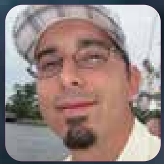
University of Wyoming, Glenn Research Center, Langley Research Center



(a), (b) Temperature-dependent changes in single-layer graphene with and without ice are optically probed and (c) rheological measurements show that as the temperature decreases, the adhesion also decreases, an effect that is increased with surface roughness.



Science PI
Bill Rice, PhD
University of Wyoming

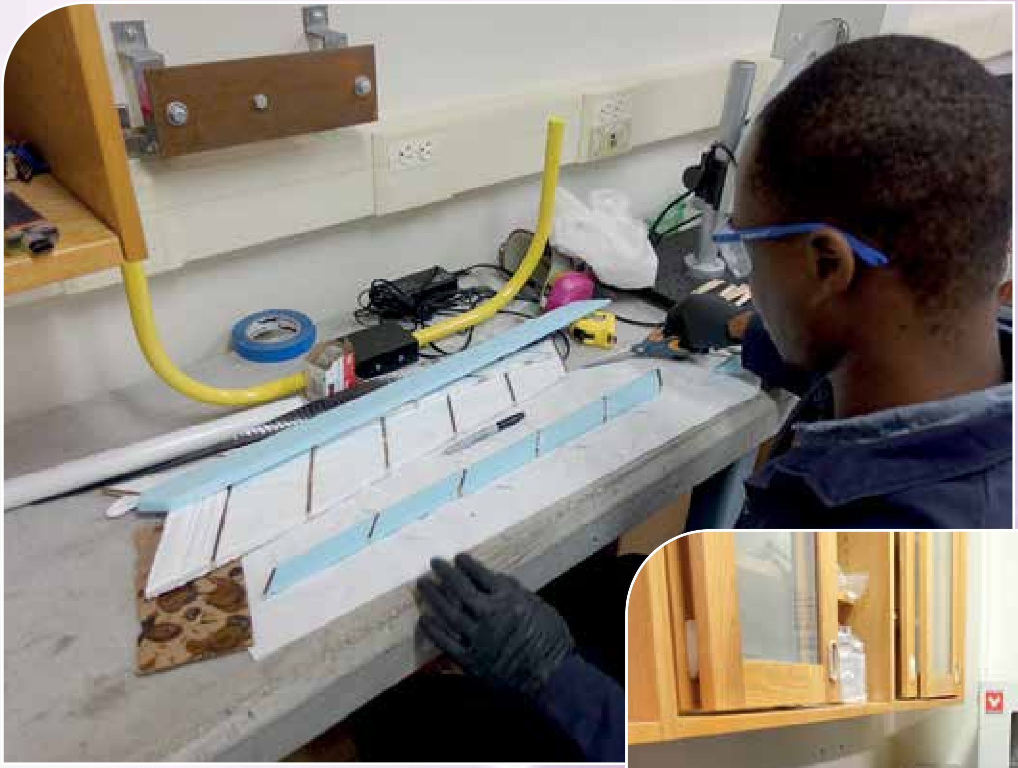


NASA Technical Monitor
Christopher Wohl, PhD
Langley Research Center

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 on 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. We are currently trying to confirm and expand on this exciting development using surface roughness, 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.

Autonomous Structural Composites for Next Generation Unmanned Aircraft Systems

New Mexico Institute of Mining and Technology, Armstrong Flight Research Center



Mongare is fabricating ATW at New Mexico Tech.

Science PI
Donghyeon Ryu, PhD
New Mexico Institute of Mining and Technology

Mongare is fabricating the corrugated P3HT-based thin films at New Mexico Tech.

NASA and university researchers could be on the cusp of a new structural health monitoring approach for aircraft and spacecraft. The technique is centered on a two-part composite material that emits light when flexed. The MLO composite consisted of two polymers: a conductive polymer with a photoactive layer and an elastomer embedded with crystals. The crystal-embedded component glowed green or orange or blue, depending on the formulation, and the other polymer component reacted to this glow by generating an electric current. The marriage of the two materials was invented about five years ago by Donghyeon "Don" Ryu, an engineer in the growing field of smart materials who at the time had just joined New Mexico Tech, where he is an assistant professor. He called his rubbery creation the MLO composite, short for mechano-luminescent-optoelectronic composite. He has a patent pending on the invention.

NASA Technical Monitor
Alexander Chin, PhD
Armstrong Flight Research Center

As designers push aircraft structural and performance limits to produce greater fuel efficiency, sensors that can tell pilots or flight control computers about the structural health of an in-flight aircraft will play a more important role. They could also help minimize inspections or develop new control laws for aircraft. Computers paired with SHM sensors could identify and avoid the type of severe wing flutter that could cause airplane wings or tail structures to explode into pieces during flight, for example. By incorporating SHM into their aircraft, designers wouldn't have to overbuild the wing structure to stiffen it, which adds weight or bulk to the airplane.

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

University of Guam, Jet Propulsion Laboratory

The University of Guam (UOG) is using novel data sets to characterize reef fish spawning aggregation sites and corresponding coral reef health around Guam. These data sets include environmental variables that are known to be related to reef fish spawning aggregation site locations that are dependent upon healthy reefs. Some of these data sets are being collected in non-traditional ways to increase the spatial extent of data collection and to improve data quality. For example, an unmanned user-controlled surface vehicle (USV) was deployed to collect bathymetric data even in relatively shallow water (< 1m depth). Other specialized instruments deployed at study sites collect certain oceanographic data used to better characterize the physical parameters present at spawning aggregation sites. Geo-spatially referenced visual surveys collect data sets that provide estimates of spawning fish distribution and abundance patterns at and near spawning aggregation sites. Of considerable interest is the use of the DiveRay, an underwater hyperspectral imager that records natural light reflectance from the benthos on the seafloor, which is an example of cutting-edge research techniques being used by GEOCORE to characterize reefs. Dr. Tom Schils, a GEOCORE Co-I, is working with collaborators at PlanBlue, the company developing the DiveRay instrument, to assign spectral signatures to different benthic reef species and quantify their presence at study sites. This process includes the creation of annotation libraries and use of machine-learning algorithms to classify the DiveRay hyperspectral data so as to reveal substrate types and species composition of benthic-dwelling organisms as indicators of healthy versus non-healthy reefs. Then, the data will be used to assess the relationship between reef health and the location of fish spawning aggregation sites. GEOCORE's field-collected oceanographic data will be analyzed along with satellite data collected or distributed by NASA. The results are relevant to the management of fish spawning aggregations and coral reefs, as well as furthering our understanding of reef biodiversity and community structure.

Science PI
Terry Donaldson, PhD
University of Guam

NASA Technical Monitor
Leo Y. Cheng
Jet Propulsion Laboratory

The DiveRay, an underwater instrument that captures hyperspectral reflectances from the benthos, in use at a coral reef off Guam. GEOCORE will use these data, along with other field-collected data and satellite data, to characterize coral reef fish spawning aggregation sites.

Fast Traversing Autonomous Rover for Mars Sample Collection

West Virginia University, Jet Propulsion Laboratory, Ames Research Center

The design of the Fast Traverse Rover at its minimum (left, 15 cm), cruise (middle, 30 cm), and maximum (right, 45 cm) ground clearance points.

(Left) A Pathfinder robot experiencing slippage due to the slope and sandy terrain in JPL Mars Yard; (Right) another Pathfinder collecting data in a Utah desert.

Science PI
Yu Gu, PhD
West Virginia University

The developed rover perception and autonomy algorithms could significantly improve the safety and performance of future planetary rovers and enable mission concepts that are not currently possible. The project also enhances the research infrastructure in the state of WV, brings educational benefits to a large number of graduate and undergraduate students at WVU, and supports outreach activities to a broad audience.

NASA Technical Monitor
Heather Justice
Jet Propulsion Laboratory

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

South Dakota School of Mines & Technology, Johnson Space Center, Glenn Research Center, Langley Research Center, Ames Research Center

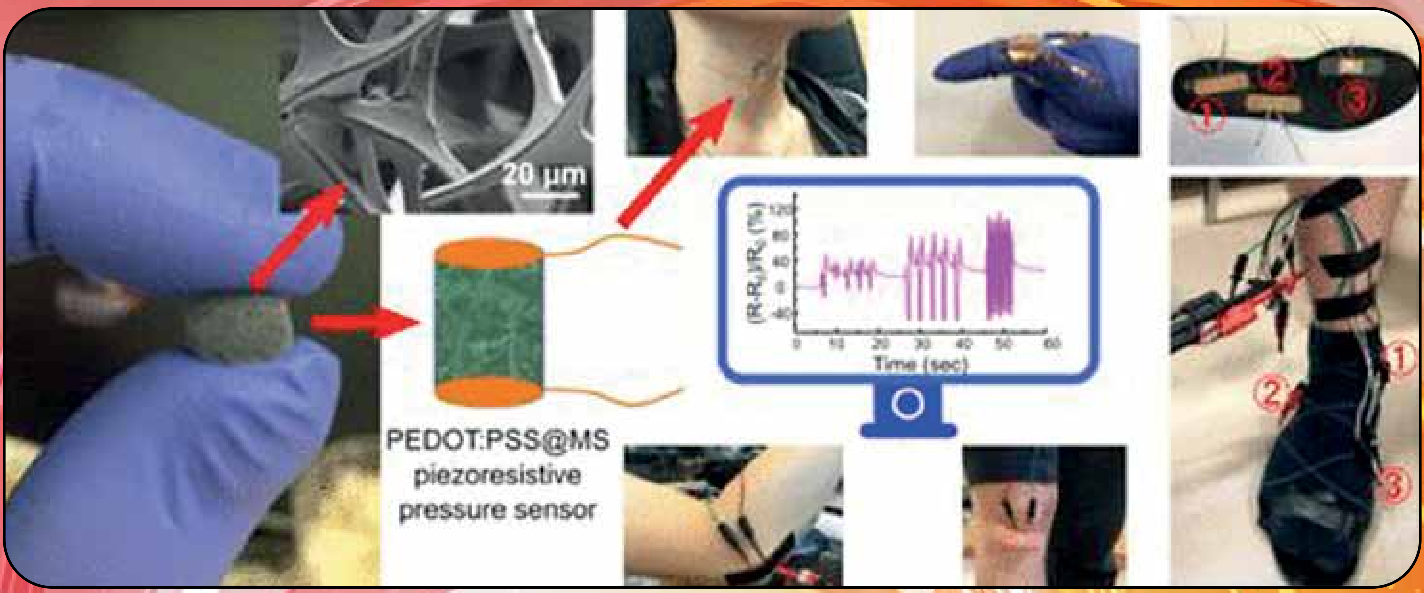
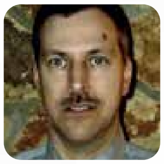


Illustration of wireless body area network with different types of sensors

Science PI
Zhengtao Zhu, 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.

Micro-Magnetic Driven Design of Multi-Component Magnetic Alloys for Advanced Electric Propulsion

The University of Alabama, Johnson Space Center, Glenn Research Center

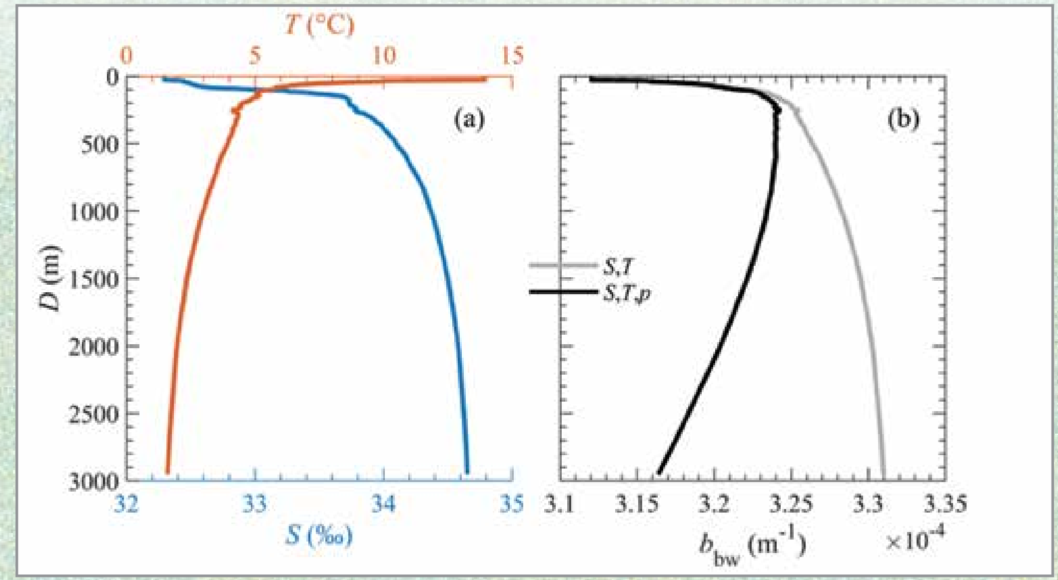
Electric based propulsion has emerged as a strategic investment for NASA Aeronautics for the design and implementation of ultra-efficient aircraft to assist our nation in the transition to low-carbon propulsion. In electric motors, magnetic materials assist in the conversion of electrical energy to mechanical energy. During this conversion, alternating current energy losses occur which will be substantially reduced through the proposed development of a new class of (Fe,Co)-based amorphous and nanocrystalline magnetic composites. Such new materials will be a key requirement for NASA as it aims to improve the efficiency of electric motors that scale from the kilowatt to megawatt levels as outlined in NASA's next generation electrical and hybrid aircraft technical readiness plan. To provide a systematic development of these alloys, faculty at The University of Alabama (UA) has teamed with Glenn Research Center (GRC) scientists and engineers to create a synergistic partnership that leverages expertise and infrastructure at each institution. This research positions UA-NASA as a formidable leader in nanocomposite magnetic material development through a closed loop interaction of modeling-processing-characterization. This research positions the state of Alabama at the forefront of the development of the next generation electrical power systems which will contribute to the state's future economic development.

Science PI
Claudia Mewes, PhD
The University of Alabama

NASA Technical Monitor
Ronald Noebe, PhD
Glenn Research Center

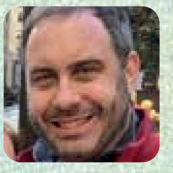
Derive Phytoplankton Size Classes, Detrital Matter, Particulate Organic Matter and Particulate Inorganic Matter from Ocean Color Observation

University of North Dakota, Goddard Space Flight Center

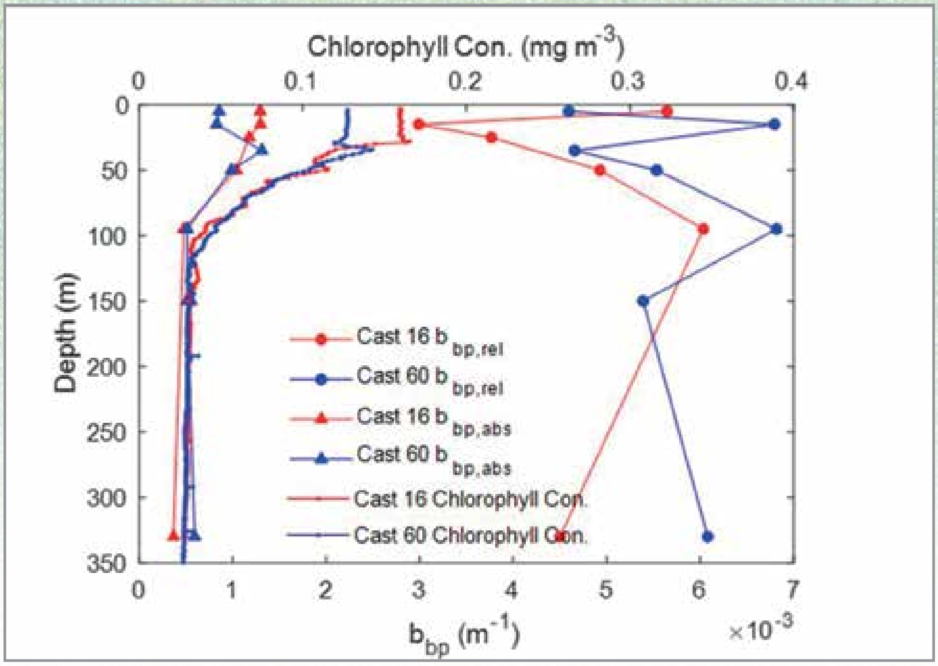


Salinity (blue) and temperature (red) profiles measured during the experiment in North Pacific Ocean. Calculated backscattering by seawater (black) becomes increasingly smaller at depths > 200 m. A wrong pattern would be obtained if the pressure effect is ignored. For the first time that we discovered that seawater scattering decreases with pressure (and hence water depth), by ~5% at 3000 m. At depths < 100 – 200 m, the pressure effect can be ignored. But for applications at deeper depths, e.g., BioGeoChemical-Argo floats, this pressure effect must be considered. Without the pressure correction, seawater scattering is over estimated and particulate scattering is underestimated.

Science PI
Xiaodong Zhang, PhD
University of North Dakota



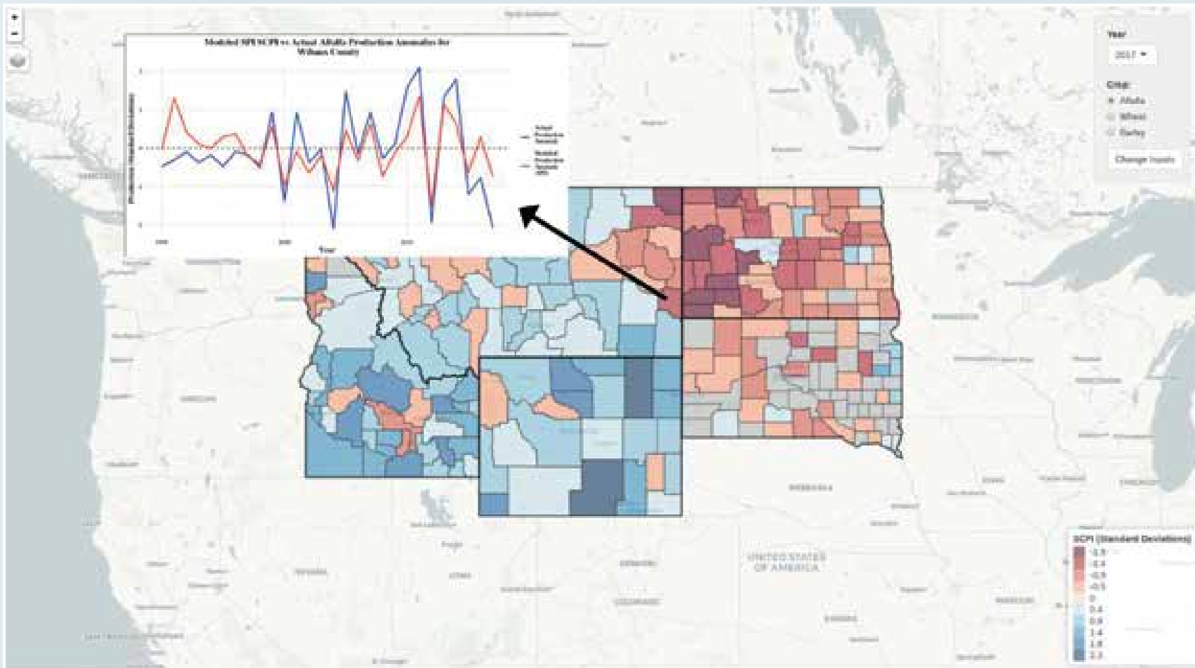
NASA Technical Monitor
P. Jeremy Werdell, PhD
Goddard Space Flight Center



We developed a rigorous calibration for the LISST-VSF, a commercial instrument measuring angular distribution of scattered light. With this calibration, the scattering measurements (triangles) we collected in North Pacific Ocean, where water is very clear, mimic very well with the chlorophyll concentration profiles (lines) as expected. Using the default calibration provided by the manufacturer, the scattering data (dots) show rather random patterns because the default calibration only works in relatively turbid waters. On the other hand, the calibration that we developed allows the instrument to be used in both clear and turbid waters.

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

University of Montana, Goddard Space Flight Center, Ames Research Center

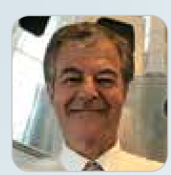


The Standardized Crop Production Index (SCPI) web app

Climate variability and drought conditions in agricultural regions affects soil moisture and available energy, increasing the risk farmers take when they make resource-use decisions such as how much land they allocate to the crops they choose to grow and where to distribute scarce irrigation water. Farmers are not only sensitive to climate conditions but also react to other factors such as crop prices or policy incentives and may choose to allocate resources to maintain agricultural production even under more adverse climate if market conditions are favorable or were favorable the previous year. Because they are easier to produce from earth observing technologies, most indices currently in use to characterize agricultural drought are often purely based on hydro-climatologic variables such as precipitation, evapotranspiration or soil moisture. However, farmers also react to economic incentives and by not taking into account their adaptive management, these indices may overestimate the impact of climate variability on crop production and food security. We have created a new Standardized Crop Production Index (http://www.umt.edu/hydro-econ-ag/cropindex.php), which analyzes crop production anomalies at the county scale based on past climatic and agricultural market stressors, and permits to quantify the sensitivity of producers to climatic and agricultural market signals. This index permits to delineate more realistically regions most economically impacted by drought, and investigate the time scales at which farmers react to climate and economic factors.

The Standardized Crop Production Index (SCPI) is a model that characterizes past and end-of-year county-scale production anomalies of alfalfa, barley and wheat for counties in Idaho, Montana, North Dakota, South Dakota, and Wyoming. Unlike other agricultural drought indices based solely on climatic factors, the SCPI takes into account climatic and economic factors by combining county-level precipitation or evapotranspiration data with state-level crop price information. Web app and more information at http://www.umt.edu/hydro-econ-ag/cropindex.php

Science PI
Marco P. Maneta, PhD
University of Montana



NASA Technical Monitor
Ali Shaykhian, PhD
Kennedy Space Center

https://nasaepscor.montana.edu/

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

University of Wyoming, Goddard Space Flight Center

www.physics.uwyo.edu

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.

Dr. Chip Kobulnicky, Co-Science PI, 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

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)."

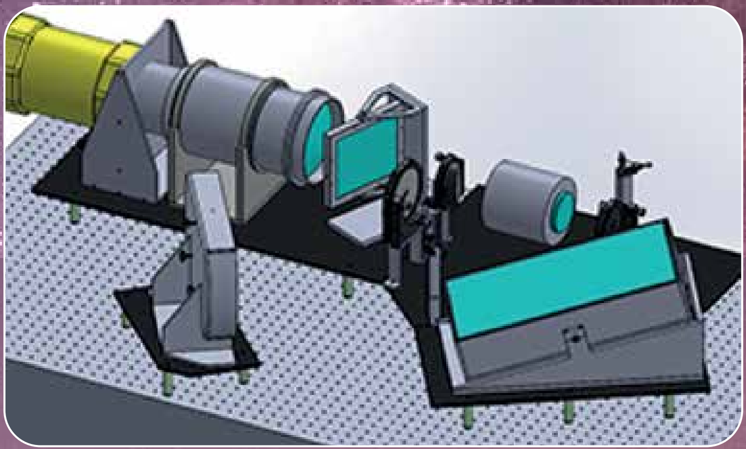
The FHiRE spectrograph eventually will play a key role in NASA's Transiting Exoplanet Survey Satellite (TESS), which is expected to discover thousands of exoplanets in orbit around the brightest stars in the sky. In a two-year survey, TESS will monitor more than 200,000 stars for temporary drops in brightness 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.

Co-Science PI
Hannah Jang-Condell, PhD
University of Wyoming

Co-Science PI
Michael Pierce PhD
University of Wyoming

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

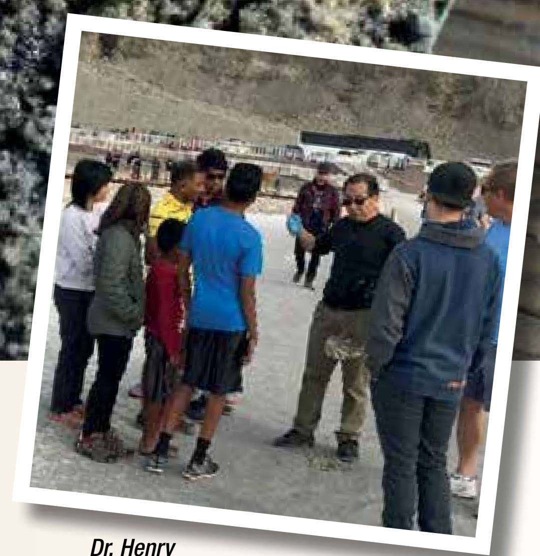


Shown is a 3-D computer-aided design, by Michael Pierce, a UW associate professor of physics and astronomy. The spectrograph provides a detailed chemical composition of the stars and measures the precise velocities, or speeds, at which the stars are moving. Hannah Jang-Condell, UW associate professor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

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

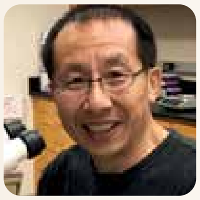
Desert Research Institute, Ames Research Center, Jet Propulsion Laboratory

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

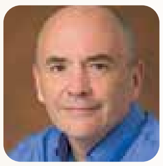


Dr. Henry Sun explains the project to the curious public while conducing fieldwork in Death Valley.

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

Understanding and Quantifying Carbon Export to Coastal Oceans through Deltaic Systems

Louisiana State University, Goddard Space Flight Center, Jet Propulsion Laboratory

SU graduate student (Hande Suslu) works with LSU graduate student (Le Zhang) on a Wax Lake Delta wetland survey

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

NASA Technical Monitor
Marc Simard, PhD
Jet Propulsion Laboratory

“Girl Power” saves the Sinking Delta

As the NASA EPSCoR project “Understanding and Quantifying Carbon Export to Coastal Oceans through Deltaic Systems” enters its second year, Louisiana State University’s oceanographers furthered their collaboration with the Southern University to understand the fate of carbon released from the “sinking” Mississippi River Delta. This project combines 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. In this project’s second year, the research team achieved six offshore cruises and seven wetland surveys. These field trips covered an area of 3,200 squire miles at the land-ocean continuum in the northern Gulf of Mexico and collected hundreds of water and soil samples. At the same time, the LSU PIs provided on-hand wetland soil sampling and analysis training to the PIs and graduate students at Southern University, which is one of the nation’s largest historically black universities. Notably, five out of the six graduate students supported by this project are female scientists working on offshore and wetland sampling, remote sensing data processing, and numerical model setup. The outcome of this project will provide an integrated assessment of regional carbon budget as well as a “tool-kit” applicable to other mega-delta systems around the world.

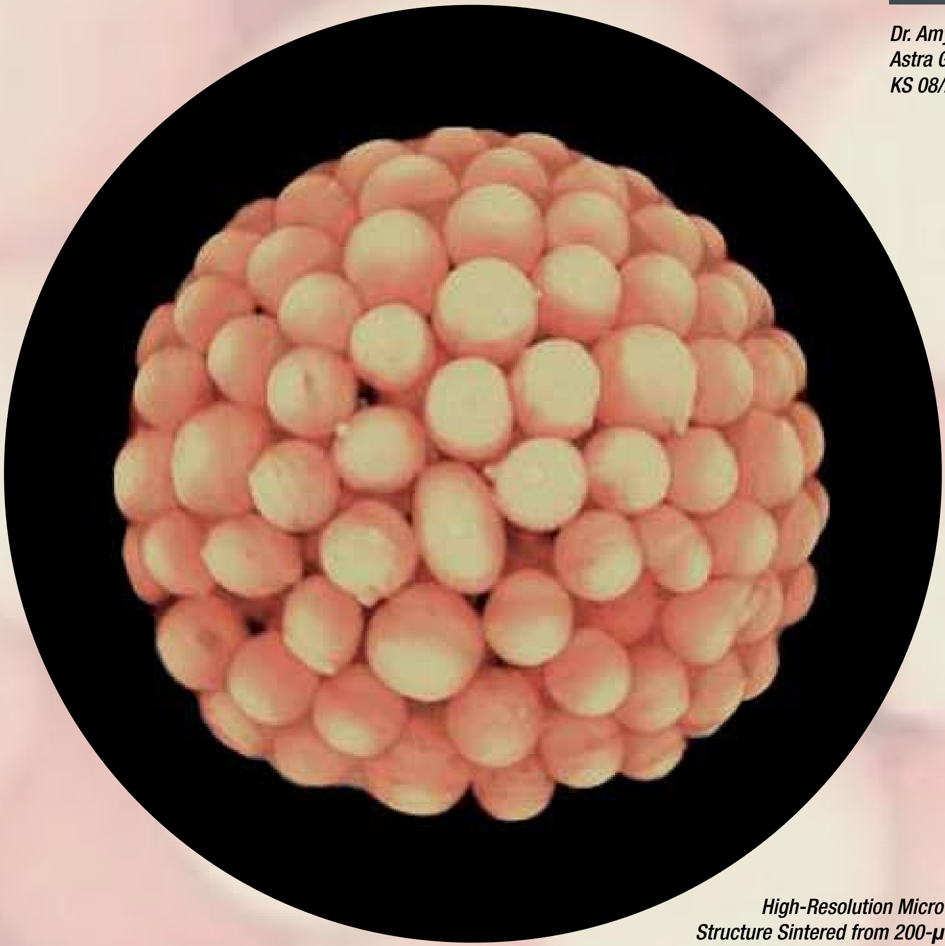
https://www.lsu.edu/cce/newsevents/news/2018/10/03-xuenasa.php

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

Wichita State University, Glenn Research Center, Jet Propulsion Laboratory

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 second year of the project, five faculty members, ten graduate students, and seven undergraduate students have conducted research; the team includes two female faculty members, six female students, and five students who are members of underrepresented groups. The project has already impacted two graduate and one undergraduate courses.

Dr. Amy Betz presents "Humans in Space," for Ad Astra Galaxy Forum at Cosmosphere, Hutchinson, KS 08/24/2019.



Science PI
Gisuk Hwang, PhD
Wichita State University

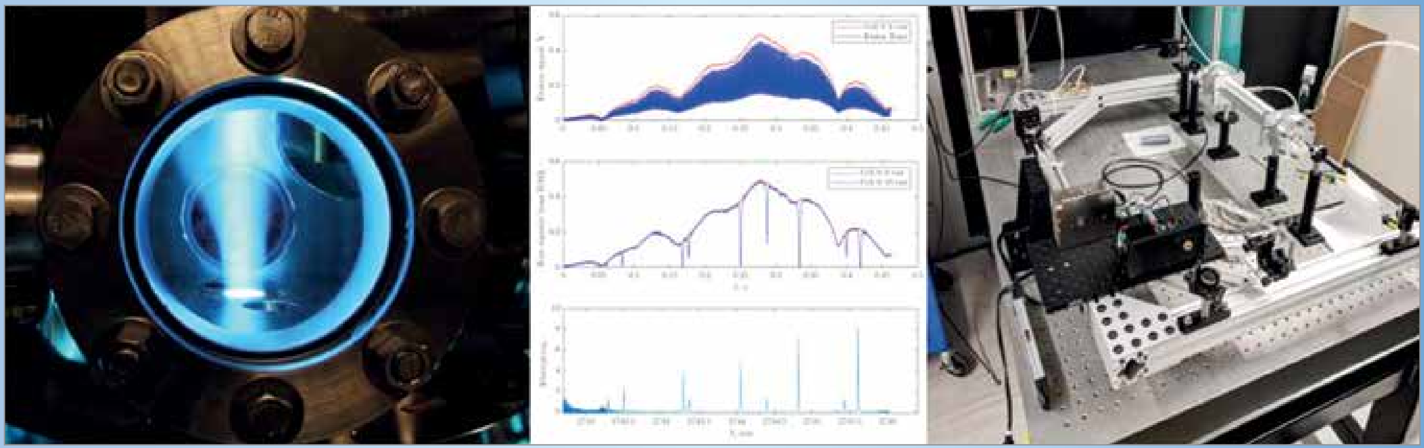
NASA Technical Monitor
Mohammad M. Hasan, PhD
Glenn Research Center

High-Resolution Micro-Tomography of a Porous Structure Sintered from 200-μm-diameter Cu Particles.

Critical Gas-Surface Interaction Problems for Atmospheric Entry

University of Vermont, Langley Research Center, Ames Research Center

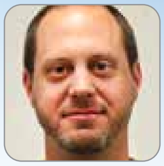
Mars atmosphere is comprised of approximately 97% CO_2 and 3% N_2 by volume, with trace amounts of other species. As a vehicle enters the Martian atmosphere at high speed, a detached shock wave forms, dissociating molecules into CO, O, and C, with N as a minor species. As part of the Mars Pathfinder Program, Mitcheltree developed a surface catalysis model for Mars entry applications, which consists of the parallel reactions at the surface $O+(s) \longrightarrow Os \Longrightarrow CO+Os \longrightarrow CO_2$ and $CO+(s \longrightarrow COs \Longrightarrow O+COs \longrightarrow CO_2$. This model ignores the possible competing recombination to form molecular oxygen, $O+O \longrightarrow O_2$. Sepka, et al. investigated the surface reactions on quartz (a low-catalytic material) in a side-arm reactor. Their measurements clearly indicated that reaction the first occurred much more readily than reaction the, which implies that further oxidation of CO to CO_2 by the surface is unlikely. This finding also suggests that the Mitcheltree model and, consequently, the super-catalytic assumption are overly conservative. However, numerical simulations of heat flux measurements from wind tunnel tests suggest that the super-catalytic recombination model is correct. Such contradictory results justify the conservative TPS design assumption of super-catalycity and warrant further investigation. Our effort to investigate this problem involves searching for evidences of CO_2 formation above various surfaces in Mars chemistry plasmas in the University of Vermont 30 kW Inductively Coupled Plasma Facility. Materials known to have catalytic and non-catalytic behavior for CO_2 recombination will be used to elucidate the relative efficiencies of proposed recombination paths. A cold wall platinum surface will serve as a reference catalytic material. Additional tests will be performed using quartz and copper samples providing data for surfaces less catalytic to CO_2 formation. Tests of all materials will include diode laser absorption spectroscopy (DLAS) of CO_2 (experiment and bench validation results pictured) and two-photon laser induced fluorescence (TALIF) measurements of CO and O atom concentrations near the surface to resolve their fluxes and recombination efficiencies.



Left: UVM 30 kW facility with full CO2 operation Center: CO2 DLAS sensor bench tests. Right: CO2 DLAS sensor on calibration test bench.

Science PI
Jason Meyers, PhD
University of Vermont

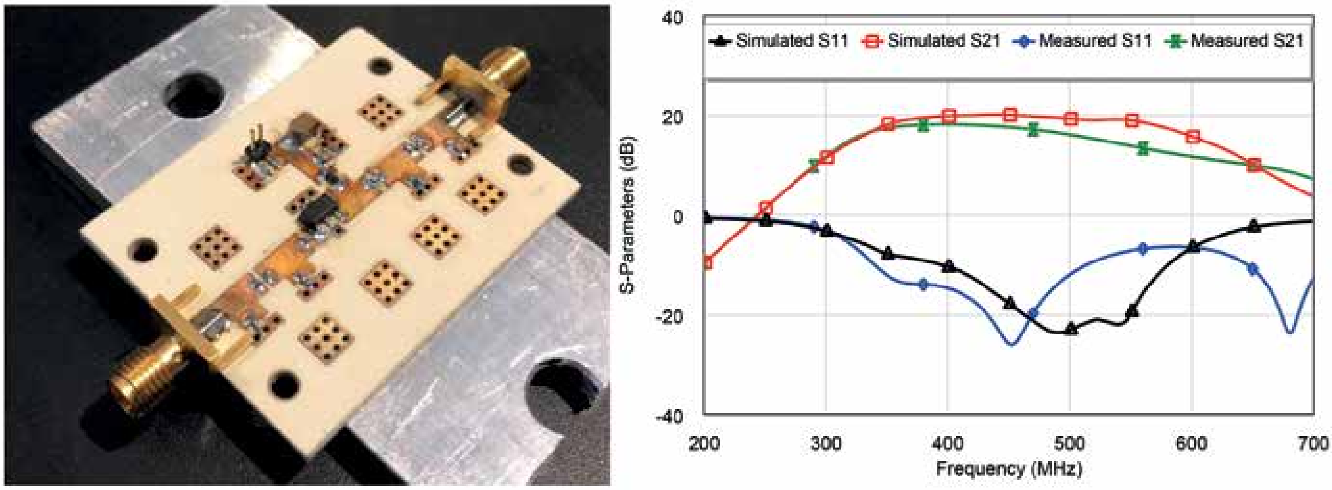
NASA Co-Technical Monitor
Michael J. Wright, PhD
Ames Research Center



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

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

University of Oklahoma, Goddard Space Flight Center



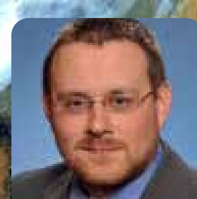
Stage 1 amplifier: Fabricated prototype on the left and measured results on the right.

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.

Photo of the Bushnell radar gun, along with an example target, that we will use in the MTPE Radar Day Workshop. Each participating school teacher will receive a radar gun.



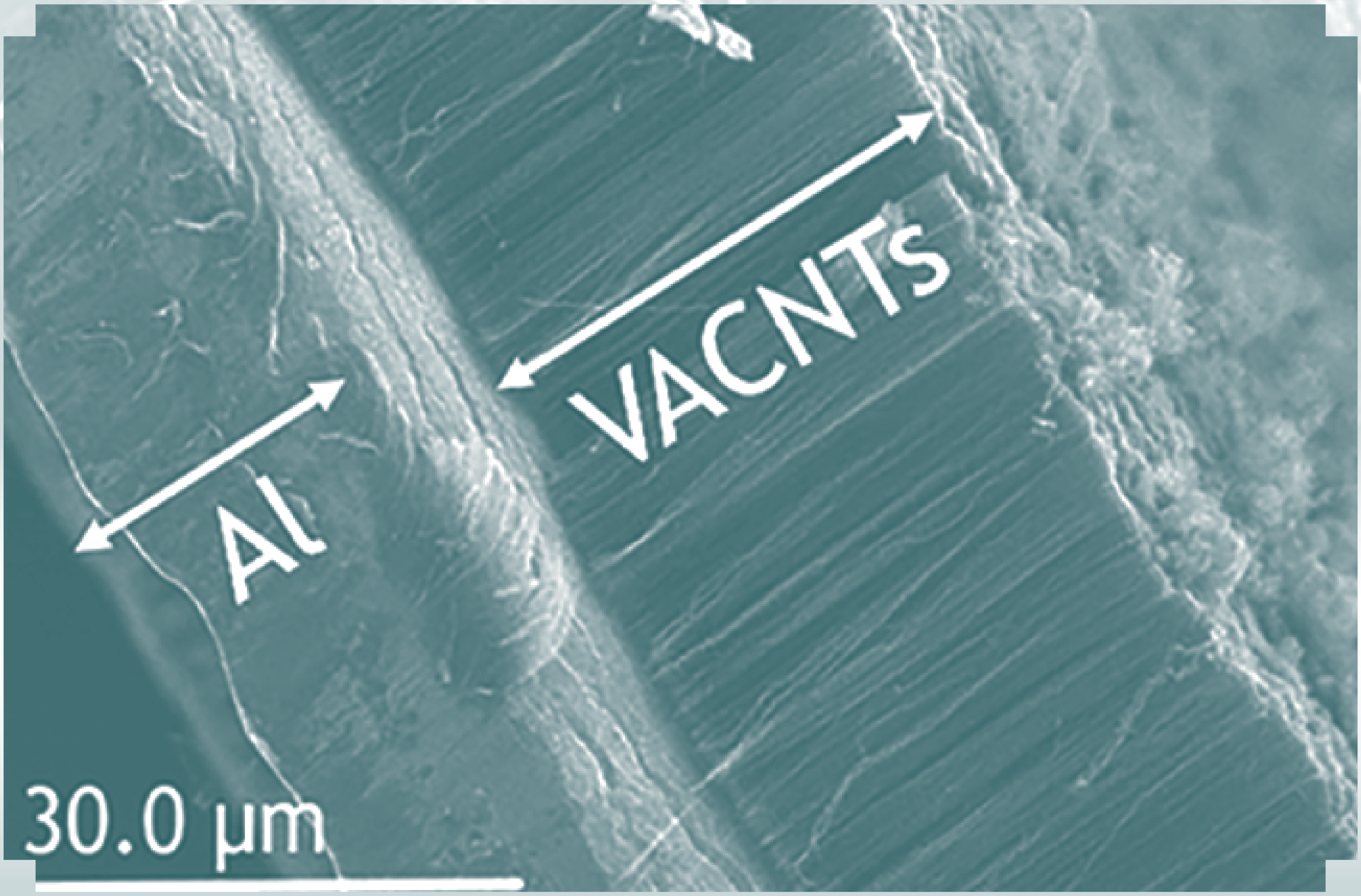
Science PI
Hjalti H. Sigmarsson, PhD
University of Oklahoma

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

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

Clemson University, Johnson Space Center, Langley Research Center, Ames Research Center

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.



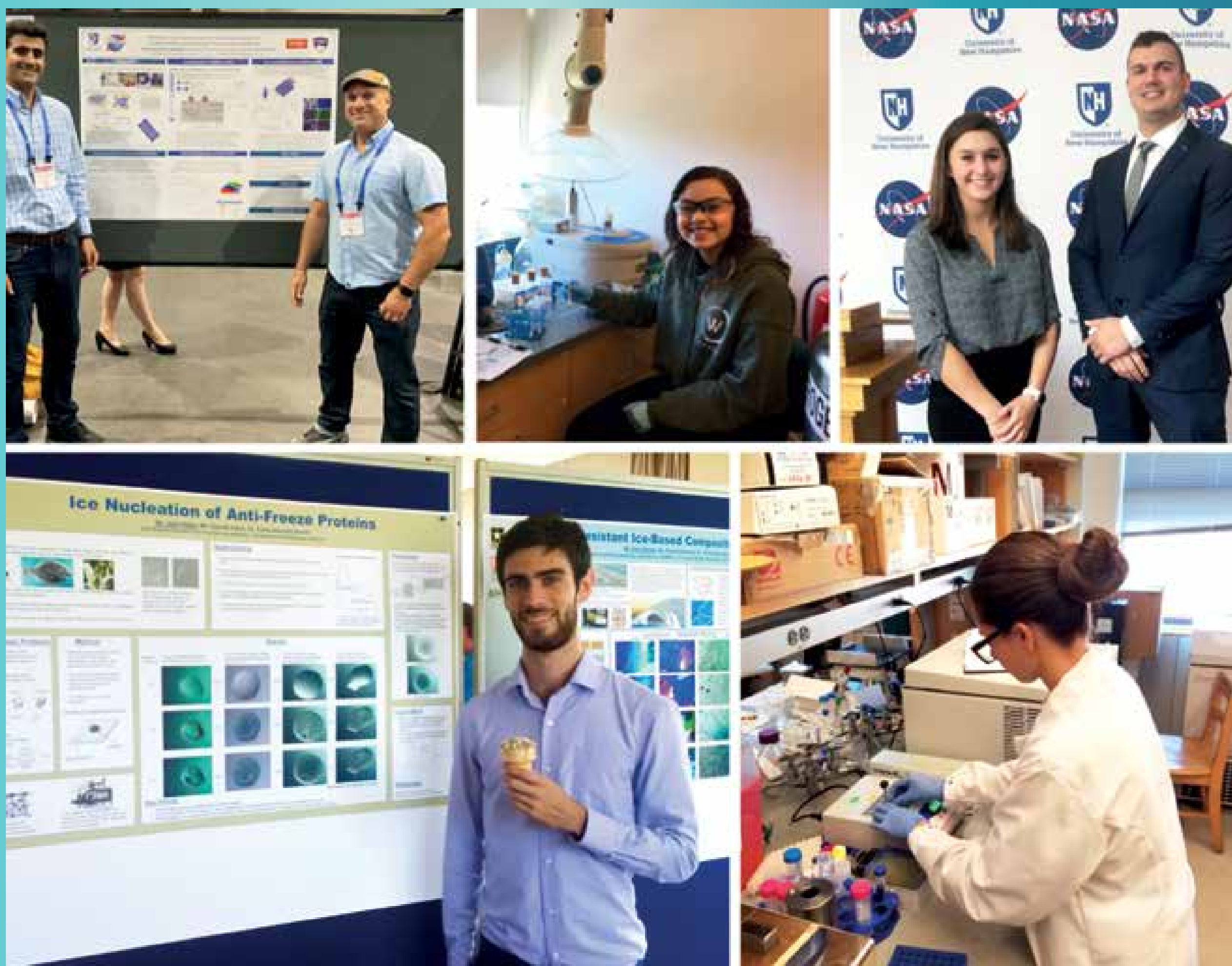
A cross-sectional scanning electron microscope image of an aluminum current collector coated with vertically aligned carbon nanotubes. The coated aluminum electrodes enable superior battery performance compared to bare aluminum electrodes. Image from PI's lab.

Science PI
Apparao Rao, PhD
Clemson University

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

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

University of New Hampshire, Glenn Research Center



Students working on application of antifreeze proteins and mimetic peptides in anti-icing surface coatings and presenting their results: Mohammad Mousazadehkasin and John Tsavalas (UNH, top left), Alayna Massie (Keene State College, top middle), Madeline Ishak and John Sreter (UNH, top left), Jack Heller (CRREL, bottom left), and Katarina Jovic (UNH, bottom right).

Science PI
Krisztina Varga, PhD
University of New Hampshire

NASA Technical Monitor
Andrew J. Trunek
Glenn Research Center

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.

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

University of Louisiana at Lafayette, Ames Research Center

Photobioreactors Cultivating High-Performing Microalgae Cultures at the University of Louisiana at Lafayette (2019)

Human activities within future human residence stations on the Moon and Mars will produce life support wastes while consuming both water and oxygen. Hence, water and oxygen will be in very limited supply resulting in these two key resources needing to be recycled as much as possible and/or produced on-site. A Biorefinery System (BIOSYS) has been designed by UL Lafayette that will effectively treat all human activity-based wastes 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, recent R&D at UL Lafayette indicates that microalgae systems could remove the high levels of carbon dioxide from the Mars atmosphere and convert the carbon dioxide into oxygen and protein that both can also be used for human life support. The Mars atmosphere is over 90% carbon dioxide.

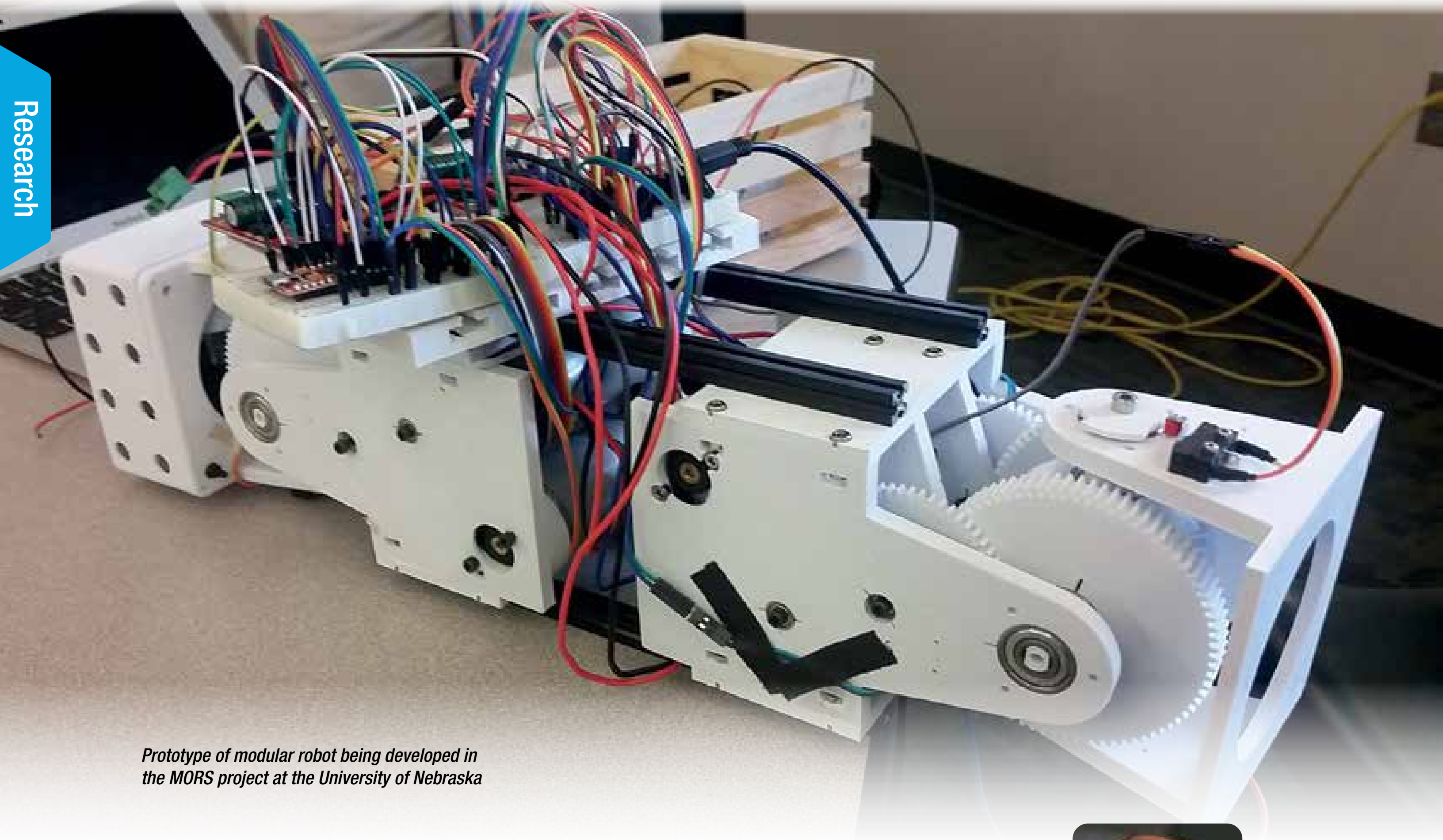
Science PI
Mark Zappi, PhD
University of Louisiana

NASA Technical Monitor
Ali Shaykhian, PhD
Kennedy Space Center

Research thus far indicates that the anaerobic biosystems (reactors supporting microbes that operate without oxygen) are highly capable of reducing the pollution content of the input wastewaters by over 70% with a high level of recovered methane produced. Also, hydrogen has been produced within these anaerobic biocells. Both methane and hydrogen can be used to power fuel cells at the space camps and for powering surface terrain transporters. Various microalgae were found to effective toward both carbon dioxide conversion and lipid production. The presence of some micronutrients were found to potentially hinder microalgae performance indicating that careful culturing of the cells may be required. Finally, two novel polymeric adsorbents were developed that show a high potential for pollutant removal from drinking water. In fact, these adsorbents out-perform currently used adsorbents in industry. Additionally, the research shows that the adsorbents can be regenerated and reused with minimal pollution removal capacity loss. When these various R&D efforts are integrated and coupled with on-going design-related modelling, it appears that an effective water treatment system capable of producing numerous products used for life support at the space camps is very possible. One particularly attractive aspect of this research is that these discoveries also show great potential for use on Earth for reducing the ecological footprint of urban areas.

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

University of Nebraska, Johnson Space Center



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

Science PI
Raj Dasgupta, PhD
University of Nebraska

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

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.

Rapid Response Research

NASA EPSCoR Rapid Response Research or R3 announcements solicit NASA identified, topic-specific research opportunities providing a streamlined method to quickly address those issues currently important to NASA. The goal of this collaborative effort between EPSCoR and the Science Mission Directorate Planetary Science and Space Biology Divisions, Commercial Spaceflight Development Office, and others is for EPSCoR researchers to work for one year with NASA to solve problems. For example, within SMD, EPSCoR researchers will study issues associated with the planet Venus, which has important scientific relevance to understanding Earth, the Solar System formation, and Exoplanets. Of particular interest is the fact that Venus has highly acidic surface conditions and an extreme environment with temperatures of ~900oF or 500oC at the surface and pressures equal to 90 earth atmospheres or equivalent to pressures at a depth of 1 km in Earth's oceans. How do you develop sensors to operate in this harsh environment? Awards are up to $100,000 for a one-year performance period. NASA intends to announce the EPSCoR R3 funding opportunity as required and pending funding availability.

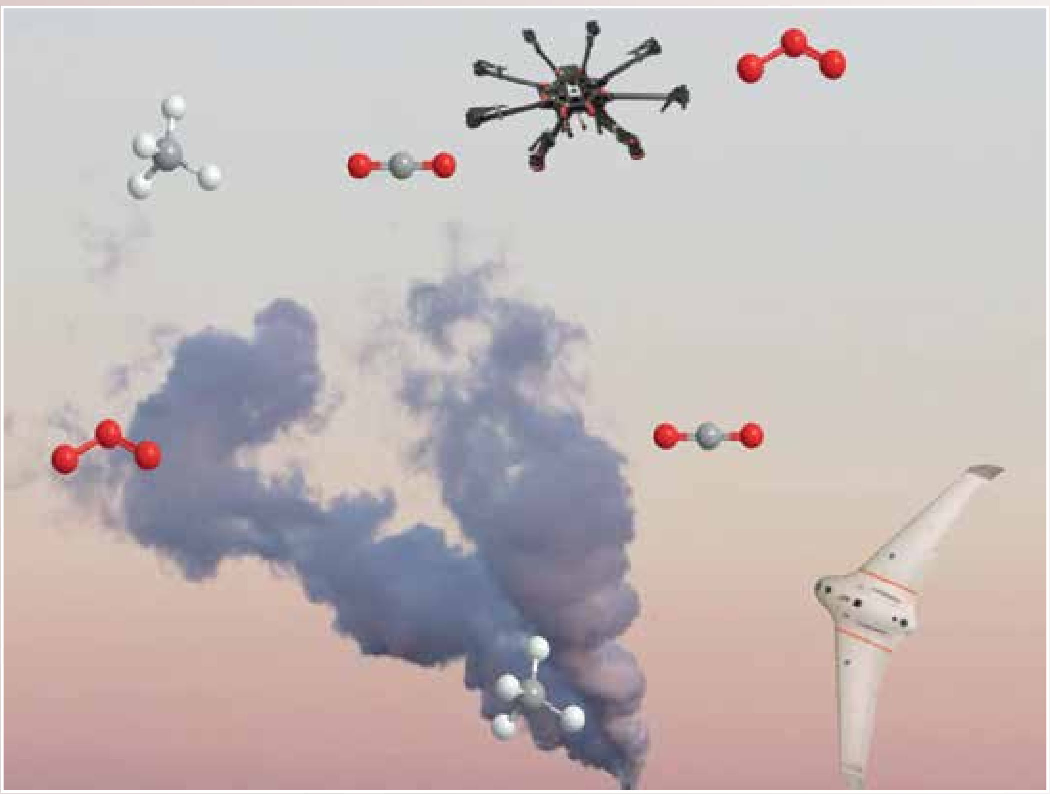
EPSCoR R3 Table of Contents

Aerial Platforms for the Exploration of Earth Volcanoes: Measuring Atmospheric Chemical and Physical Properties

University of Kentucky, Langley Research Center

Volcanic eruptions, like the recent Kilauea volcano eruption in Hawaii, release large amounts of gases such as hazardous sulfur dioxide (SO2) and hydrogen sulfide (H2S) for nearby populations. These eruptions also have global effects by altering the Earth's radiative forcing.

Researchers from the University of Kentucky proposed a new application of unmanned aerial vehicles, more commonly known as drones, to sample air masses over volcanic environments. Dr. Marcelo Guzman and Dr. Sean Bailey will work with NASA to utilize small unmanned aerial systems (sUAS) for exploration of chemical and physical properties over volcanic environments on Earth. Utilizing sUAS for atmospheric exploration of volcanic environments on Earth provides a step towards developing platforms suitable for measuring the atmosphere of Venus. This research project, titled "Aerial Platforms for the Exploration of Earth Volcanoes: Measuring Atmospheric Chemical and Physical Properties," will help inform NASA about extreme scenarios expected during future missions to study Venus, the solar system's hottest planet.

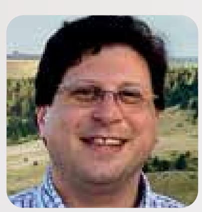


Artwork depicting the use of drones for monitoring emitted gases in the atmosphere. Credit: Travis J. Schuyler and Marcelo I. Guzman

The outcome of this project will provide a better understanding of the role that volcanic systems play in climate and air quality by measuring profiles of emitted Greenhouse Gases (GHG) such as H2S, NO2, and SO2.

This novel approach will develop a robust mobile platform with surface-coated heat shielding for monitoring volcanic gases, which can achieve high spatial and temporal resolution, on the order of meters and seconds, respectively. Platforms with wingspans under 3 meters (~10 feet) that can carry up to 5 kg (~11 pounds) can be deployed on-site in minutes including designed analytical systems for monitoring the atmosphere.

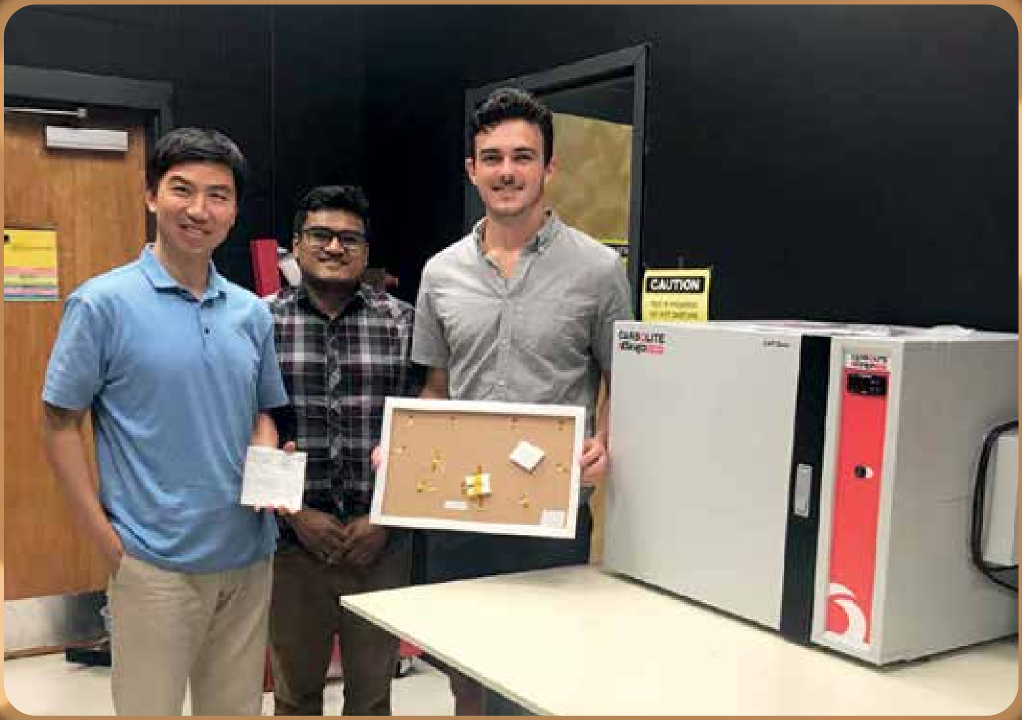
NASA Technical Monitor
John Lekki
Glenn Research Center



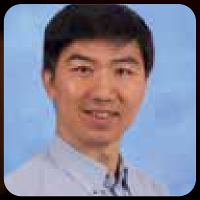
Science PI
Marcelo Guzman, PhD
University of Kentucky, Lexington

Development of Fiber-Optic High-Temperature Heat Flux Sensors for Venus

The University of Alabama in Huntsville, Marshall Space Flight Center



UAH undergraduate student Owen Thome is pictured holding the gold-coated fiber sensors next to a high-temperature oven, along with graduate student Nabil Hoque (middle) and the Principal Sc-I Dr. Lingze Duan.



Science PI
Lingze Duan, PhD
The University of Alabama in Huntsville

PHOTO UNAVAILABLE

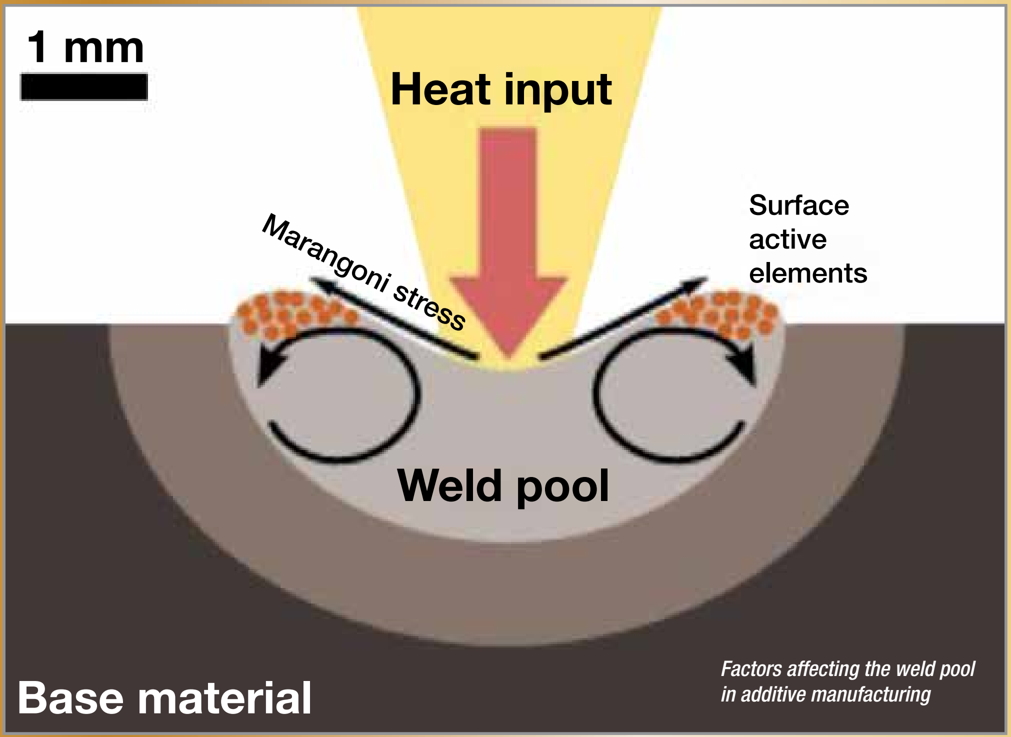
NASA Technical Monitor
Michael Kulis, PhD
Glenn Research Center

The gold-coated FBG sensors developed in this project provide a viable option for the high-temperature heat flux sensors needed in NASA's future Venus landing missions. They can also find applications in geophysical research, aerospace engineering, and gas/oil industry, where sensors often need to operate under extremely harsh conditions, such as high temperature, high pressure, and corrosive environment. On the institutional level, the current work has strengthened existing collaboration between UAH and NASA MSFC in their common interest in fiber-optic sensors (as evident from instrument sharing). A number of educational opportunities have been created as a result of this work, including one graduate research assistantship, two summer student research positions, one PH499 capstone research project and one undergraduate extracurricular research project.

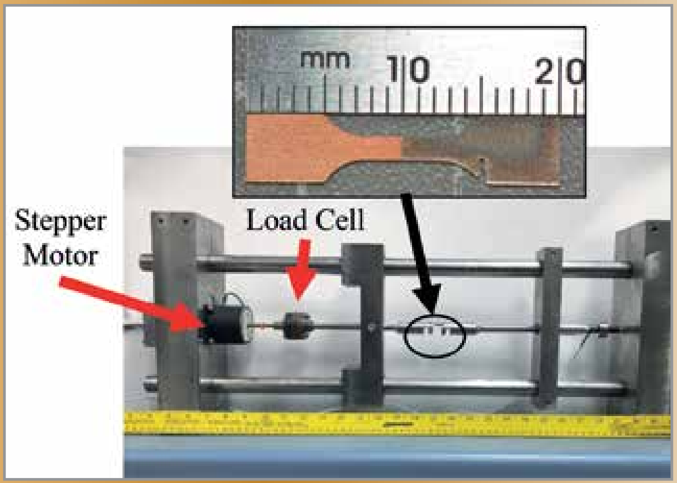
RRR

Characterization of Bi-Metallic Joints Formed by Different Processes

The University of Alabama in Huntsville, Marshall Space Flight Center



Factors affecting the weld pool in additive manufacturing



Left: Miniature tensile specimens are taken from actual hardware to investigate scaling effects on properties.

To provide insight into selection of blown powder deposition, additive manufacturing, a qualitative model has been developed. This is serving as a platform for continued discussion with vendors who seek to improve their processing. Four vendors have provided samples, all with varying microstructures and properties due to differences in equipment configuration and operation. The modeling effort provides guidance for fabrication of uniform and consistent properties of the bi-metallic component.

Through this program, two students have completed their Master of Science Degrees, Mr. Myles Fullen in Mechanical Engineering and Mr. Jordan Terrell in Materials Science. Through the course of this effort, several undergraduates were involved to assist the graduate students. Mr. Noah Naden and Mr. Giancarlo Puerto were previously undergraduates who are now graduate students in my research group and are continuing the bi-metallic thrust.

This program has led to continued collaboration with the NASA in their understanding of blown powder deposition, additive manufacturing. It is anticipated that after NASA-MSFC reopens following the COVID-19 closure in March, the predictive capabilities of the qualitative modeling efforts will be demonstrated on their newly installed blown powder deposition equipment.

Science PI
Judy A. Schneider, PhD
The University of Alabama in Huntsville

NASA Technical Monitor
Robert Carter
Glenn Research Center

RRR

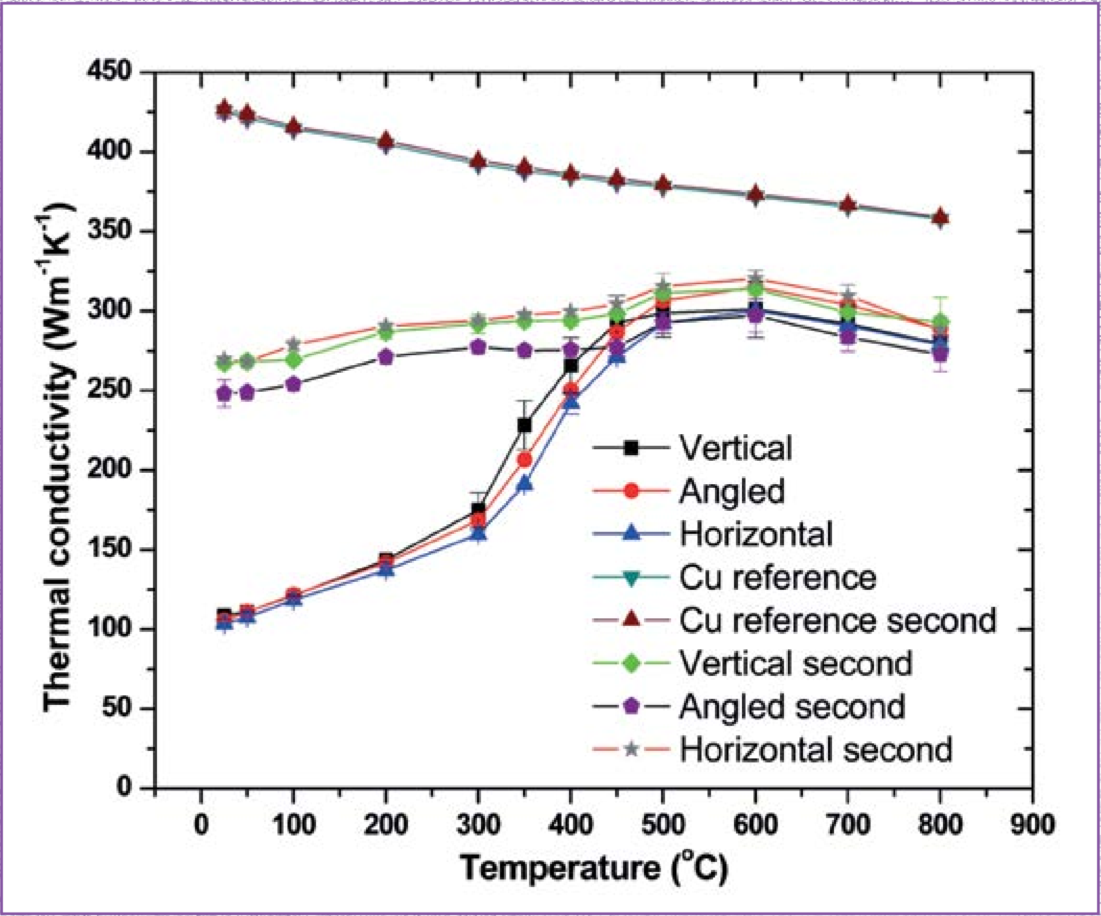
Characterization of C-18150 Additively Manufactured Material

Louisiana State University, Johnson Space Center

Science PI
Shengmin Guo, PhD
Louisiana State University

NASA Technical Monitor
Paul Gradl
Marshall Space Flight Center

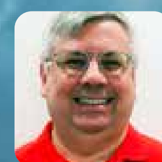
To reduce overall mission costs, NASA and their aerospace industry partners are exploring metal additive manufacturing methods for building liquid rocket engine components. One of the primary technologies of interest is the Laser Powder-Bed-Fusion (L-PBF) additive manufacturing (AM) process, which is an ideal tool to fabricate parts with complex shapes —such as regeneratively-cooled combustion chambers and nozzles— that incorporate internal coolant channels. However, due to the rapid laser heating and subsequent rapid solidification of the fine laser tracks, the as-fabricated L-PBF parts tend to have unique thermal and mechanical properties. C-18150 (Cu-Cr1.5-Zr0.5) alloy is a promising candidate for combustion chambers and nozzles applications due to its high thermal conductivity. To better understand the properties of C-18150 alloy samples prepared by the L-PBF AM process, a Louisiana team studied the thermal/physical properties of C-18150 specimens with different AM processing parameters. Thermodynamics simulations were also carried out to facilitate the analysis of the phase structures. It's found that due to the complex thermal gradients and rapid cooling feature of the AM process, small-sized, irregular-shaped and hierarchical grain structures are formed in the AM specimens. The specimens with different building orientations display identical X-ray diffraction (XRD) patterns, indicating almost the same phase constituents. Thermal diffusivity and thermal conductivity of the samples are found to be unique for the as-fabricated AM parts. A carefully designed heat treatment process has been identified to ensure the quality of the AM parts.



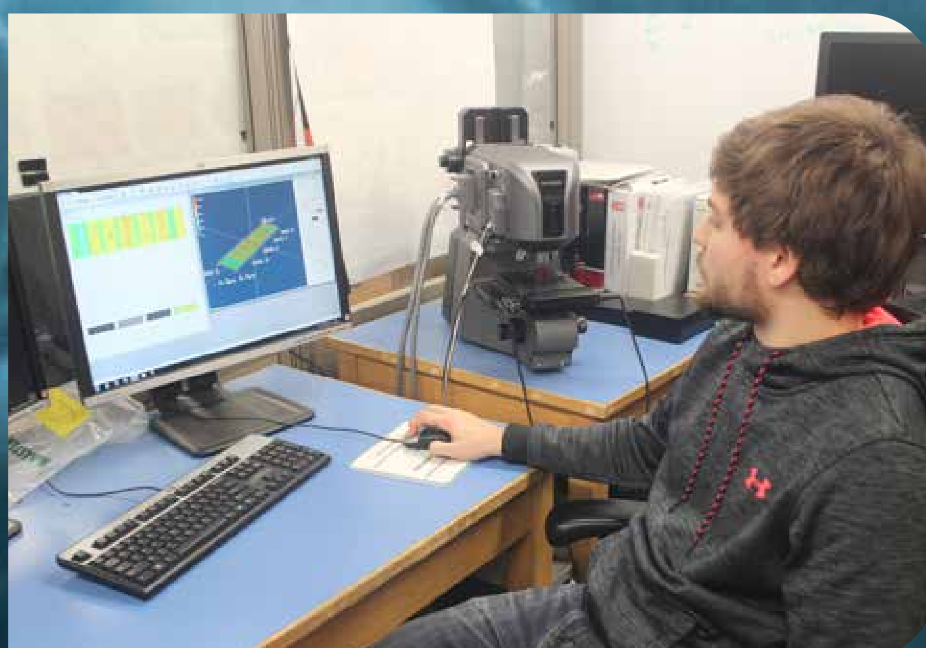
Characterization of GRCop-42 Additively Manufactured Material (CSCO-2017-03 rev A)

South Dakota State University, Johnson Space Center

Science PI
Todd Letcher, PhD
South Dakota State University



NASA Technical Monitor
David Ellis, PhD
Glenn Research Center



Besides technical knowledge generated for a new class of material, the project has made a significant impact on the university environment and to a broader audience. Within the university, the project has trained two graduate students in materials and manufacturing, an industry of extreme importance to the state's economy. It has also led to the revival of two courses, "Advanced Metallurgy" and "Nondestructive Testing," which will have a long-lasting impact on undergraduate and graduate education. The project has also impacted a broader audience through STEM outreach. It is well recognized that early intervention is essential to increasing STEM participation, and access to high-quality, hands-on tools is one key component of early intervention. The South Dakota team worked with a local museum and the NASA@MyLibrary project to develop and distribute a hands-on STEM kit for middle and high school classrooms. So far, the SD team has reached 20+ science educators in the state through the NASA@MyLibrary project and the SD Education portal avenue.

Rock, H2O, and H2: Energy from Water-Rock Interactions on Mars

University of Nevada, Las Vegas, Johnson Space Center

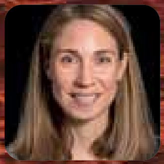
The human mission to Mars comes with many challenges. One of them is to find resources on Mars to significantly reduce the need to transport resources from Earth. The overarching objective of this research is to determine the resources available from water-rock interactions on Mars, potentially including hydrogen, perchlorate, and Fe and Mg sulfates and chlorides. These resources would enable significant advancement in the long-term human exploration of Mars. The project has already detected hydrogen gas production from the interaction of water and the Mars-relevant mineral magnetite, in an anoxic environment like Mars. Hydrogen gas harvested this way could be used as a fuel source on Mars to power rockets or other surface based equipment.

The project used Mars simulants including JSC Mars-1 and JSC Rocknest, provided by NASA Johnson Space Center, reacting with liquid water to determine what resources would be available.

Photograph of experiments combining Mars simulant and Mars-relevant minerals with liquid under a controlled atmosphere.

Dr. Elisabeth Hausrath (PI), Richard Panduro (undergraduate assistant) and Dr. Christopher Adcock (collaborator) in the UNLV Laboratory where the project research is being performed.

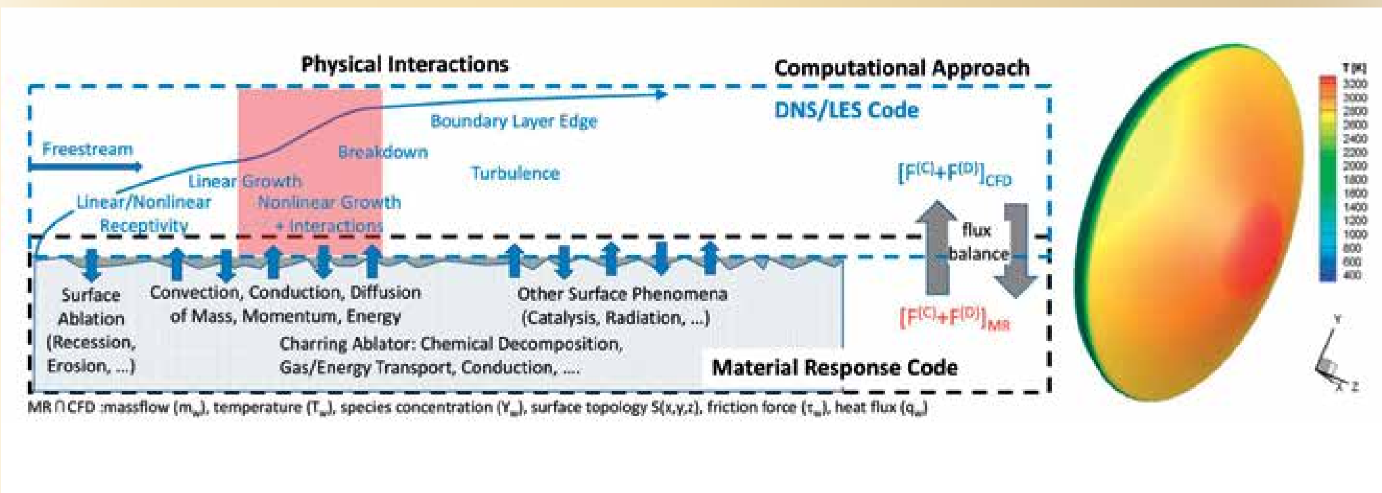
Science PI
Elisabeth Hausrath, PhD
University of Nevada, Las Vegas

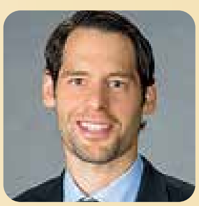


NASA Technical Monitor
Elizabeth Rampe, PhD
Johnson Space Center

A Fully Eulerian Simulation Approach for High-Temperature Fluid-Solid Interaction

University of Kentucky, Johnson Space Center





Science PI
Christoph Brehm, PhD
University of Kentucky. Lexington

NASA Technical Monitor
Michael Barnhardt
Ames Research Center

Although Venus is the planet closest to Earth, exploration of Venus is severely limited due in part to its dense atmosphere. In order to land or navigate near the planet's surface, a spacecraft must survive extreme conditions. Two faculty members at the University of Kentucky are combining their research expertise to help NASA engineer thermal protection systems for spacecraft that may travel to Venus.

This NASA EPSCoR Rapid Response Research project, "A Fully Eulerian Simulation Approach for High-Temperature Fluid-Solid Interaction," is aimed at development of high-fidelity modeling and simulation capabilities for the analysis of thermal protection systems that will help spacecraft survive entering the Venusian atmosphere. With the opportunity to work together under this project, Dr. Christoph Brehm and Dr. Alexandre Martin have developed a complementary computational modeling approach that combines transition and turbulence modeling with modeling the material response of state-of-the-art heatshield materials.

Planetary atmospheric entry remains a significant challenge for spacecraft traveling at high velocity in space on course to transition through dense gas that surrounds a planet. The extreme atmosphere of Venus is especially challenging. Spacecraft traveling to Venus at high speeds through the vacuum of space must transition into a gas atmosphere that is dense and hot – the hottest planet in the solar system, with atmospheric pressure at the surface about 92 times that of the Earth, similar to the pressure found 3,000 ft below the surface of Earth's oceans.

Investigate Potential of Mars and Lunar Resources

University of Delaware, Kennedy Space Center

Dr. Maria Katzarova (left), Associate Scientist in the Chemical and Biomolecular Engineering Department and Jennifer Mills (right), a fourth year PhD student in Chemical Engineering advised by Professor Norman J. Wagner and Professor Paramita Mondal in Civil Engineering.

NASA's Artemis program has set the goal of landing on the Moon by 2024, and "establish(ing) sustainable exploration by 2028", with the ultimate goal of sending an astronaut to Mars. To enable this vision, NASA has identified in-situ resource utilization (ISRU) in the development of construction materials as critical in building exploration infrastructure on both the Moon and Mars (landing pads, storage silos, habitats) while limiting the materials which must be shipped from Earth. Our project explores the hypothesis that Lunar and Martian regolith can be formulated as geopolymer-like binders due to their similar aluminosilicate composition to commonly used solid particulate blend components such as fly ash, slag, or clay which when mixed with an alkaline 'activator' become cementitious slurries that will harden and set to a similar strength as traditional cement. Moreover, geopolymers are gaining attention for extraterrestrial construction applications due to their resilience capable of meeting the environmental challenges there. We are investigating different types of Lunar and Martian regolith simulants available and assessing their potential for geopolymer binders by testing compressive strength, particle size, and morphology as well as the nature of the alkaline activating solution. These results will help inform future studies on binder mix optimization and how to affect binder workability for processing.

Co-Science PI
Maria Katzarova, PhD
University of Delaware

Co-Science PI
Norman J. Wagner, PhD
University of Delaware

NASA Technical Monitor
Warren Ruemmele
Johnson Space Center

https://sites.udel.edu/wagnergroup/

RRR

High Speed Electronic Devices Using SiGe on Sapphire Technology for Advanced NASA Space Communications

University of Arkansas, Fayetteville, Langley Research Center, Goddard Space Flight Center

The researchers at the University of Arkansas Fayetteville (UAF) are working on the material growth using ultra-high-vacuum chemical vapor deposition (UHV-CVD) equipment located at Engineering Research Center at UAF campus.

Researchers at the University of Arkansas Fayetteville in collaboration with other universities in Arkansas (UA Pine Bluff) have studied silicon-germanium (SiGe) high speed semiconductor devices on sapphire substrate to be utilized in the future of space communication systems. Efforts toward a systematic study of SiGe material growth and device fabrication on sapphire substrate in this NASA project resulted in a thorough understanding of that powerful semiconductor alloy. A significant material analysis was developed for the growth of high-quality SiGe crystalline films using different growth (UHV-CVD and MBE) mechanisms. This NASA project has contributed significantly to explore different aspects of the SiGe on Sapphire (SGOS) materials and devices. The breakthrough results on the SGOS technology could largely affect the transceiver systems (i.e., transmitter, receiver, frequency synthesizers and amplifiers) with much higher speed and wider bandwidth. Implementation of this technology can substantially improve the data rate of space communications, operations and data collection and transfer. Working as a basic building block, devices based on SGOS technology are expected to play a key role in fulfilling the needs of a variety of space exploration missions at NASA.

Science PI
Zhong Chen, PhD
University of Arkansas, Fayetteville

NASA Technical Monitor
Sang Choi, PhD
Langley Research Center

On the northwestern coast of Madagascar, the salty waters of the Mozambique Channel penetrate inland to join with the freshwater outflow of the Betsiboka River, forming Bombetoka Bay. Numerous islands and sandbars have formed in the estuary from the large amount of sediment carried in by the Betsiboka River and have been shaped by the flow of the river and the push and pull of tides. Photo taken from the ISS.

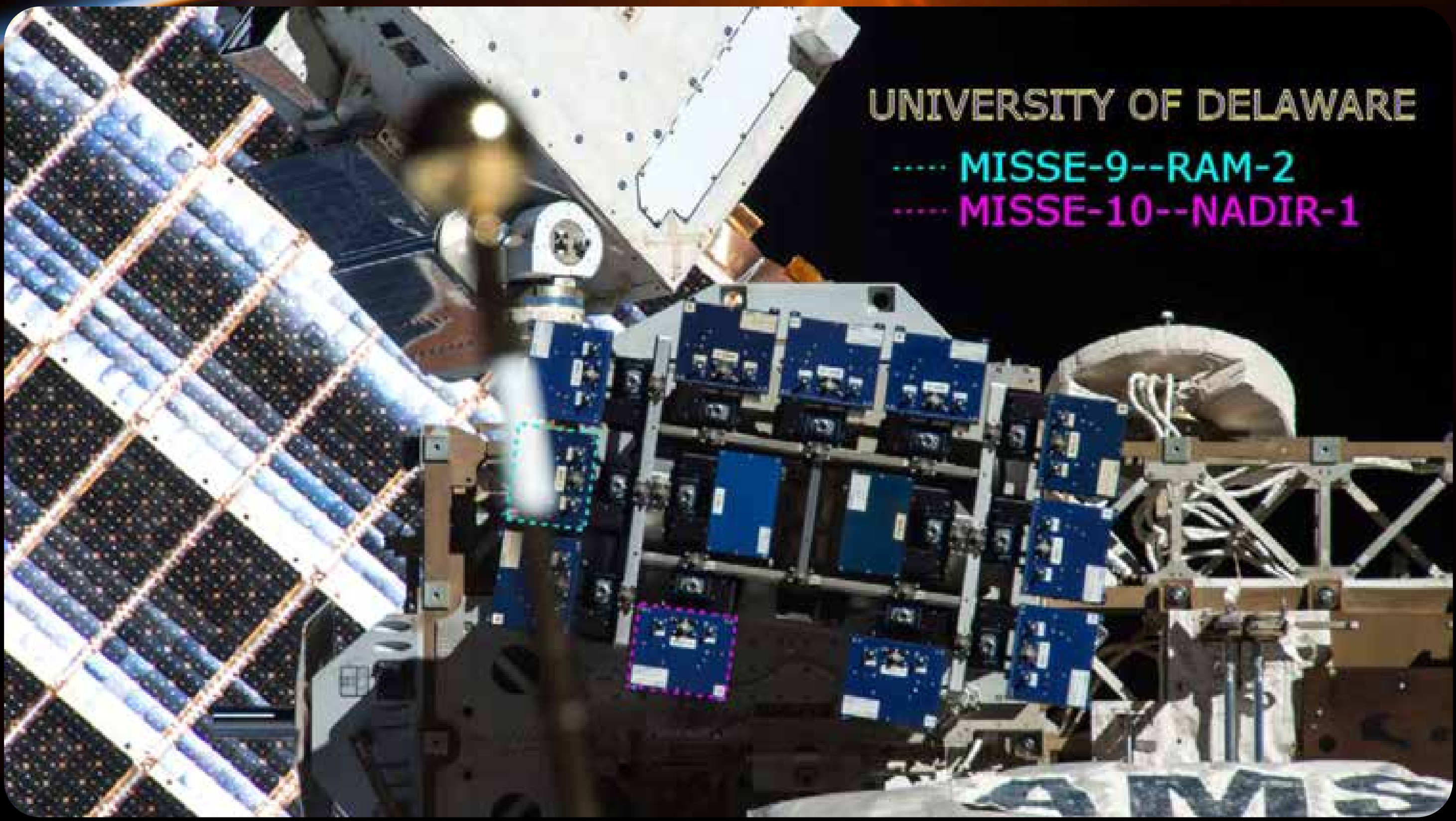
International Space Station

NASA EPSCoR International Space Station (ISS) flight awards provide opportunity for researchers to engage in research experiments applicable to low-earth orbit and beyond. The EPSCoR ISS research projects are candidates to be flown on the International Space Station, advancing the near zero-gravity studies, while providing opportunity for researchers to experience launch prep with NASA researchers and payload integration managers. The project awards are up to $100,000 for a three-year period of performance. The EPSCoR ISS Flight awards are announced yearly, pending fund availability and approval.

EPSCoR ISS Table of Contents

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

University of Delaware, Johnson Space Center



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.

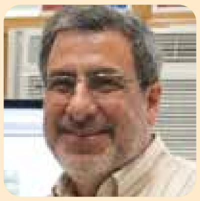
The longevity and robustness of LEO-STF-treated spacesuit materials, successfully launched with the Materials International Space Station Experiments, MISSE-9, aboard SpaceX-14 resupply mission on April 2nd, 2018, will be tested over the next year. The samples will be exposed to extreme levels of solar- 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

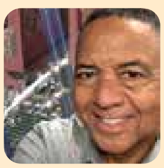
NASA Technical Monitor
Dr. Willie Williams
Johnson Space Center

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

University of Puerto Rico, Johnson Space Center



Science PI
Carlos Cabrera, PhD
University of Puerto Rico



NASA Technical Monitor
Dr. Willie Williams
Johnson Space Center

Willie Williams, NASA Technical Monitor, discussing the progress of the NASA EPSCoR ISS project with Mr. Alomar, UPR Board of Trustees President, and Carlos Cabrera (Science Lead).

Carlos Cabrera (Science Lead), Camila Morales (Payload Developer – Research Assistant), and Willie Williams, NASA Technical Monitor, discussing the progress of the NASA EPSCoR ISS project at UPR Rio Piedras Campus.

This NASA EPSCoR ISS project is a collaborative effort between the University of Puerto Rico and NASA Ames Research Center to advance the forward osmosis secondary treatment technology (FOST) of urine reclamation in microgravity conditions. In the electrochemical process, ammonia molecules are oxidized to gaseous nitrogen while reducing oxygen molecules from air at the cathode producing hydroxide molecules, which are diffused through an anion exchange membrane to the anode side to produce water. The formation of stagnant nitrogen gas on the catalyst materials under microgravity conditions disrupts these chemical reactions. By nanostructuring the catalyst materials, we enhanced the ability of nitrogen gas molecules to drift away from the catalysis site responsible for the ammonia oxidation and energy production, thus enabling the use of FOST in the ISS and other manned NASA missions.

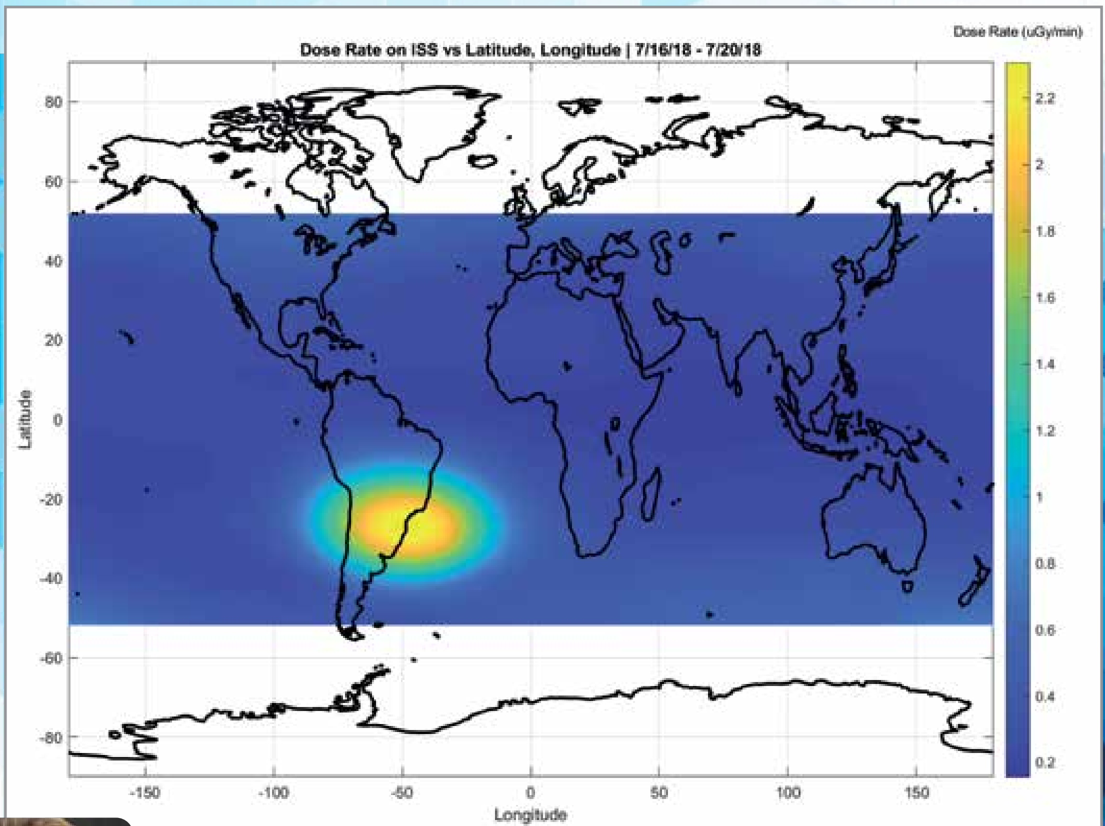
https://www.upr.edu/

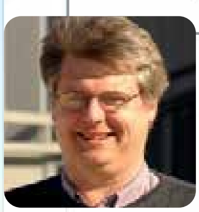
Demonstration of the OSU Tissue Equivalent Proportional Counter for Space Crew Dosimetry Aboard the ISS

Oklahoma State University, Johnson Space Center

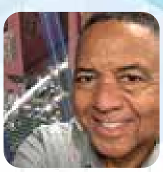
The Active Tissue Equivalent Dosimeter (ATED), developed by the Radiation Physics Laboratory at Oklahoma State University, is a compact, portable, low cost ionizing radiation detector designed for use on a range of different platforms including manned spacecraft, unmanned satellites and space probes, high altitude balloon flights and on commercial, civil (business) and military aircraft. The instrument is based on a gas-filled tissue equivalent proportional counter designed to simulate a ~2 micron diameter biological cell so that the sensitivity of the detector to ionizing radiation is nearly the same as that of human tissue.

Exposure of astronauts to elevated levels of ionizing radiation is one of the major hazards of spaceflight—especially long duration space missions such as the human exploration of Mars or the establishment of human habitats on the Moon. Real time monitoring of the radiation levels that space crews are exposed to will be essential on human exploration missions. ATED was successfully demonstrated aboard the ISS in summer 2018 and analysis of the flight data has been completed. Below is a plot showing absorbed dose from ionizing radiation as a function of the orbital position of the ISS.





Science PI
Eric Benton, PhD
The University of Oklahoma



NASA Technical Monitor
Dr. Willie Williams
Johnson Space Center

https://okpvri.okstate.edu/

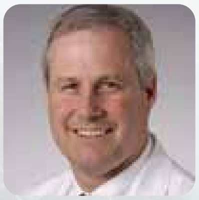
ISS

Time Course of Micogravity-Induced Visual Changes

The Geisel School of Medicine at Dartmouth, Johnson Space Center, Marshall Space Flight Center

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

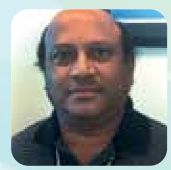
NASA Technical Monitor
Dr. Willie Williams
Johnson Space Center

Growth of Large, Perfect Protein Crystals for Neutron Crystallography

University of Nebraska Medical Center, Johnson Space 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 necessary 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



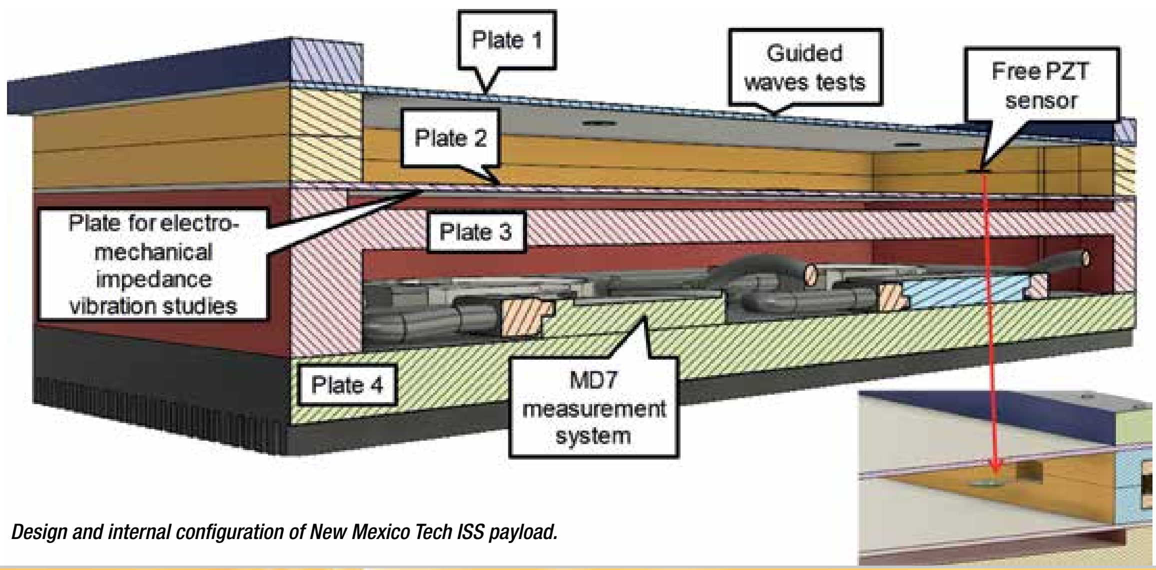
NASA Technical Monitor
Sridhar Gorti, PhD
Marshall Space Flight Center

Preparing human MnSOD crystals for the beamtime experiment at ORNL MaNDi

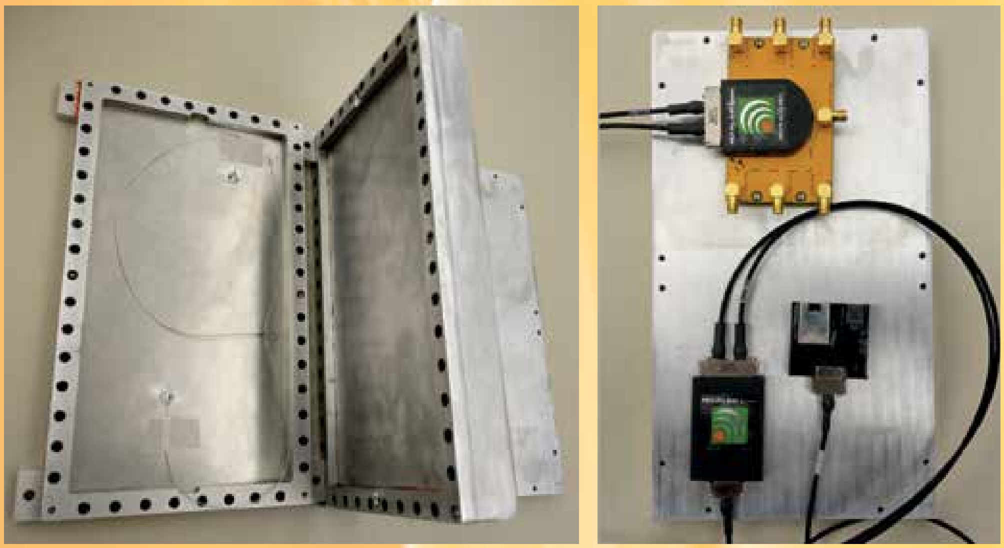
In Orbit Structural Health Monitoring of Space Vehicles

New Mexico Institute of Mining and Technology, Johnson Space Center

Ever expanding space operations in commercial and government sectors encourage advancements in flight safety, reduction of mission risk and improvements in affordability of space travel. Structural health monitoring (SHM) is seen as an enabling technology to achieve these goals. A research team from New Mexico Institute of Mining and Technology is developing an ISS payload to explore SHM of space vehicle on low Earth orbit (LEO). The payload integrates a number of SHM experiments to study elastic wave propagation, damage detection in space structures and smart material sensor behavior in space environment. It is envisioned that the results of in-orbit SHM experiments will help to understand structural diagnostics during space flight, study LEO environmental factors affecting SHM and guide designs of future smart space structures with embedded sensors, actuators, and artificial intelligence decision support.



Design and internal configuration of New Mexico Tech ISS payload.



New Mexico Tech ISS payload carrying SHM LEO experiments. (a) top section with sensor layout for guided wave experiment, (b) bottom plate with electronic hardware for SHM experiments.

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

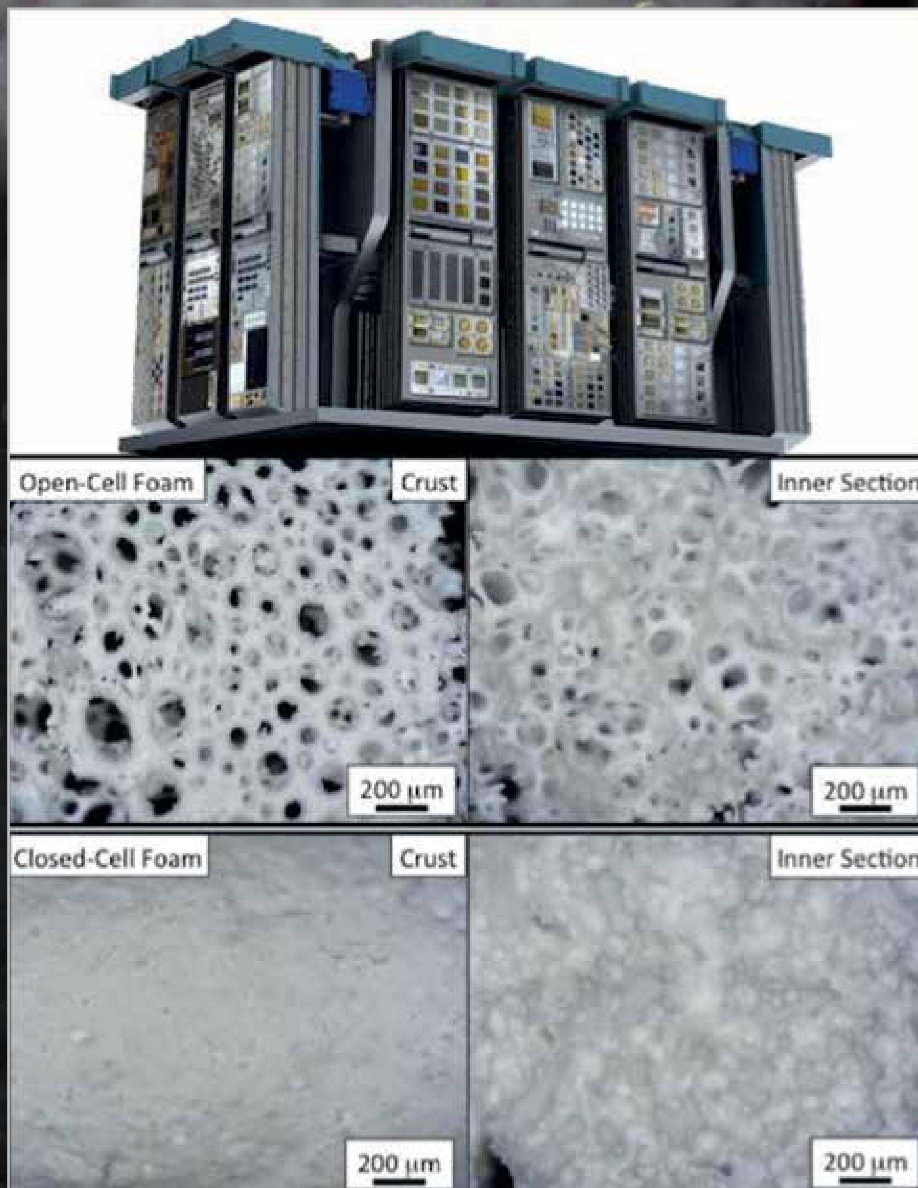
NASA Technical Monitor
Ali Shaykhian, PhD
Kennedy Space Center

ISS

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

West Virginia University, Johnson Space Center

This project has significantly helped to develop further capabilities for 3D printable metal oxide foams in the science-PI's lab in particular and West Virginia University in general. Specifically, we were able to further develop and test our in-house built 3D foam printer and we were also able to gain further insights into metal-oxide foam 3D printing and characterization. Of particular interest are new relationships that we are currently establishing between foam processing conditions and resulting mechanical and photocatalytic properties. Furthermore, through the project we were able to hire and train a PhD researcher who is now working on the project. Finally, through this project we were able to expand our funded research with another NASA new award (complementary to this award) which is focusing on 3D printing of TiO2 foams in microgravity conditions (i.e. parabolic flight 3D printing).



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

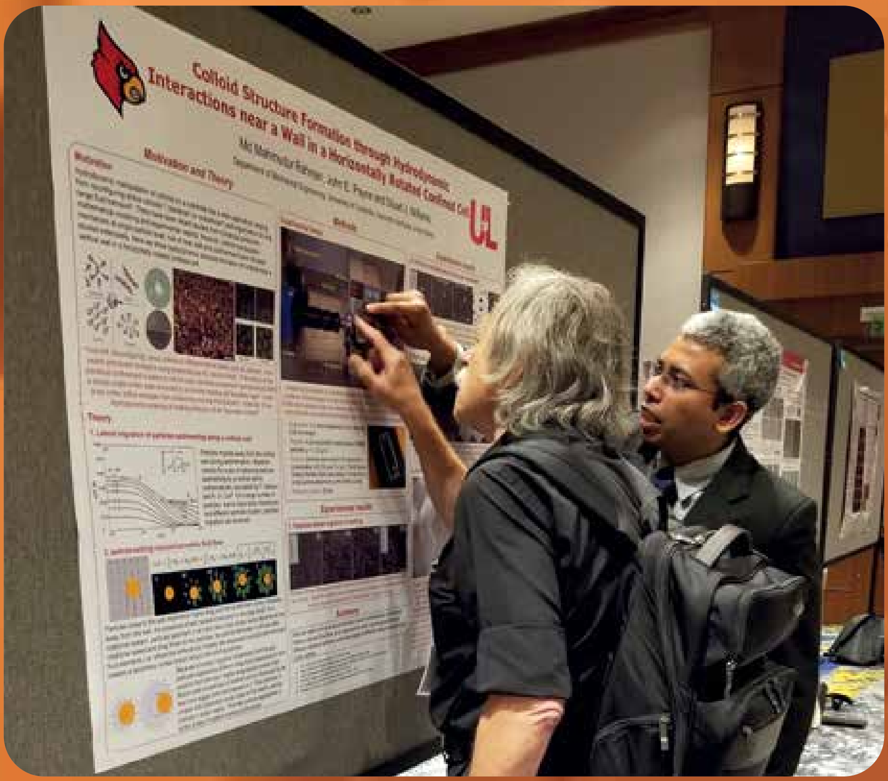
Science PI
Konstantinos Sierros, PhD
West Virginia University

NASA Technical Monitor
Justin R. Morris
Goddard Space Flight Center

ISS

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

University of Louisville, Johnson Space Center



Science PI
Stuart J. Williams, PhD
University of Louisville

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

University of Louisville faculty and graduate students presented results of their award-winning International Space Station (ISS) microgravity research conducted with the NASA Glenn Research Center. Credit: Williams Research Group, University of Louisville.

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 physics that govern colloidal stability and assembly. The project's first experiment samples were launched in 2018 on SpaceX CRS-16. Experiments on the ISS were conducted May-June 2019. Additional experiment samples were launched on SpaceX CRS-20 March 2, 2020.

UofL researchers were awarded these additional ISS launches to follow up on results of a previous ISS research flight from 2016. The Kentucky research team will now utilize insight gained from their previous experiment as well as benefit from the space station's newly upgraded confocal microscope.

On the ground, additional experimentation and sample characterization are being conducted at UofL 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.

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

University of Arkansas, Fayetteville, Johnson Space Center

Arkansas Center for Space and Planetary Sciences Ph.D. student Cassandra Sands presenting her EPSCoR-ISS project poster at the 2019 ISS R&D Conference in Atlanta, Georgia.

The design of a novel cold-gas (like a duster can) in-space 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 non-pressurized at launch conditions is currently being developed at the University of Arkansas (UA). These design attributes will enable new capability for small satellites, especially for entities/institutions with limited resources such as universities and small companies. Once proven, the ARKSAT team will utilize CSAPS to provide rapid (on the order of seconds) pointing and maneuvering capabilities for a paired or formation flight of small spacecraft; as a novel planetary atmosphere measurement instrument using active spectroscopy. The development of ARKAT-2 also helps train UA students in space science and technology, at the undergraduate and graduate level, in addition to supporting the establishment of the small-spacecraft technology development and operations capability at UA. The project manager of ARKSAT-2, Ms. Cassandra Sands, is shown in the figure below presenting the ARKSAT team's research efforts at the 2019 ISS Research and Development Conference in Atlanta.

NASA Technical Monitor
Elwood Agasid
Ames Research Center

Science PI
Po-Hao Huang, PhD
University of Arkansas

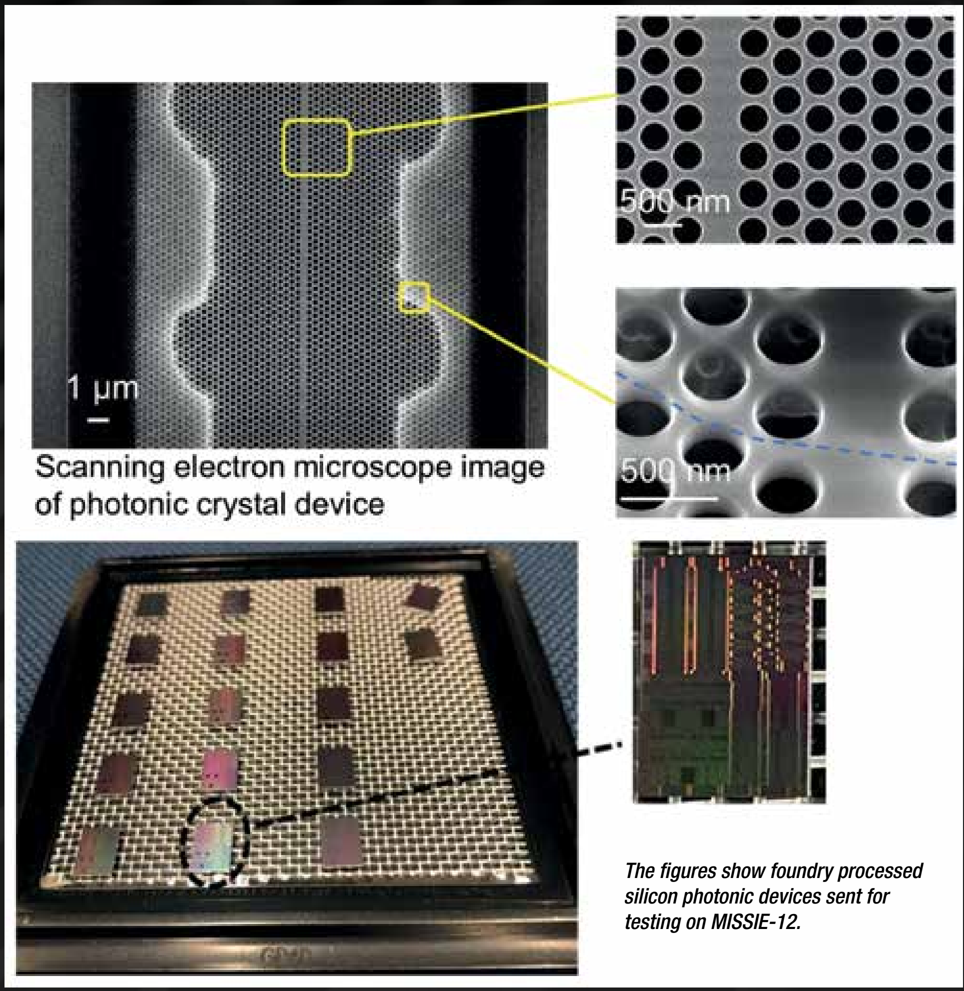
ISS

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

University of Delaware, Johnson Space Center

ISS

Integrated photonics allow dense integration of photonic system on chip for a wide range of applications from laser communication to remote sensing. Without any mechanical moving part, the lithography defined systems are low power, light weight and energy efficient. Collaboration effort between University of Delaware, Goddard space flight center and Nokia Bell Labs are pushing the silicon photonic components to higher technology levels for implementation in space environment. Those nanoscale devices are manufactured at AIM photonics and post-processed at University of Delaware Nanofabrication Center. The nano-manufactured devices exhibit superior transmission, homogeneity and optoelectronic bandwidth compared to the devices created in individual cleanrooms. The postdoc, graduate and undergraduate students involved in the project are inspired by the potential contribution/impact to the future avionic instrument development.



The figures show foundry processed silicon photonic devices sent for testing on MISSIE-12.

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

https://www.sciencedaily.com/releases/2019/03/190329134756.htm

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

Oklahoma State University, Johnson Space Center

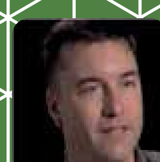
Filament extrusion set up (top and side views)

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

ISS

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

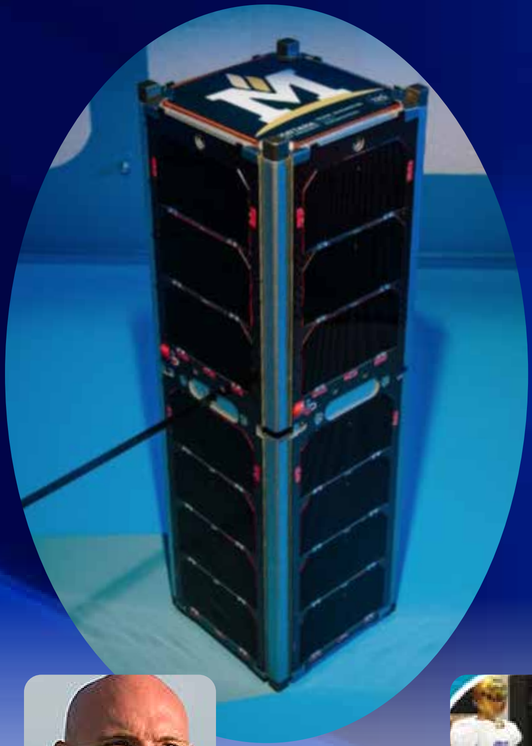
Montana State University, Bozeman, Johnson Space Center

RadSat-g coming out of the CubeSat Deployer on the ISS in July of 2018.

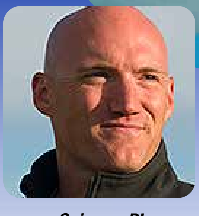
RadSat leaving the CubeSat Deployer on the ISS in July of 2018.

RadSat entering Low Earth Orbit in July of 2018.

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 radiation.



Science PI
Brock J. LaMeres, PhD
Montana State University

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

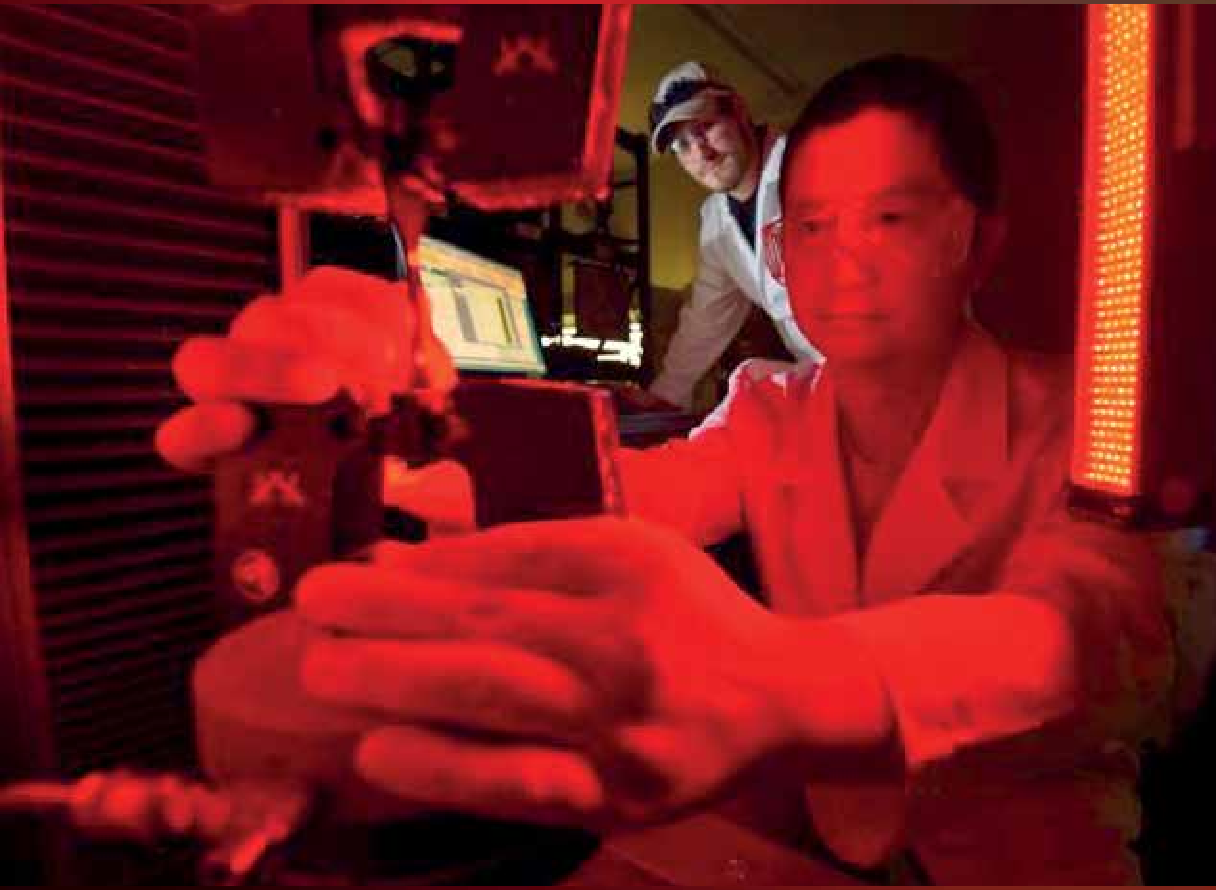
http://www.montana.edu/blameres/research_overview.html

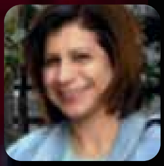
Utilizing ISS as a Test Bed to Validate the Performance of Nano-Enhanced Polymers Subjected to Atomic Oxygen and/or Hypervelocity Impact

The University of Mississippi, Johnson Space Center

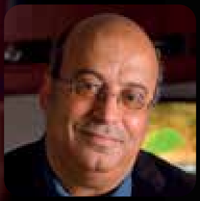
The current EPSCoR funded research is aimed at developing and testing a new class of ultra-lightweight nano-composite sheet that can provide significant improvement in the shock absorption/attenuation and dispersion of modern debris shields. These new shields could be retrofitted on ISS and also used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

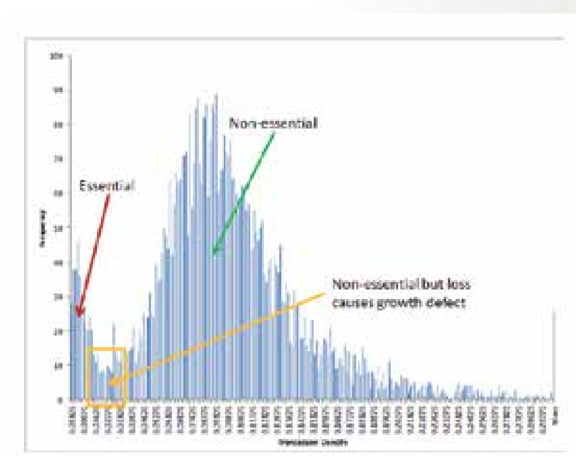
A research associate tests Graphene Reinforced Polymers for Hypervelocity Impact Application.

Assessment of Whole Genome Fitness of Bacteria Under Microgravity

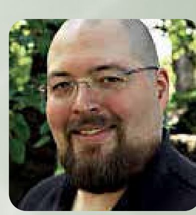
University of Mississippi, Glenn Research Center

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

ISS

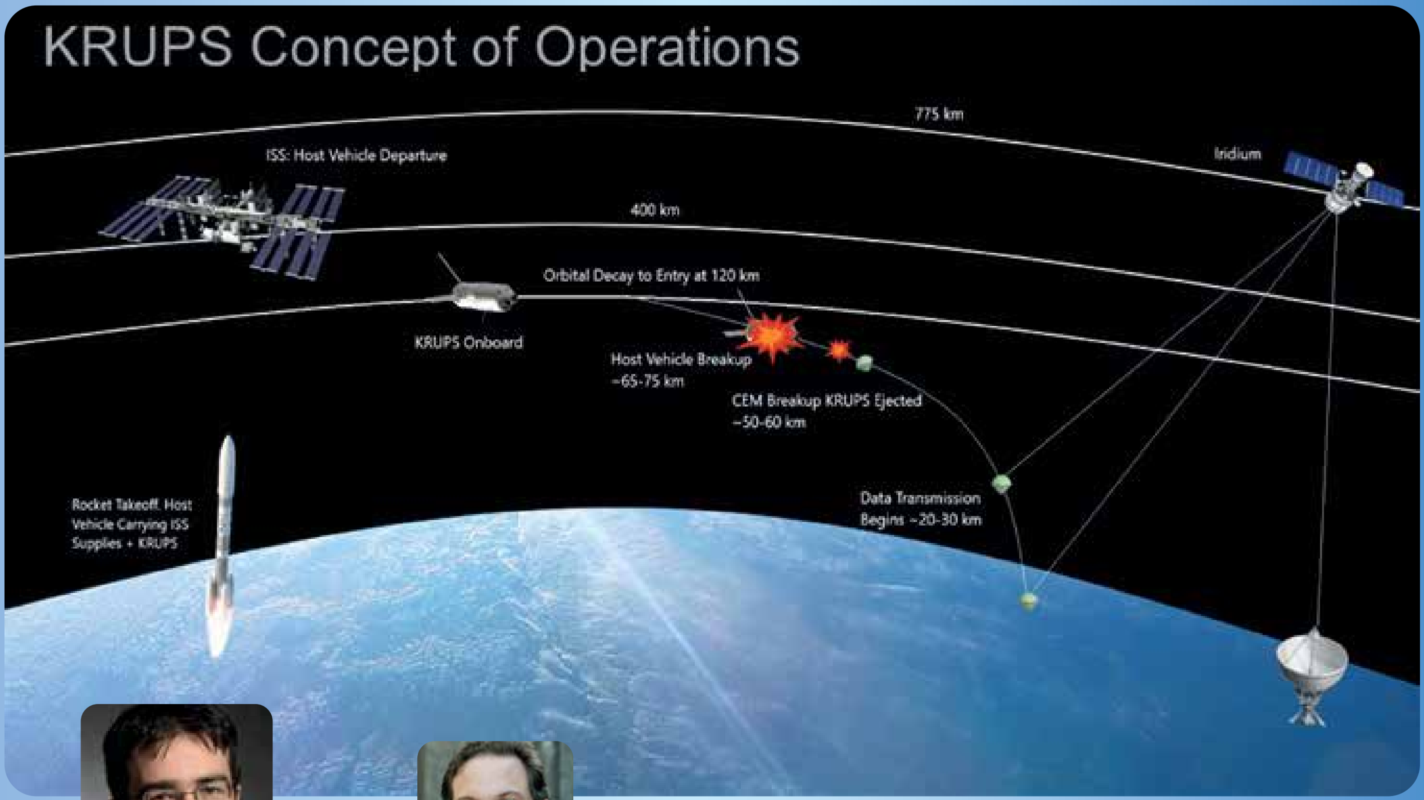
KRUPS: ISS Flight for Heat Shield Testing

University of Kentucky, Johnson Space Center, Ames Research Center

Over the last 50 years, only a handful of high-speed atmospheric re-entry experiments from beyond low-Earth orbit (LEO) or similar have been performed: Apollo 4, Apollo 6, FIRE-II, MER, MSL, and very recently, Orion EFT-1. Not only were these flights part of elaborate and costly programs, but the Thermal Protection Systems (TPS) tested were at the final stage of design. Design of efficient thermal protection systems to shield spacecraft from high-temperature conditions remains one of the most challenging tasks for planetary exploration missions. Because of the harshness of atmospheric entry environments, no ground facility can adequately replicate all of the pertinent conditions. Consequently, engineers rely on numerical models to close the loop on TPS designs

Inspired by previous small capsule re-entry design (REBR, SPRITE), the PI, Dr. Alexandre Martin, and his students at the University of Kentucky (UK) started designing their own re-entry capsule, the Kentucky Re-entry Universal Payload System (KRUPS). The KRUPS capsule was designed as a cost-efficient atmospheric entry experiment test-bed. The KRUPS project has been ongoing for the last 5 years, starting from conceptual design to initial flight qualifications.

Under the current NASA EPSCoR ISS Flight Project, "KRUPS: ISS Flight for Heat Shield Testing," the research team will fly three capsules to ISS, carried to the station on a cargo re-supply mission. After it delivers supplies to ISS, the cargo ship will de-orbit and disintegrate in the atmosphere, leaving the 3 KRUPS capsules to re-enter Earth's atmosphere on their own and gather data to validate numerical models for the flight environment and the heat shield response, thereby contributing to better thermal protection system design for future spacecraft.



Kentucky Re-entry Universal Payload System (KRUPS) concept of operations for atmospheric re-entry from the International Space Station.

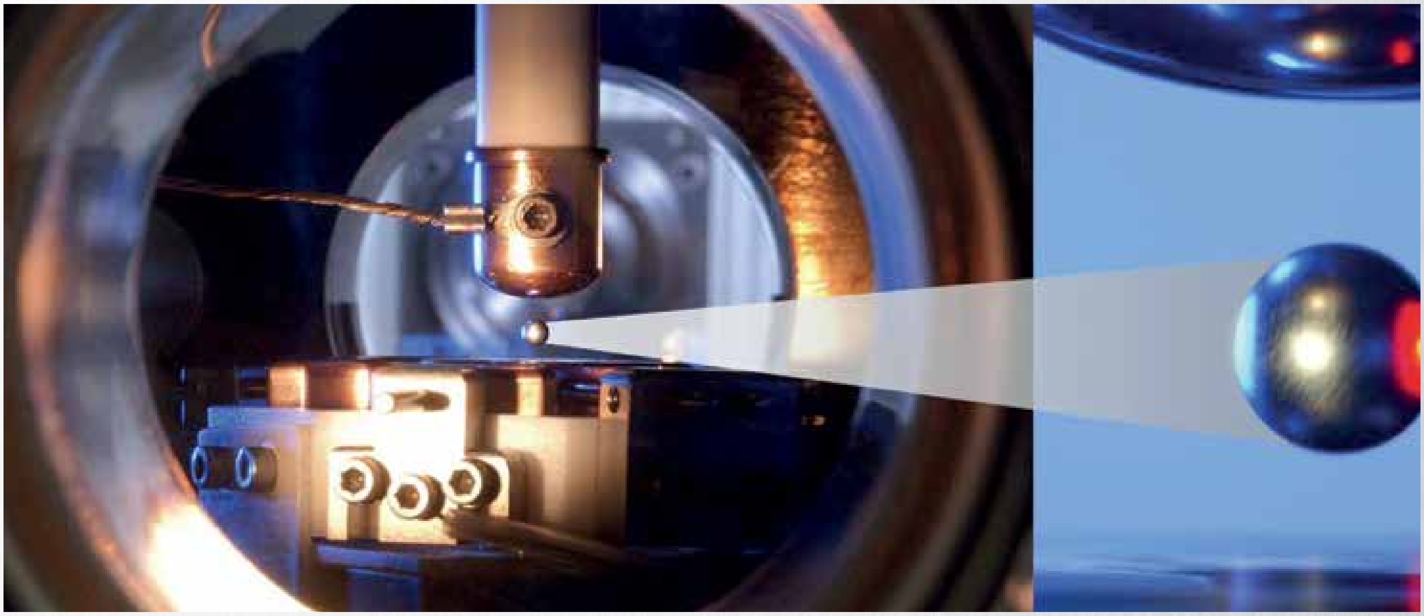
Science PI
Alexandre Martin, PhD
University of Kentucky

NASA Technical Monitor
Michael Wright, PhD
Ames Research Center

ISS

Silicon-Cobalt Alloy Properties

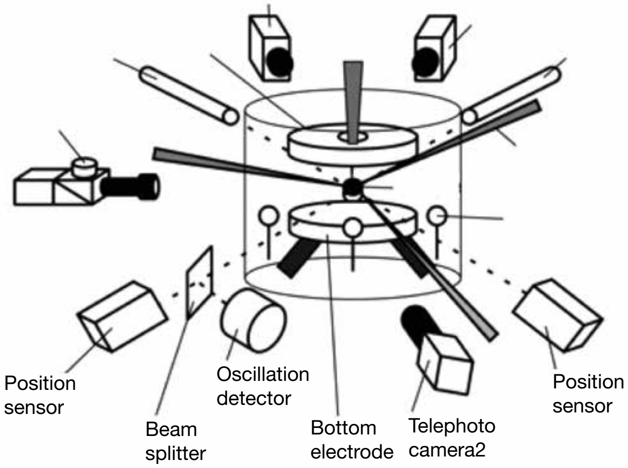
The University of Alabama in Huntsville, Marshall Space Flight Center



A sample in the Electrostatic Levitator prior to melting. On eutectic SiCo alloys were successfully levitated, melted and, thermophysical properties obtained. Off-eutectic SiCo alloys became unstable and oscillated out of the containment field.

Science PI
R. Michael Banish, PhD
University of Alabama

NASA Technical Monitor
Michael SanSoucie
Marshall Space Flight Center



Schematic setup of electrostatic levitation hardware. The major components are the levitation electrodes, the positioning electrodes, the position monitoring laser and camera, and the heating laser. The hardware is enclosed in a high vacuum chamber and controlled from a remote station.

The original intent and objective of this proposal was to use the JAXA ESL to confirm the already measured thermophysical properties of the silicon-transition metal binary eutectic and then to determine the thermophysical properties of the off-eutectic alloys. Due to the unavailability of the JAXA-ESL and after several discussions with MSFC and NASA-HQ personnel, it was decided that the best course of action was to return to MSFC and to re-determine the thermophysical properties of the binary eutectics, investigate if we could levitate and determine the thermophysical properties of alloys that had minimum deviation from the binary eutectic composition, and to investigate possible compositions of ternary eutectics; this would be done by approximating the composition of ternary eutectics and then attempting to levitate that composition. Ternary eutectic are predicted to exist for silicon-transition metal alloys. At the present time, there is limited research and publications about silicon-transition metal alloys, and no research into their thermophysical properties. This was the research that we expected to complete during the summer of 2020. However, due to the COVID-19 pandemic, and the lock-down of MSFC, the MSFC ESL facility is closed. When MSFC reopening we will conduct this research.

Demonstration of Radiation Tolerant Memory Synchronization within a Reconfigurable Flight Computer

Montana State University, Bozeman, Marshall Space Flight Center

RadSat-u from Montana State University tests a new computer architecture that can recover from faults caused by space radiation on its core+memory blocks.

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 called "RadPC" 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. RadPC has been matured through a series of projects funded by NASA EPSCoR. In the most recent project, a small satellite named "RadSat-u" carried the computer into orbit in order to collect data on how well the memory system copes with radiation.

Science PI
Brock J. LaMeres, PhD
Montana State University

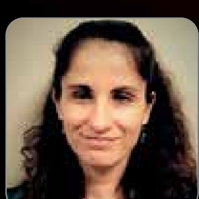
NASA Technical Monitor
Eric A. Eberly, PhD
Marshall Space Flight Center

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

Louisiana Tech University, Kennedy Space Center

The aim to support an extended human presence in space has led to the establishment of NASA's GeneLab, which combines a database repository dedicated to ISS biological experiments and corresponding ground base studies. The components of the WetLab-2 tools have been validated on the ISS and includes RT-qPCR system in which RNA is reverse transcribed and analyzed. Part of the lab suite is a rather complicated suite of sample preparation hardware that is used to extract and purify RNA from biological material. Although functional, the sample preparation relies heavily on crew time. Furthermore, the amount of liquid handling required for the sample preparation requires two levels of containment for those steps.To simplify the specimen sample prep time, we are validating our solid-phase gene sampling technology as part of the WetLab-2 RNA workflow. The implementation of the RNA capture pin technology is expected to reduce crew time by nearly two orders of magnitude, provide sampling that will be less invasive than existing methods, and enable repeated sampling of the specimen. The solid phase-extraction method avoids the transfer of biological material and the probes needs no further processing to separate the RNA from the tissue.

The RNA capture pins interface elegantly with the COTS reaction tubes. The pins are functionalized with capture thymine nucleobases. The RNA capture pin is punctured into biological tissue, the RNA tail attaches to the pin, and is collected for analysis by simply removing the pin from the tissue.



Science PI
Gergana G. Nestorova, PhD
Louisiana Tech University

NASA Technical Monitor
Matt Romeyn
Kennedy Space Center

ISS

MUREP Institutional Research Opportunity

NASA's Minority University Research and Education Project (MUREP) **Institutional Research Opportunity** (MIRO) was established to strengthen and develop the research capacity and infrastructure of Minority Serving Institutions (MSIs) in areas of strategic importance and value to NASA's mission and national priorities. Overall, MIRO awards aim to promote STEM literacy and to enhance and sustain the capability of institutions to perform NASA-related research and education, which directly supports NASA's four mission directorates—Aeronautics Research, Human Exploration and Space Operations, Science and Space Technology.

Torry A. Johnson
National Manager, Minority University Research and Education Project (MUREP)

EPSCoR MIRO Table of Contents

MIRO

Data Intensive Research and Education Center for STEM

California State University Los Angeles, Jet Propulsion Laboratory

Science PI
Hengchun (Haley) Ye, PhD
Associate Dean and Professor
Geosciences and Environment

In 2015, California State University Los Angeles, a Hispanic-Serving Institution (HSI), established Data Intensive Research and Education Center for STEM (DIRECT-STEM) to recruit and train students from under-represented groups and inspire them to become future leaders in STEM-related professions with strong NASA science competence. In collaboration with the Jet Propulsion Laboratory (JPL) and the Ames Research Center, the center contributes to NASA's research priorities of Earth Science (Atmospheric Sciences, Water & Carbon Cycles), Astrophysics & Space Sciences (Origins of Stars and Planets), Mars, International Space Station, and Data Science and Technology.

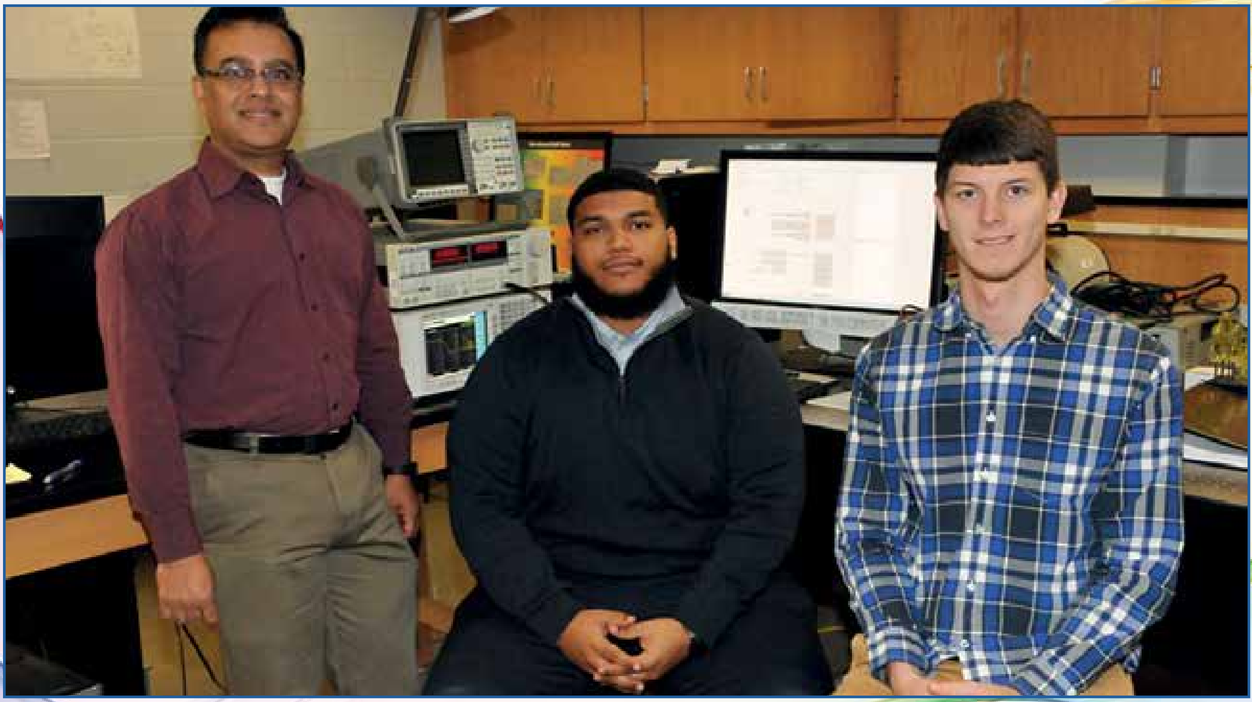
The Center conducts workshops in mathematics, statistics, computation, Python and Matlab coding for 316 students from Cal State LA, community colleges, and other local universities each year. We introduce NASA's products into upper division and graduate level classrooms where scientists and post-doctorates from JPL are the instructors. We provide intensive research training to 59 STEM students in areas include (1) Earth's changing hydrological cycle; (2) machine-learning-based large-scale data processing and neural networks of deep learning models for cloud computing; (3) understanding the origin of the solar system using Spitzer Space Telescopes; (4) space health using Artificial Intelligence analytics; (5) robotic rover simulation for landers on Mars; (6) Pore Formation and Mobility Investigation (PFMI) and simulation of solidification in castings of changing cross sections.

DIRECT-STEM Graduate students Michelle De Luna (L) and Sara Johnson (R) discuss their research.

MIRO

Optics for Space Technology & Applied Research Center

Delaware State University, Goddard Space Flight Center



Dr. Mukti Rana with Danzel Hill and Andrew Voshell, OSCAR undergraduate and graduate students, respectively.

In 2015, Delaware State University, a Historically Black College and University (HBCU), established the Optics for Space Technology & Applied Research (O*STAR) Center to conduct research on applications of optical sciences on space explorations. In collaboration with Goddard Flight Space Center, the Center has contributed to NASA mission in the research areas of laser-induced breakdown spectroscopy investigations for planetary science, development of sodium-LIDAR altimetry, development of mid-infrared integrated sensing and imaging systems, and design and fabrication of uncooled infrared detectors.

To build institutional research capacity, we have enhanced the research capabilities of Optical Sciences of Applied Research (OSCAR) labs. Significant progress was made in areas of developing novel systems, novel materials and technologies for space application e.g. laser-based sensors and LIDAR systems for extra-terrestrial exploration, MARS rover 2020 program. The University has supported this effort by providing a new building for doing research on optical sciences and applications. Two patents have been awarded on uncooled infrared detection by Dr. Rana, with students listed as co-applicants. Since the fall of 2016, we have trained and supported 37 Graduate students, 108 Undergraduate students, 42 high school, 98 middle school, 6 elementary school and science 9 teachers.

To enhance student knowledge and research skills, the Center has contributed to offering a PhD in Optics degree (only to be such program at an HBCU). This degree includes academic curriculum with specialization in optical technologies, photonic materials and research areas integrated with all-year round internships to prepare future workforce for NASA.

Critical partners of the Center have included the University of Delaware, Los Alamos National Laboratory, and University of Massachusetts at Lowell. We have also engaged in outreach to Delaware Aerospace and Educational Foundation, local school districts and Dover Public Library through activities related to our research on applications of optical sciences.

Science PI
Mukti Rana
Professor
Engineering, Division of Physical and Computational Sciences

MIRO

Hampton University Center for Atmospheric Research and Education

Hampton University, Langley Research Center

In 2015, Hampton University, one of the nation's leading Historically Black Colleges and Universities (HBCU), established the Center for Atmospheric Research and Education (HU: CARE) to develop multiple research efforts in atmospheric sciences using remote-sensing, in-situ, and laboratory techniques, and creating educational programs in atmospheric science, Earth system science, and science communication. In collaboration with NASA Langley Research Center, the center's work is aligned primarily with the Science Mission Directorate and its Earth Science programs.

To build institutional research capacity, we have deployed a Satellite Direct Broadcast Receiving System as well as upgraded our optics research facility. The University has supported this effort by providing space for the DBRS antenna. We have leveraged support from DoD and NSF to add complementary facilities including an AERONET Sun Photometer, a PANDORA atmospheric composition instrument, a tunable laser DIAL system, new optics laboratory equipment, meteorological and ozone sondes, and a state-of-the-art massively parallel computer. With this equipment, Hampton University has become part of national and international atmospheric monitoring networks including AERONET (aerosols) and TOLNET (ozone) and are developing validation techniques for upcoming missions such as TEMPO. With support from the City of Hampton's Development office, we have created a Severe Weather Center to develop new methods of combining satellite weather data with forecast models for improved warnings of severe thunderstorms and tornadoes. Students and faculty have been participating in studies of ozone around the Chesapeake bay, developing new lidar techniques to measure and understand the atmosphere, and launching balloon sondes to validate satellite measurements.

To enhance student knowledge and research skills, the Center has developed a joint course in satellite meteorology with our partner, the University of Wisconsin Madison. In addition, we have developed the Virginia Earth Systems Science Scholars program for high-school and junior college students to give students an Earth-science advanced placement option and to inspire them to study the complex and interdependent web of systems that make our planet work. Finally, we have partnered with the Scripps Howard School of Journalism and Communications at Hampton University to train future journalists in science communication and public outreach.

HU; CARE Direct Broadcast Antenna installed on top of the Harbour Centre

Science PI
William B. Moore
Professor
Atmospheric and Planetary Science Department

MIRO

Langston University NASA Advanced Research in Biology Center

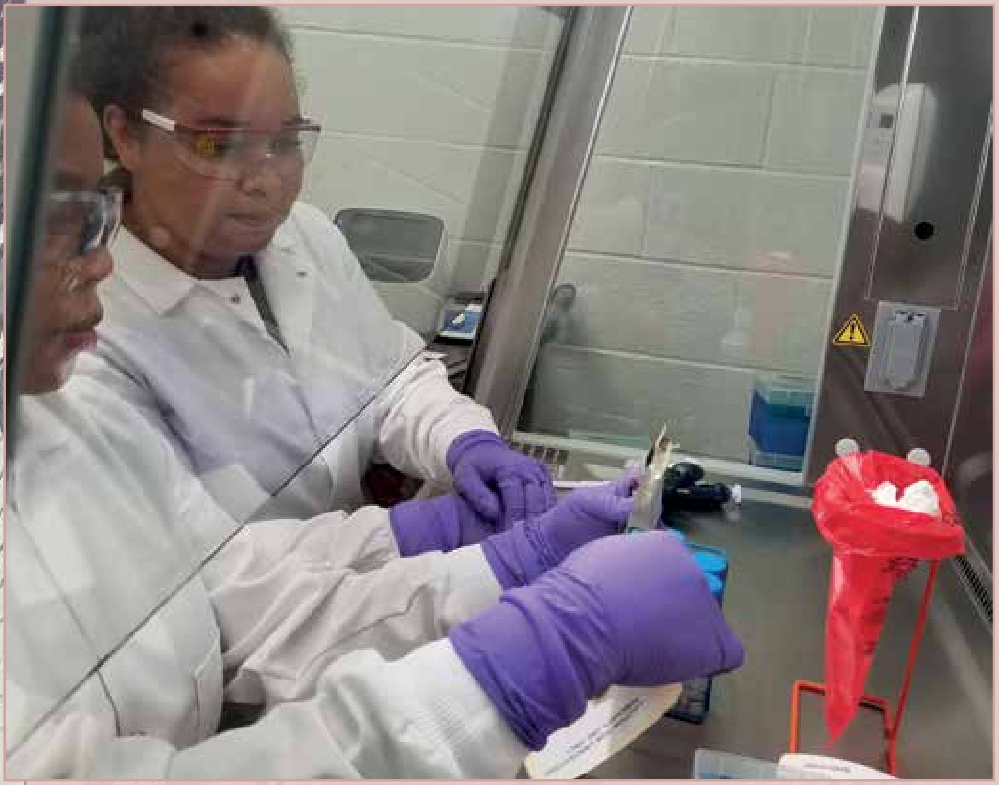
Langston University, Johnson Space Center

In 2015, Langston University, a Historically Black College and University (HBCU), established the Langston University NASA Advanced Research in Biology Center (LUNAR-BC) to develop natural countermeasures to the dysregulated immune system affecting crewmembers under extended spaceflight conditions. This research will lead to an increase in the knowledge of natural compound formulations to enhance the immune system in humans, allowing for low cost natural treatments for immune related diseases in humans and sustaining the immune system for astronauts on extended space missions.

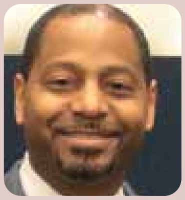
Critical partners of the Center are NASA Johnson Space Center, University of North Texas Health Science Center (UNTHSC), Harvard Medical School and Stanford University. The director of the UNTHSC animal facility is also helping to set up a small animal model facility in the Science Research Institute, allowing LU to scale up the NASA studies from the test tube to small animal models.

To build institutional research capacity, the Science Research Institute is now equipped with advanced instrumentation for high impact biomedical research. Langston University has supported this effort by providing an entire building on campus to house the NASA MIRO research center. A QToF mass spectrometer, cell sorter and an Illumina sequencer was acquired to conduct an in-depth study of immune cells and natural countermeasures under micro-gravity conditions.

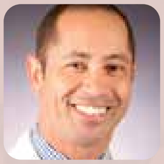
To enhance student knowledge and research skills, the Center has contributed to revisions of Natural Science Biology I course. Students taking this course participate in the LUNAR-BC NASA challenge award, where they develop proposals for a NASA human health countermeasure. The winning team receives a stipend and a trip to NASA JSC.



Cari Quick Campbell and Brooklyn Baker, LUNAR-BC students, prepare immune cells for simulated microgravity countermeasure



Science PI
Byron Quinn
Chair, Department of Biology



Co-Science PI
Harlen Jones, PhD
North Texas State University

MIRO

Center for Applied Atmospheric Research and Education

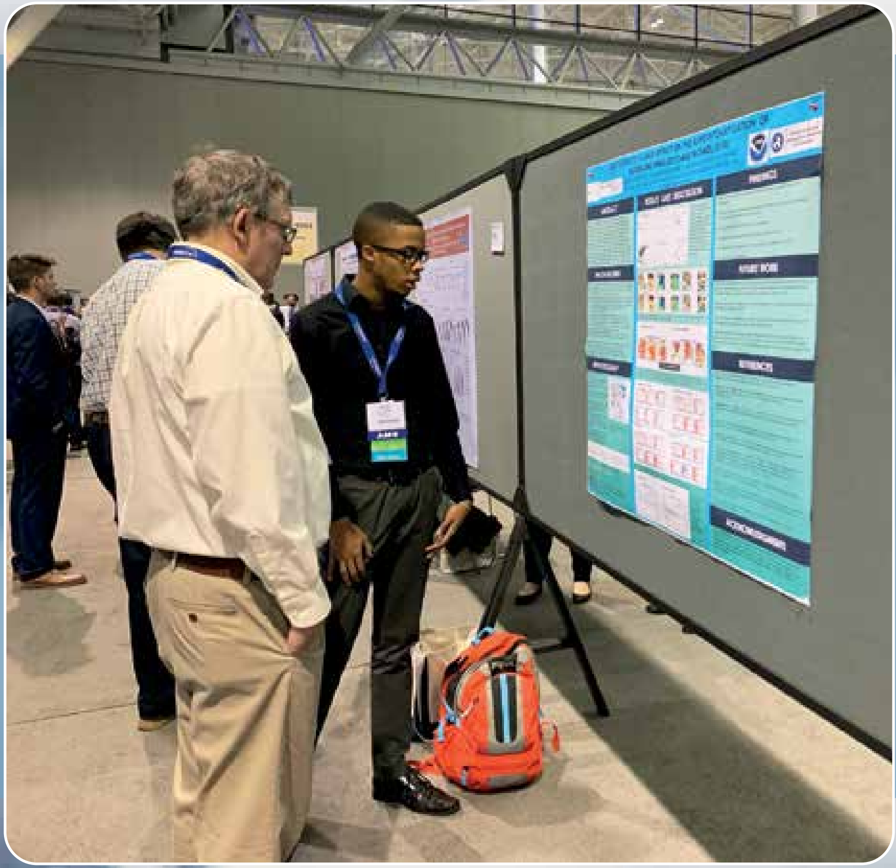
San Jose State University, Marshall Space Flight Center, Ames Research Center

The Center for Applied Atmospheric Research and Education (CAARE) was established in 2015 at San Jose State University (SJSU), an Asian American Native American Pacific Islander (AANAPISI) and Hispanic (HSI) Serving institution. The goal is to expose undergraduate and graduate students to the various research projects associated with the field of atmospheric sciences. In collaboration with NASA ARC and MSFC, CAARE interns complete projects to assist in areas such as analyzing snow cover changes using satellite imagery and remote sensing for the Navajo Nation in response to climate change; public health and PM2.5, orbiting carbon observatory, oceano¬graphic applications of remote sensing, and climate-related factors of Harmful Algae Blooms, assessing the environmental impacts of Hurricane Irma and Maria on the U.S. Virgin Islands, and many more. CAARE has supported more than 70 students including summer interns, undergrad and grad at SJSU since 2015.

NASA ARC scientists serve as thesis committee of CAARE grad students and teach classes in the Department of Meteorology and Cli¬mate Science at SJSU. The goal is to broaden the Center research capacity and better align with the NASA research activities in Science Mis¬sion Directorate (SMD). To advance our research capacity, CAARE researchers and partners utilize High Performance Computing, greenhouse gas analyzer, ozone analyzer, aethalometer, nephelometer, ceilometer and disdrometer as our research facilities.

Our critical partners, University of Alabama in Huntsville (UAH), Universities Space Research Association (USRA), and Fond du Lac Tribal and Community College (FDLTCC) influence a diverse environment in atmospheric-related disciplines in graduate and undergraduate levels. Our external partners, who support our program, are California Air Resources Board (CARB), Santa Clara Valley Water District (SCVWD), Advanced Clustering Technologies Inc., the Bay Area Quality Management District (BAAQMD) and other private sectors.

Science PI
Sen Chiao
Chair and Professor
Meteorology and Climate Science



Alrick Green (CAARE student) delivers poster presentation at the American Meteorological Society (AMS) 100th annual meeting in Boston, MA. January 2020.

Merced nAnomaterials Center for Energy and Sensing

University of California at Merced, Ames Research Center, Jet Propulsion Laboratory, Langley Research Center, Glenn Research Center

MACES Key Personnel: Sauantani Ghosh (L), Ashlie Martini (C), and Jennifer Lu (R)

Science PI
Jennifer Lu
Associate Professor
and MACES Director

MIRO

MACES (Merced nAnomaterials Center for Energy and Sensing) investigates nanomaterials for advancing space technologies while also ushering disadvantaged students into STEM-related careers. Incorporating hands-on research has greatly enhanced STEM educational experience at UC Merced where more than 55% of students come from Hispanic minority grups. MACES' outreach activities have made significant inroads in promoting K-12 STEM education in the local Central Valley, where the number of college graduates sits far below the California average, 18% vs. 33%.

MACES focuses on creative nanomaterial solutions for developing (a) power management systems that are efficient, lightweight and reliable, and (b) compact and energy-efficient sensing systems that can monitor human health and environment in the extreme context of space exploration and terrestrial enviornment. MACES has attracted 18 faculty members and secured more than $13.2 million extramural funding. This includes $2.5 million of state-of-the-art instruments to bolster the campus' materials research infrastructure. These funds have fueled the rapid transformation of UC Merced's materials research infrastructure to match or surpass that of many established campuses. MACES has generated over over two dozens of team-based peer reviewed journal papers and is developing into a significant and multidisciplinary research center.

Fellowships and Internships in Extremely Large Dataset

University of California, Riverside, Jet Propulsion Laboratory

Mars 2020, which needs autonomous robotic sensing algorithms to handle unknown or harsh environments on the Mars surface. Image credit: NASA/JPL-Caltech

In 2015, University of California, Riverside, a Hispanic Serving Institution (HSI), established the Fellowships and Internships in Extremely Large Dataset (FIELDS) Project to train and educate students in Big Data analysis techniques. The overall structure of the FIELDS program includes activities at multiple levels:

- High school students attend summer academy at UCR, taking college level courses in STEM fields.
- Undergraduate students in STEM disciplines complete research internships at JPL or UCR. A number of these students joined NASA/JPL upon graduation.
- A new, self-supporting, online Master of Science and Engineering program in Data Science was established in 2017. With a focus on big data, the program is designed for scientists and engineers who work in industry, educational, financial, government and academic institutions using data analysis and processing techniques.
- Over 35 graduate students, supported by multi-year graduate-student fellowships, work on data-intensive areas of interest to NASA. They often work under the mentorship of a NASA science staff as well as their advisor.
- Post-Doctoral fellows conduct research in areas directly related to future NASA missions (WFIRST and Euclid).

FIELDS-supported students and post-doctoral scholars are working on data-intensive topics in astrophysics, earth sciences, neuroscience, material engineering, and electrical and computer engineering that directly contribute to current and future NASA missions. A FIELDS undergraduate intern is developing software for autonomous robots, under the co-mentorship of a UCR faculty member and a JPL scientist. These robotic sensing algorithms support mobility, perception, autonomy, and communication for unknown or harsh sensing environments, have both terrestrial and planetary applications, and are essential for the subsurface exploration on Mars and beyond. With available data from both NASA and Longevity Consortium, a FIELDS-funded Genomics graduate student is researching how space travel impacts the lifespan of astronauts.

Science PI
Bahram Mobasher
Professor of Physics and Astronomy

Center for Space Exploration and Technology Research

The University of Texas at El Paso, Johnson Space Center, Marshall Space Flight Center, Glenn Research Center, White Sands Test Facility

Science PI
Ahsan Choudhuri PhD
Associate Vice President for Strategic Initiatives
Director, MIRO Center for Space Exploration & Technology Research

In 2009, the University of Texas at El Paso (UTEP), a Hispanic Serving Institution (HSI), established the Center for Space Exploration and Technology Research (MIRO cSETR) to support NASA's vision of space exploration by focusing on advanced capabilities in the areas of chemical propulsion and small spacecraft. MIRO cSETR has ~36,100 square feet of on & off campus laboratory space for research projects, a 400-acre airport and flight test range, and 8,000 acres of land for development in Fabens and Tornillo, Texas. Research capabilities include small satellite development, green-monopropellant research & system integration, unmanned aerial systems, fundamental combustion research, reactive material testing, material characterization, computer-modeling (CFD & FEA), testing of cryogenic propulsion systems & high-pressure combustion devices, support unmanned traffic management system, test long range/long endurance aircrafts, and career development.

UTEP, industry, and local government partners have supported research capacity development by providing more than \$7M in funds and secured \$70M infrastructure development. Since 2009, cSETR has received more than \$18M from other federal agencies through competitive grant funding. MIRO cSETR supports research and professional development of more than 200 employees, mainly student researchers. Research teams have published over 60 articles, presented over 140 posters and papers at over 20 national conferences, and received 2 patents during the 2015 project cycle. Since 2009, cSETR has supported more than 600 students and 160 internships. The center has institutionalized its research and education mentoring pedagogy by contributing to UTEP's Engineering Programs through expansive student engagement in projects and curriculum developments.

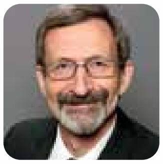
cSETR Students troubleshooting software glitch for Unmanned Aerial System.

Co-Science PI
Alejandra Castellanos

Co-Science PI
Jack Chessa

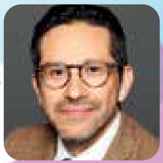
Co-Science PI
Amelia Greig

Co-Science PI
Md Mahamudur Rahman



Co-Science PI
Evgeny Shafirovich

Co-Science PI
Ryan Wicker



Co-Science PI
Joel Quintana

MIRO

Physics and Astronomy with Authentic Research Experience

University of Virgin Islands St. Thomas, Goddard Space Flight Center

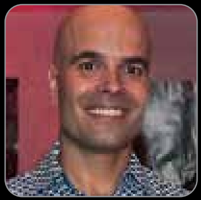
The University of Virgin Islands St. Thomas, a Historically Black College and University (HBCU), established the Physics and Astronomy with Authentic Research Experience (PAARE) Center in 2015. The PAARE degree program is designed to focus on enhancing students' university STEM education through increased opportuni¬ties to engage in research. In collaboration with NASA's Goddard Space Flight Center (GSFC), PAARE efforts connect our students to research opportunities throughout the astrophysics community and, ultimately, connect our graduates to employment opportunities in the United States Virgin Islands (USVI) and throughout the country.

UVI now offers a 4-year Bachelor of Science degree in physics with an astronomy research application, graduating its first majors in 2019. Two newly hired physics faculty have joined the university in support of this effort.

An X-ray detector test stand at UVI has been built and actively engages UVI students in detector development activities associated with the GSFC X-ray detector lab. Substantial refurbishment and upgrades to the Etelman Observatory began during the Fall 2016. These upgrades and refurbishments make the facility better capable to house students during research projects, to support faculty research activities, and to welcome visitors to Etelman Observatory outreach and education activities.

The Etelman Observatory, located at 1325 feet atop Crown Mountain on the island of St. Thomas in the US Virgin Islands, houses a research-grade 0.5m automated Cassegrain telescope.

Undergraduate and graduate students continue to participate in Research Assistant and Teaching Assistant opportunities, and many participate in NASA/GSFC internships and projects each summer. A partnership with Orangewave Innovative Science (OWIS) has expanded opportunities for research in solar physics and climate change. Together with NASA/KSC, the Etelman Observatory USVI Regional Educator Resource Center (ERC) has been established to provide educational outreach and resources in astrophysics. We have also begun new collaborations with the Harvard–Smithsonian Center for Astrophysics, University of Wisconsin-Madison, University of Texas-Austin, US Department of Agriculture and the Environmental Protection Agency.



Science PI
David Morris, PhD
Associate Professor
Department of Physics

MIRO

Solid High Energy Lithium Batteries Center

Xavier University of Louisiana, Glenn Research Center

Ms. Jere Williams, Research Assistant at the SHELiB Center.

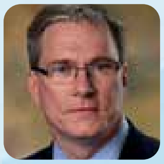
Li-ion batteries are ubiquitous in our daily lives. Yet, developing safer and higher capacity rechargeable Li and Li-ion batteries remains a great challenge. From electric cars to NASA space exploration, we need to pack more energy per weight and volume in the batteries. The current Li-ion technology is reaching its limits, while the use of flammable liquid electrolytes is vulnerable to fire hazards. Scientists predicted that solid-state electrolytes coupled with Li metal or Li alloy anodes could solve these issues.

To address these two issues, Xavier University of Louisiana, a Historically Black Colleges and University (HBCU), established the SHELiB Center in collaboration with the NASA Glenn Research. Our work focuses on deepening our fundamental understanding of the key factors affecting the performance of both (i) solid ceramic electrolytes and (ii) hybrid composite polymer electrolytes. Many of our studies demonstrated great promise, where Li dendrites (needle-like structures) that may induce a short circuit do not form. All-solid-state cells were made with commercial cathodes and showed excellent capacity and stability for over 100 cycles at 40-60 °C. In addition, the Center is also working on light-weight high-capacity conversion-type cathodes, such as Li_2S and others. The center is focused heavily on workforce development by preparing minority students for exciting careers in sustainable energy technologies.

Co-Science PI
Asem Abdulahad, PhD
Assistant Professor
Xavier University of Louisiana

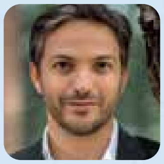
Co-Science PI
Oleg Borodin, PhD
Scientist
US Army Research Lab

Science PI
Lamartine Meda, PhD
Professor
Department of Chemistry



Co-Science PI
Jeffrey Fergus, PhD
Professor
Auburn University

Co-Science PI
James Wu, PhD
Scientist
Glenn Research Center



Co-Science PI
Gleb Yushin, PhD
Professor
Georgia Institute of Technology

Autonomy Research Center for STEAHM

California State University, Northridge, Armstrong Flight Research Center, Jet Propulsion Laboratory

Science PI
Nhut Ho, PhD
ARCS Founding Director
Mechanical Engineering

The Autonomy Research Center (ARCS) for STEAHM (Science, Technology + engineering, Entreprenership + business, Art, Humanities, and Mathematics) at California State University, Northridge, a Hispanic Serving Institution (HSI) contributes to NASA's research in autonomy for civil aviation and space exploration. Through a collaboration among six CSUN colleges (Art, Media, and Communication; Humanities; Science and Math; Engineering and Computer Science; Business; Social and Behavioral Sciences) and NASA Armstrong Flight Research Center (AFRC) and Jet Propulsion Lab (JPL) and DoD and industry partners, ARCS utilizes NSF Convergence Research (deep integration of approaches from different fields) to address three transdisciplinary and broad autonomy research areas: Assured and Trusted Autonomy; Human Autonomy Teamwork with Explainable AI; and Societal Barriers to Acceptance and Impact.

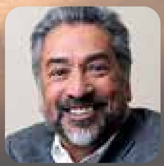
ARCS research aligns the following mission directorates: Aeronautics Research; Human Exploration Operations; Science; and Space Technology. ARCS substantially increases CSUN's capacity to contribute to NASA through three strategies that address our current institutional capacity gaps: First, building on an emerging set of collaborations with NASA and partners' researchers; second, targeting a wide range of multidisciplinary expertise necessary to address NASA needs; and, third, by closing gaps in our research infrastructure by synergistically combining CSUN institutional investment with resources provided by our collaborators.

ARCS Faculty

NASA-CCNY Center for Advanced Batteries for Space

The City College of New York, Jet Propulsion Laboratory

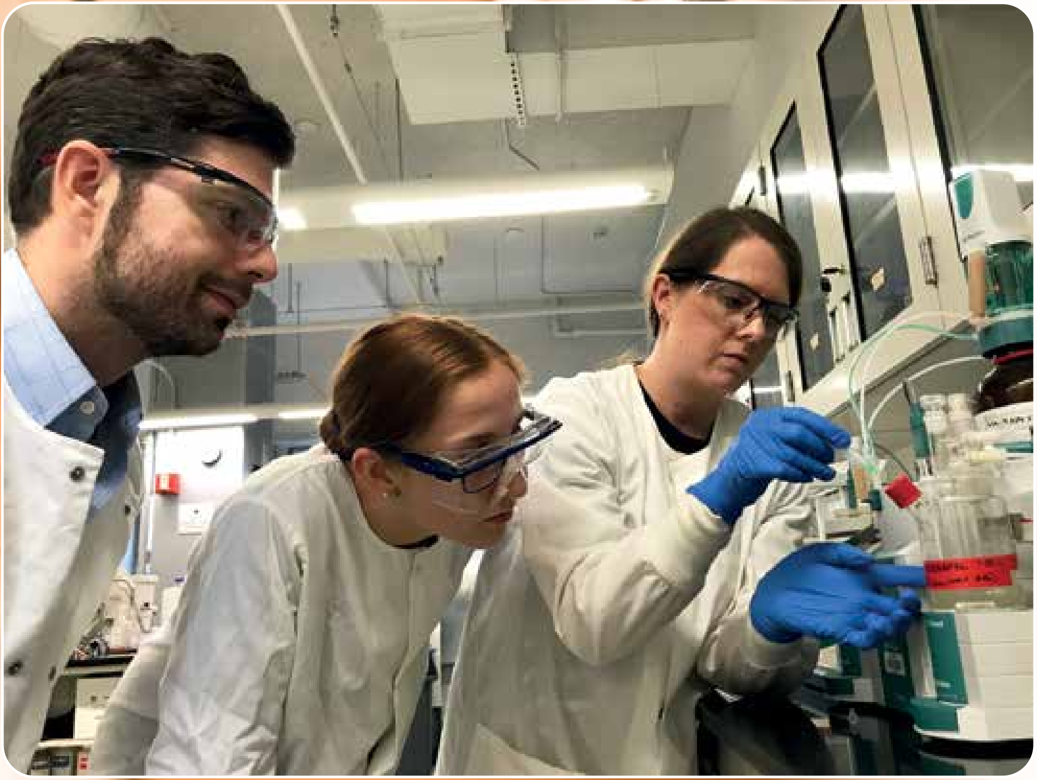
Science PI
Robert J. Messinger
Assistant Professor
Chemical Engineering



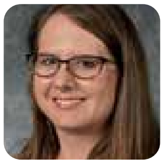
Co-Science PI
Sanjoy Banerjee
Professor
Chemical Engineering

The NASA-CCNY Center for Advanced Batteries for Space (ABS) is a joint research and education center between The City College of New York (CCNY), NASA's Jet Propulsion Lab (JPL), Northeastern University, and regional colleges. Housed at The City College of New York, a Hispanic (HSI) and Asian American Native American Pacific Islander (AANAPISI) Serving Institution, the ABS Center was established to create a highly collaborative research network in electrochemical energy storage. The Center draws on CCNY's expertise in novel batteries and electrochemical systems, minority student training, and management, JPL's deep knowledge of batteries for planetary science missions and facilities to test devices under extreme conditions, and Northeastern University's experience in advanced battery characterization.

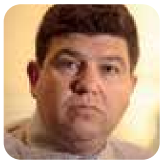
The Center enhances CCNY's research infrastructure and ability to attract highly skilled students by using funds to invest in advanced scientific equipment, including advanced 3D printers capable of printing metals, devices for advanced electrochemical characterization, state-of-the-art equipment for improved processing of battery materials and electrodes, and environmental chambers that enable battery testing over wide temperature ranges. Center research efforts focus on development of novel batteries composed of metal anodes and ionic liquid electrolytes designed to operate under the extreme temperatures and radiation encountered by spacecraft during planetary science missions. High-energy-density aluminum, zinc, and lithium metals are used with ionic liquid electrolytes designed to exhibit large temperature and electrochemical stability windows, high radiation stability, and negligible vapor pressures.



Dr. Elizabeth Biddinger demonstrates Karl Fischer titration as doctoral student Nicole Donovan and Dr. Rob Messinger observe.



Co-Science PI
Elizabeth Biddinger
Assistant Professor
Chemical Engineering



Co-Science PI
Alex Couzis
Professor
Chemical Engineering

MIRO

Center for Research and Education in 2D Optoelectronics

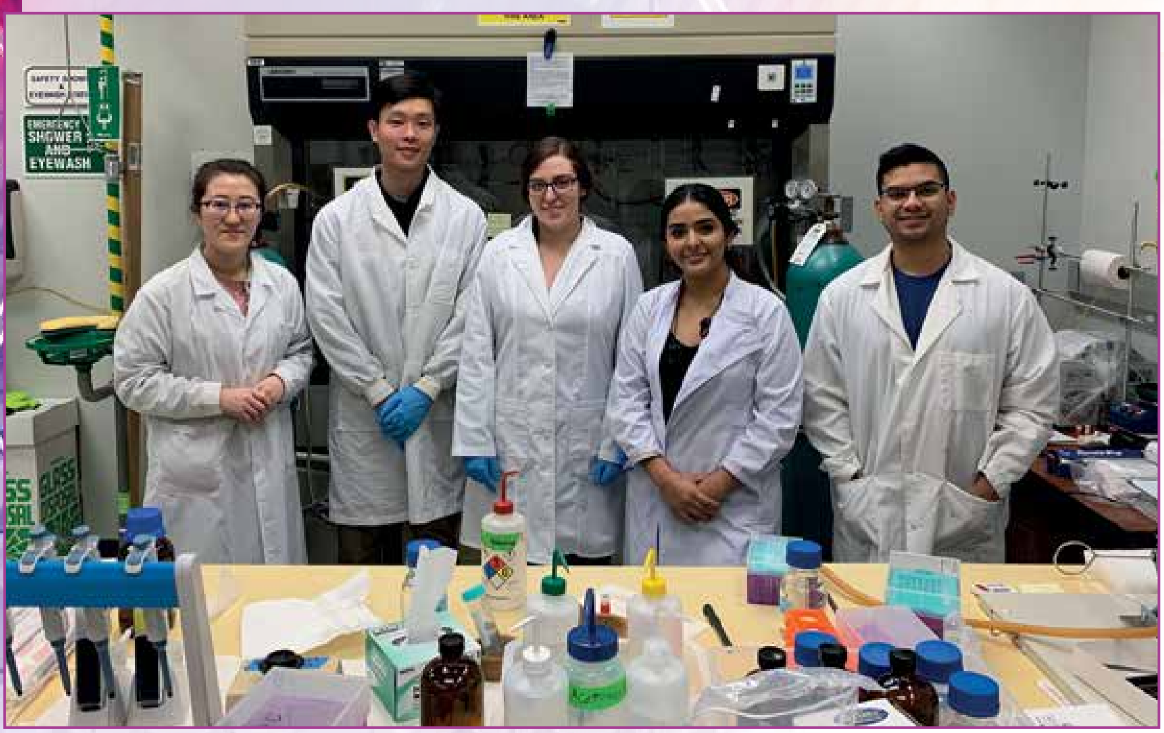
Florida International University, Jet Propulsion Laboratory, Glenn Research Center

The Center for Research and Education in 2D Optoelectronics (CRE2DO) at Florida International University (FIU), a Hispanic Serving Institution (HSI), engages in innovative research and education to explore novel two-dimensional functional materials to be incorporated into sensors, wearable electronics, integrated optics/photonics, detectors and superconducting materials, novel antenna architectures, and small satellite (CubeSats) technology for space applications. CRE2DO partners with Pennsylvania State University's 2D Crystal Consortium to characterize the new 2D materials and with Broward College to include talented students participating alongside with FIU in the center research. CRE2DO originated technologies will be tested at NASA Jet Propulsion Laboratory and NASA Glenn Research Center.

CRE2DO efforts aligns with NASA's Science Mission Directorate (SMD) in exploring novel two-dimensional (2D) functional materials within three integrated thrusts:

- **Thrust # 1:** Chemical transformations in 2D chalcogenide materials to enable advanced functionality in sensors, integrated optics/photonics, superconductors. This thrust will focus on synthesizing 2D nanomaterials with superior properties to their bulk counterparts, and on fabrication of devices and their testing in simulated extreme space environments, the latter being an overarching theme of the collaboration with JPL.
- **Thrust # 2:** Mechanical Integrity of 2D TMD Materials in Polymer Composites to enhance space reliability of mechanical and electrical components in spaceship devices and wearable electronics. This thrust will explore mechanical properties of 2D nanocomposites.
- **Thrust # 3:** Thin Film In-Package High-Data Rate mm Wave Communication development for CubeSats. In addition, novel antenna architectures will be explored. CubeSats and novel antenna will be tested at Glenn.

Science PI
Daniela Radu, PhD
Associate Professor
Mechanical and Materials Engineering



The 2D Materials Synthesis Team of MIRO FIU Center CRE2DO

MIRO

Navajo Tech Additive Manufacturing Education and Research Center

Navajo Technical University, Marshall Flight Space Center

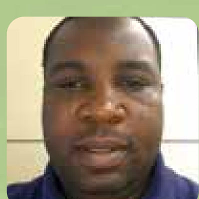
NTU students use 3D metal printer for additive manufacturing

The Navajo Tech Additive Manufacturing Education and Research (NAMER) Center housed at Navajo Tech University (NTU), a Tribal Colleges and Universities (TCU), conducts additive manufacturing research around directed energy deposition of bi-metallic components: powerheads, nozzles etc. for NASA RS-25 engine for Space Launch System (SLS). NASA's Marshall Flight Space Center provides process guidance for the components development and facilitates 1-year internship for NTU students. University of Alabama-Huntsville contributes finite element analysis (FEA) modeling; Optomec provides printing parameters development, and V&M Global Solutions assists with NTU's metrology laboratory certification.

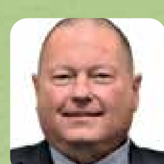
To support these efforts, Navajo Technical University (NTU) is acquiring American Isostatic Presses AIP8- 30H, Netfabb Ultimate Software for predictive analysis, and sensors and a high-speed camera to capture images of DED Inconel-Cu alloy bi-metallic parts in situ.

The NAMER Center research project involves additive manufacturing (AM) of Inconel-copper (Cu) alloy bi-metallic parts and is closely aligned with the NASA's Space Technology Mission Directorate's Space Launch System—an advanced launch vehicle for a new era of exploration beyond Earth's orbit into deep space.

Researchers will focus on characterization (micro and nano-scale) of the microstructure of AM Inconel-Cu alloy bi-metallic parts, under three conditions: (i) as built, (ii) hot-isostatic pressing and heat treatment, and (iii) after a combined hot-isostatic pressing and heat treatment, which are used in order to establish the necessary linkages between microstructure, post-processing, dimensional accuracy and mechanical properties. This research will utilize state-of-the-art metrology capabilities to provide insights into the dimensional accuracy and material strength of DED printed parts for use in the Space Launch System.



Science PI
Monsuru Ramoni
Assistant Professor
Industrial Engineering



Co-Science-PI
Peter Romine
Associate Professor
Electronics and Computer Engineering

MIRO

Center for High Pressure Combustion in Microgravity

Prairie View A&M University, Glenn Research Center

Drs. Ziaul Huque and Yuhao Xu supervise students in the High Pressure Combusion in Microgravity Center.

Prairie View A&M University (PVAMU), a Historically Black Colleges and Universities (HBCU), houses the Center for High Pressure Combustion in Microgravity (HPC Center), a comprehensive ground-based research program that investigates the droplet combustion dynamics of liquid fuels at elevated pressures. Cornell and Georgia Tech contribute to high-pressure experiments and the companion simulations, respectively, and NASA Glenn Research Center (GRC) hosts student interns.

Center research focuses on the transition to alternative propulsion and energy. This work advances our understanding of combustion dynamics of alternative fuels, which will guide the transition to achieve higher efficiency with reduced emissions for aviation. These efforts align with Physical Science Research Program in NASA's HEOMD to conduct fundamental and applied research to improve space systems, produce new products offering benefits on Earth, and reveal how physical systems respond to the near absence of gravity.

To support the HPC Center, PVAMU is developing two major laboratory facilities: a droplet combustion experimental facility and a combustion simulation facility. In these facilities, a combustion apparatus will be used to perform combustion experiments at elevated pressures and computation workstations will be used to simulate the combustion experiments.

This project aims to understand how liquid fuels burn at elevated pressures with the following specific aims: (1) Perform high-pressure combustion experiments for n-decane, n-butanol, and their mixtures; (2) Establish a computational framework to numerically simulate the combustion experiments; (3) Produce butanol with an enhanced fermentation process; and (4) Build the combustion research capability at PVAMU.

Science PI
Ziaul Huque
Professor
Mechanical Engineering

Co-Science PI
Yuhao Xu
Assistant Professor
Mechanical Engineering

MIRO

Facility for Innovative Atmospheric Research and Education

Sitting Bull College, Langley Research Center, Goddard Space Flight Center

The Facility for Innovative Atmospheric Research and Education (FIARE), housed at Sitting Bull College (SBC), a Tribal Colleges and Universities (TCU), serves as a research site with capability to provide validation measurements for atmospheric composition satellites. The objective is to develop a long-term data set of measurements for the study of how air quality measured at the surface is related to column level observations and satellite measurements. SBC will team with collaborators from NASA Langley Research Center (LaRC), NASA Goddard Space Flight Center (GSFC) and the University of North Dakota Atmospheric Science Department (UNO). This award is part of a MIRO/MAIANSE [MUREP for American Indian Alaska Native STEM Engagement] Pilot, aimed at providing support to TCUs as they join the MIRO portfolio.

Activities will be in conjunction with the NASA Tropospheric Emissions Monitoring of Pollution (TEMPO) science team members from the Smithsonian Astrophysical Observatory (SAO), the Environmental Protection Agency (EPA) Office of Research and Development and the Standing Rock Sioux Tribe (SRST) EPA.

FIARE will install a ground-based atmospheric-composition/air-quality monitoring station with the capacity to acquire and report data on ambient air quality. Research instruments to be installed will provide a suite of independent correlative data for direct validation of tropospheric column 03, NO2, SO2, HCHO, and H2O mixing ration profiles, and aerosols mixing layer height. The FIARE based at SBC will serve as a research site with capability to provide validation measurements for atmospheric composition satellites, such as the NASA TEMPO Earth Venture mission. One specific opportunity our students will have is access to Pandora, an instrument that will assist in NASA and EPA air quality measurement efforts. Students will be able to participate in NASA internships to receive intensive training in the use of air quality instrumentation. Six students will attend internships at LaRC or GRCS each year of the program.

Science PI
Gary Halvorson, PhD
Instructor
Environmental Science

SBC will add up to six courses in Atmospheric Science for undergraduate students to take as part of their ENS coursework as well as additional new courses to the MS graduate program in ENS. Students who receive training in FIARE instrumentation will complete their research thesis project based on data from the FIARE studies.

NASA Research Team at Sitting Bull College. Pictured are graduate student Saul Bobtail Bear(L) discussing research results of water analyses with Dr. Mafany Mongoh(C) and Dr. Gary Halvorson(R).

Co-Science PI
Joshua Mattes
Instructor
Environmental Science

Co-Science PI
Mafany Mongoh
Instructor
Environmental Science

MIRO

Asteroid Science, Technology and Exploration Research Organized by Inclusive eDucation Center

University of Arizona, Jet Propulsion Laboratory

UA ASTEROID Center – Strength in Diversity

The Asteroid Science, Technology and Exploration Research Organized by Inclusive eDucation (ASTEROID) Center housed at University of Arizona, a Hispanic Serving Institution, advances fundamental science, technology and exploration research through education and advancement of underrepresented students. Key partners of the ASTEROID Center include NASA Jet Propulsion Laboratory; University of Puerto Rico, Humacao; and Pima College.

The ASTEROID Center advances NASA's SMD goals in understanding the origin of the solar system out of primitive materials, the formation of Earth-like planets, and the early evolution of water and biologically significant materials. The Center seeks to advance both the science and technology of asteroid exploration. Science research focuses on terrestrial planet formation and evolution, the physics of planetesimals collisions, asteroid and comet geologic structure, small body surface morphology, and granular mechanics. Technology research focuses on advancing next generation missions and technologies to asteroids and comets.

Science PI
Jekan Thangavelautham
Assistant Professor
Aerospace and Mechanical Engineering

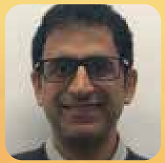
The Center explores asteroids in near-Earth space and creates asteroid-analogs in low-Earth orbit. The Center will develop a series of CubeSat centrifuge laboratories to recreate asteroid surface environments for advancing student-led science and technology, for advancing next-generation technologies for asteroid/comet missions and landers, and for developing innovative In-Situ Resource Utilization (ISRU) processes for the emerging space economy.

NASA's MIRO program will help establish end-to-end capabilities at UA to conceptualize, design and build CubeSats that will operate as on-orbit centrifuge science laboratories to simulate asteroid surface conditions, working with teams of undergraduate and graduate students. The effort will upgrade UA's concurrent design facilities, and small-satellite propulsion test facility, and will advance state-of-the-art machine learning based automated methods for rapid conceptualization, design and execution of next-generation small-spacecraft missions, swarms and constellations.

Center for Advanced Manufacturing in Space Technology & Applied Research

University of the District of Columbia, Johnson Space Center

The Center for Advanced Manufacturing in Space Technology and Applied Research (CAM-STAR), housed at the University of the District of Columbia (UDC), a Historically Black Colleges and Universities (HBCU), focuses on research investigating various Advanced Manufacturing (AM) techniques with application in Space Technology, and pedagogical innovations accelerating the development of a diversified future workforce in AM. Advanced Manufacturing enables innovative and sophisticated, yet low-cost manufacturing processes and products that can support both NASA missions and Manufacturing USA. UDC is leading this effort in collaborations with NASA Johnson Space Center, University of Maryland, Clemson University, Advanced Cooling Technologies, and the National Institute of Standards and Technology to tackle these technical tasks.

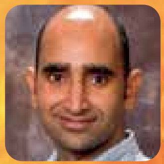


Co-Science PI
Sasan Haghani, PhD

CAM-STAR aims to contribute to the mission of NASA's Space Technology Mission Directorate (STMD) through advancing the research and educational capacity in AM-enabled devices and tools for space technology at UDC, with a new dedicated AM research space and infrastructure that enables cutting-edge research. CAM-STAR's research activities focus on the following three areas:

- Passive Thermal Control, with the aim to reduce the overall mass of on-board thermal management system and minimize the temperature fluctuation when the environmental temperature changes dramatically, through the combination of a) Nano-enhanced phase change materials (PCM) with exceptional thermal properties; and b) AM manufactured low-mass PCM heat exchanger;
- Thermal Protection System and Materials, with the aim to fabricate space-application suitable surface finishing for AM produced components, through the combination of: a) Nano-manufactured variable emissivity coatings with robust thermal and mechanical properties and b) Novel AM compatible thermal protection system structures and/or coating materials; and
- In-Situ Resource Utilization-Mars (ISRU), with the aim to understand the fundamental behavior of drill-regolith interaction and energy-efficient geotechnical tool for in situ measurement of engineering properties of lunar regolith, through: extraterrestrial subsurface regolith characterization using AM fabricated Lunar/Mars regolith processing tools.

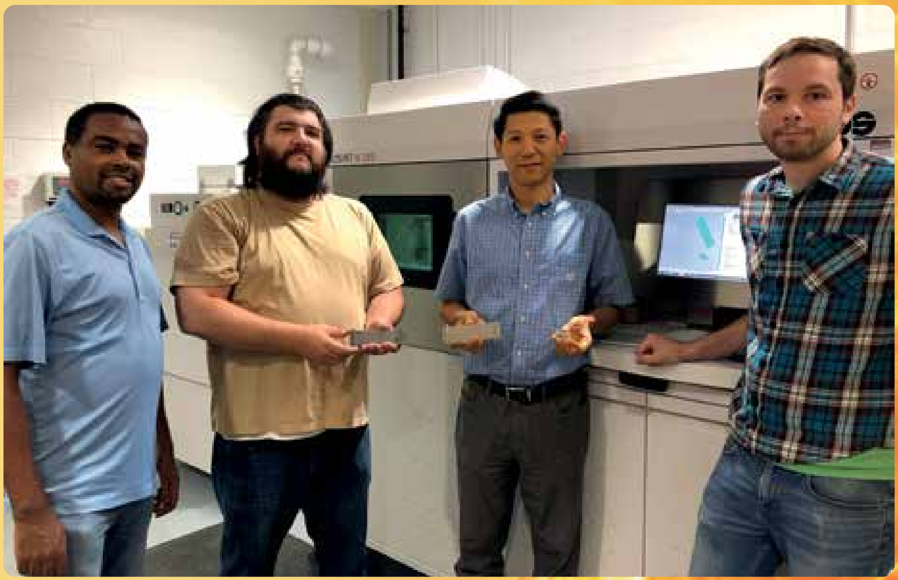
Co-Science PI
Kate Klein, PhD



Co-Science PI
Pawan Tyagi, PhD

Co-Science PI
Lei Wang, PhD

Science PI
PI: Jiajun Xu, PhD, PE
Associate Professor
Mechanical Engineering



Dr. Xu and his students demonstrate the additively manufactured micro-channel heat exchanger.

MIRO

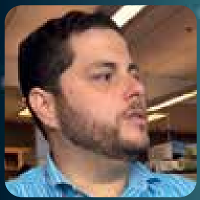
The Puerto Rico-Space Partnership for Research, Innovation and Training

University of Puerto Rico, Ames Research Center, Jet Propulsion Laboratory

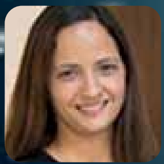
The Puerto Rico-Space Partnership for Research, Innovation and Training (PR-SPRInT) to Engage the Next Generation of Explorers is a strategic partnership between campuses of the University of Puerto Rico System and the Ana G. Méndez University System. Housed at the University of Puerto Rico, Rio Piedras, a Hispanic Serving Institution (HSI), the primary objective of the PR-SPRInT is to strengthen STEM education. The PR-SPRInT has forged collaborations with the UPR-Rio Piedras Faculty Improvement Network and the Puerto Rico Louis Stokes Alliance for Minority Participation to provide faculty with the latest trends in best practices in teaching and learning. In addition, the PR-SPRInT has been granted renewed office space with the resources for the participants to conduct virtual and in-person meetings. As part of this effort, the PR-SPRInT is collaborating with the UPR-Rio Piedras Fab Lab and new equipment will be installed to provide PR-SPRInT participants the opportunity to learn about prototyping.

Guided by the NASA Space Technology Roadmap Areas, PR-SPRInT will engage in the following interdisciplinary research and education groups (IREGs):

- Human Centered Research, Environmental Control and Life Support to Enable Long term Duration Missions: This research group will be working on innovation, research and education in air revitalization, water reclamation and purification, and resource recovery. In particular, robust adsorbent materials and composites for CO2 removal and treatment, and membrane-based water purification systems will be developed.
- Design and Development of High-Performance Batteries for Space Exploration Missions: This research group will be working in energy storage and will develop advanced materials for Li-based batteries focused on solid-state batteries.



Science PI
Eduardo Nicolau
Associate Professor
Chemistry



Co-Science PI
Liz Diaz
Associate Professor
Chemistry

PR-SPRInT Principal Investigator Eduardo Nicolau works on an experiment with Perla Cruz-Tato (former NASA ASTAR Fellow).

MIRO

Center for Advanced Measurements in Extreme Environments

The University of Texas at San Antonio, Goddard Space Flight Center, Jet Propulsion Laboratory, Langley Research Center

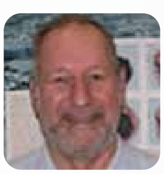
Housed at the University of Texas at San Antonio, a Hispanic Serving Institution (HSI), the overall goal of the Center for Advanced Measurements in Extreme Environments (CAMEE) is to develop a diverse workforce in earth system sciences, remote sending technologies, computational fluid dynamics, and experimental fluid mechanics in support of NASA's Science, Aeronautics, and Space Technology Mission Directorates. This multi-institution partnership will provide the breadth and depth of resources necessary to enable multi-disciplinary education and research in STEM fields that will significantly exceed the sum of the individual contributions.

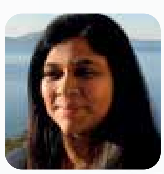

Sea ice field work in Antarctic

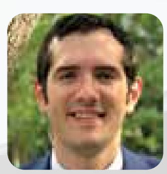
The University of Texas at San Antonio has approved a proposal to designate 1,600+ square footage towards the physical development of the center to support student research collaborations, training and instrument facilities, research exhibits, office spaces for the Director and Assistant Director, and an Extreme Environmental Chamber. A drone-borne real-time hyper-spectral imaging system will be purchased for research and education purposes.

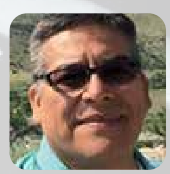
Center researchers are engaged in five research focus areas: Polar Sea Ice and Sea Level Rise, Gulf of Mexico and Polar Oceans, Atmospheric Science and Extreme Events, Aerodynamics, and Modeling, Simulation, and Big Data. The four research goals are: (i) characterize changes in polar sea ice and ice sheets, especially areas undergoing rapid change; (ii) improve our understanding of extreme atmospheric and oceanic processes with data-driven models using improved measurement techniques; (iii) develop new data assimilation and modeling methods and algorithms to combine multi-sensor measurements for resolving turbulent fluxes across a variety of surfaces (atmosphere- ocean; ice-ocean; atmosphere-ice) and flow scale regimes; and (iv) execute a synergistic experimental and computational effort to develop improved turbulence models with applicability over a range of flow scale regimes.


Science PI
Hongjie Xie, PhD
Professor
Geological Sciences

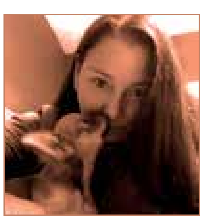

Co-Science PI
Stephen Ackley
Associate Professor of Research
Geological Sciences


Co-Science PI
Kiran Bhaganager
Associate Professor
Mechanical Engineering


Co-Science PI
Christopher Combs
Assistant Professor
Mechanical Engineering


Co-Science PI
Alberto Mestas-Nunez
Associate Professor in Practice
Geological Sciences

NASA EPSCoR



Our graphic designer is Amy Lombardo, a Graphics Specialist with ASRC Federal at the John F. Kennedy Space Center in Florida. Amy specializes in publication design and has been the primary artist on all editions of the EPSCoR Stimuli document.

We appreciate the amazing work Amy has done preparing the 2019-2020 Stimuli document representing EPSCoR and MIRO research.

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