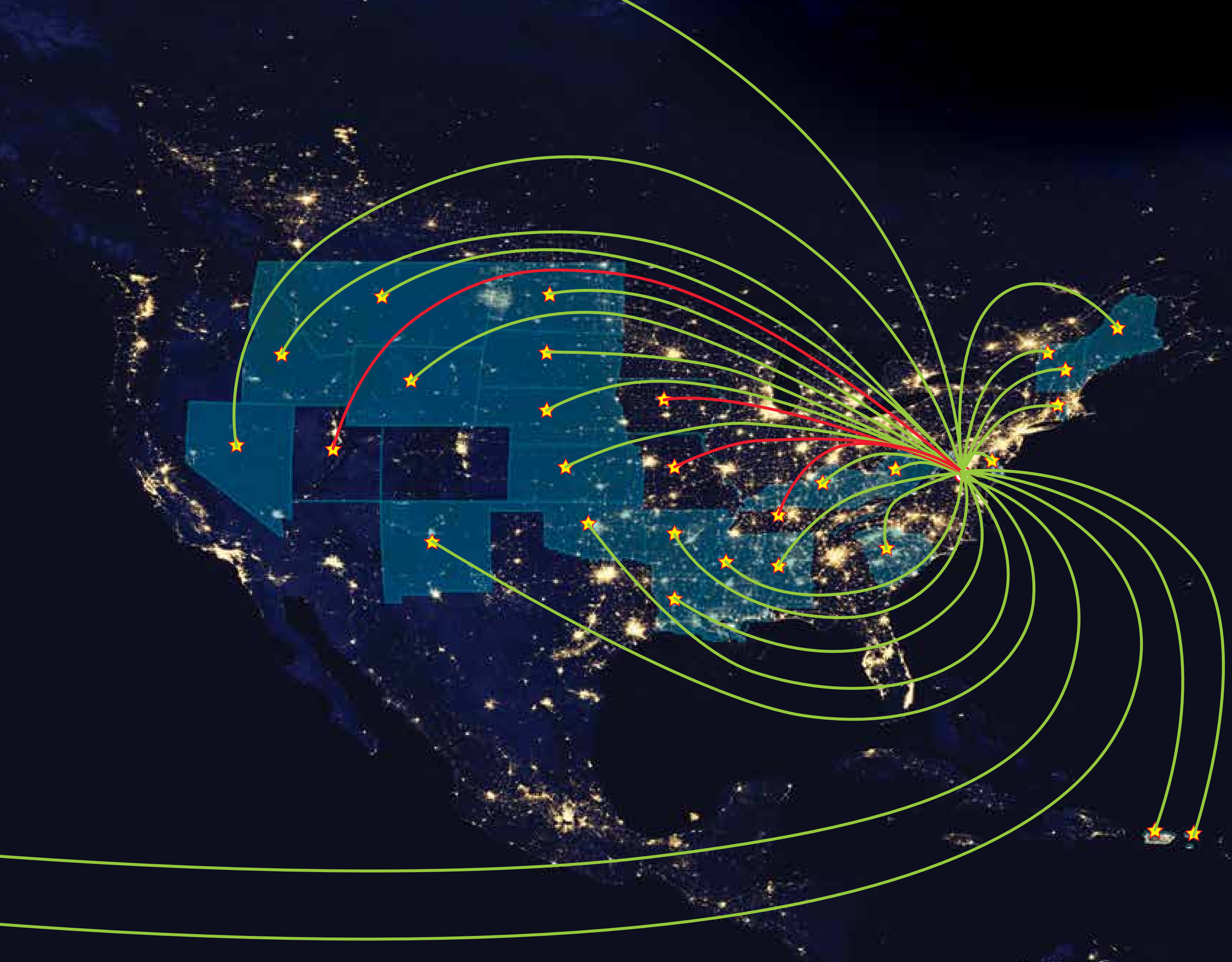
National Aeronautics and
Space Administration



NASA EPSCoR
Stimuli

2014-15

National Aeronautics and Space Administration

Headquarters
Washington, DC 20546-0001

Reply to Attn of: Office of Education

October 3, 2015

Greetings,

On behalf of the National Aeronautics and Space Administration's Office of Education, I welcome you to *Stimuli*, a summary collection of college and university basic research and technology development reports impacting NASA's earth science, aviation, and human and robotic deep space exploration programs. This document addresses research which is relevant to NASA's mission, and currently administered by the agency's Experimental Program to Stimulate Competitive Research (EPSCoR).

EPSCoR's impact 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 is improving the science and research capabilities at recipient universities while also stimulating partnerships between government, higher education and industry.

NASA EPSCoR exemplifies how your tax dollars work to improve our nation. As you browse through *Stimuli*, remember that the projects you read about help keep us at the forefront of aerospace and aerospace-related research and development; strengthen our long-term economic well-being; and, of special pride to me, advance the noble and exciting goals of America's Space Program.

Sincerely,

Donald G. James
Associate Administrator
NASA Office of Education

EPSCoR JURISDICTION

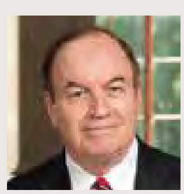
Table of Contents

ALABAMA

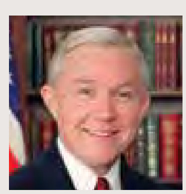
Aerospace science and engineering has a major impact on the economic life of the people of Alabama. Fifty years ago, the image of Huntsville, Alabama changed from that of a regional center for cotton and agriculture, to that of the home of America's Moon rockets and Apollo Program, and the center of technological leadership in the international race to the Moon. Marshall Space Flight Center has been joined by 300 aerospace companies in Cummings Research Park. Over the last 2 decades, the NASA EPSCOR Program has allowed Alabama's universities to participate fully in academic research in key areas of aerospace engineering and science that support America's Space Program. Alabama researchers have competed for and won research awards in astrophysics, novel metal alloys and distributed systems of embedded sensors in rockets. In recent years we have won awards related to aeronautics, for example, awards for novel composites for use in aero-structures and research in lean-burning aircraft engines. This reflects Alabama's growing role in aircraft building.

Dr. John Gregory,
AL EPSCoR Director,
The University of Alabama
in Huntsville

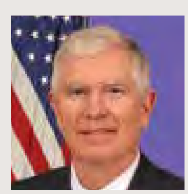
Alabama TOC



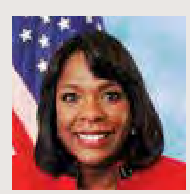
Senator
Richard Shelby



Senator
Jeff Sessions



Representative
Mo Brooks
(5th District)



Representative
Terri Sewell
(7th District)

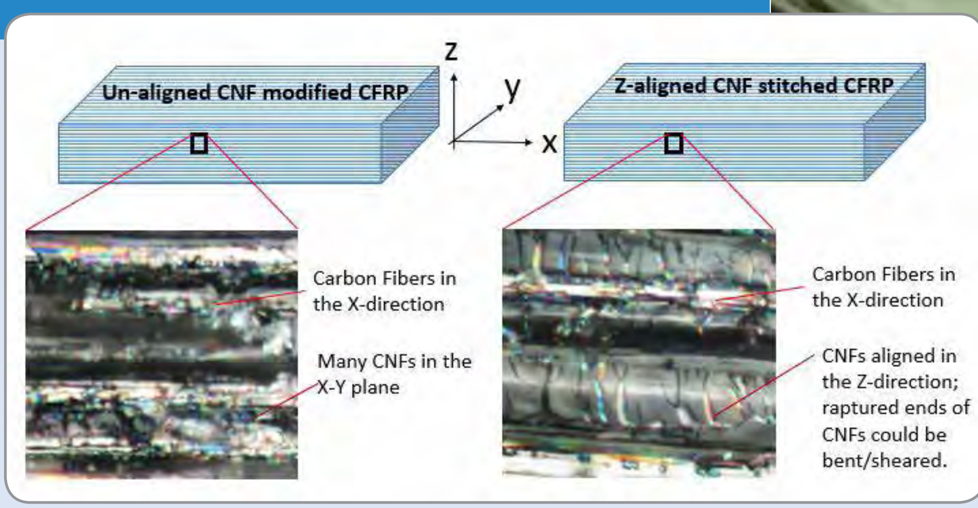
Development of Prepreg and Out-of-Autoclave Process for Z-Aligned Carbon Nanofiber Toughened Lightweight Composites

University of South Alabama/NASA Human Exploration & Operations Mission Directorate

The stated goals for the research project regarding the Z-aligned-nanofibers toughened fiber reinforced polymer (FRP) lightweight composite materials included a higher survival rate against impact damage, interlaminar crack growth, and fatigue failure, a higher stability against varying environmental temperature (high/medium/low) and a lower cost than industrial state-of-the-art prepreg/autoclave-processed composites.

The advent of these novel materials and methods has drawn significant attention from industry. After announcement of the discovery of the new CFRP composites, the Science-I (Hsiao) and the University Administrators were joined by the mayor of Mobile, Alabama in discussions with Airbus Group. On November 7, 2014, Airbus Group took the action to donate a 28 ft by 6 ft, 200 lb A330 composites elevator for Hsiao's group and the university to do research and education. This donation indicates Airbus' interest in investing in the University of South Alabama and the Mobile City area's composites science and technology development in both research and education. Future collaboration in research of applying the z-aligned-nanofibers stitched FRP in aero-structures looks promising. In addition, other discussions of collaboration with companies and government labs developed during this project. The meaningful collaboration in this cutting edge composites technology may transform the education, workforce development, and high tech driven economics in the south Alabama region. ✺

⮟ Researchers of Dr. Kuang-Ting Hsiao's Composites Research Lab at the University of South Alabama are examining the A330 elevator donated by Airbus. From left to right: Dr. Kuang-Ting Hsiao, Capt. John Brewer, USFA (mechanical engineering graduate student), and Mr. Kendrick Henderson (electrical engineering undergraduate student).



⮝ Comparison of side-view microscope pictures of the z-aligned CNF-stitched CFRP laminate with unaligned CNF-modified CFRP laminate.

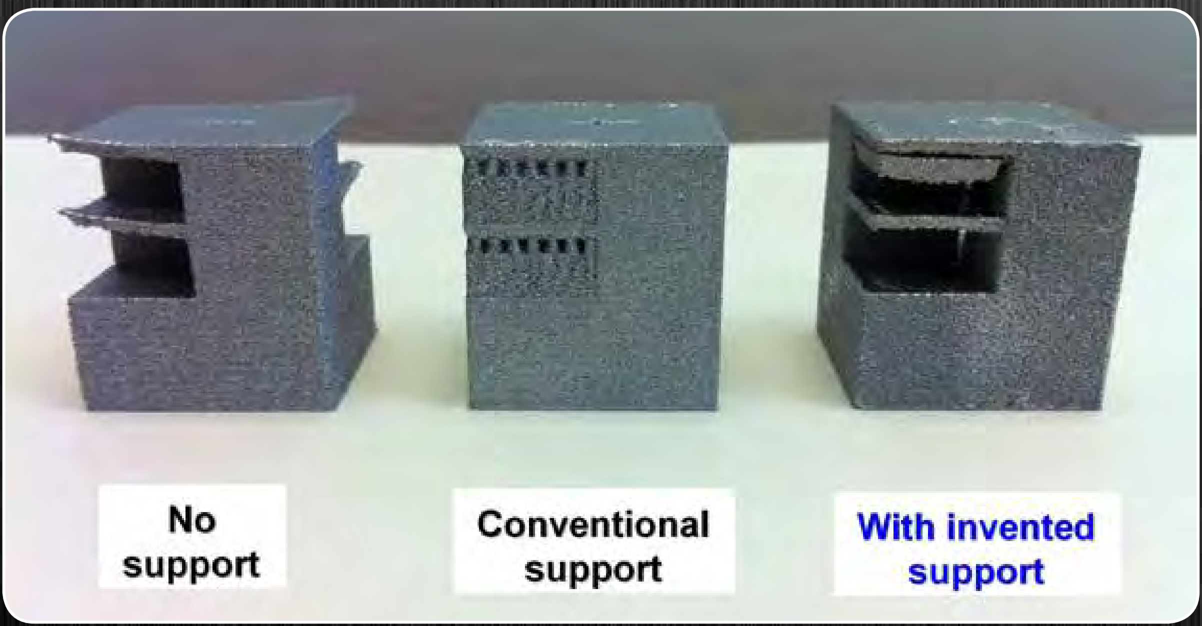
Prof. Kuang-Ting Hsiao, Ph.D., Science PI, University of South Alabama

NASA Technical Monitor: Dr. Brian W. Steinert, Marshall Space Flight Center

Electron Beam Additive Fabrication Technology for Rapid Manufacturing of Space Vehicle Hardware

University of Alabama/NASA Marshall Space Flight Center, Space Technology Mission Directorate

The purpose of this project is to broaden the effective usage of the electron beam additive fabrication (EBAF) technology, through fundamental process understanding, for NASA applications to aid the development and manufacturing of hardware for space vehicles. The EBAF technology is tactically important to the space vehicle developments and is aligned with the research and technology priority of NASA's Human Exploration and Operations Mission Directorate. The research from this program has resulted in an invention, which has been filed for a utility patent application (Application Serial No: 14/276,345) on May 13, 2014. The title is "Systems and Methods for Designing and Fabricating Contact-Free Support Structures for Overhang Geometries of Parts in Powder-Bed Metal Additive Manufacturing." The invention was jointly developed by The University of Alabama (UA) and the project partner Marshall Space Flight Center (MSFC). The invention was also highlighted in the NASA Technology Opportunity Sheet (MFS-33075-1) in 2014. MSFC has expanded its Additive Manufacturing (AM) facility including installing several high-end Selective Laser Melting metal AM systems for making Space Launch System (SLS) components. Further, UA has recognized the importance of additive manufacturing, and has had strong interest in metal AM and made strategic investments in additional faculty positions in metal AM (total 3 positions in 2 departments). The metal additive manufacturing capabilities in the state of Alabama have been significantly improved, evident by the expanded AM facility in MSFC, the enhanced AM research infrastructure in The University of Alabama, and the collaborations between UA and MSFC as well as the industry, e.g., CFD Research Corp. (Huntsville, AL). ✺



The far-right piece in the photo demonstrates the effectiveness of the invented technology, contact-free support structures, in making complex-geometry parts in electron beam additive fabrication process. The invented technology will reduce part distortion and eliminate post-processing.

Dr. Kevin Chou,
Science PI,
University of Alabama in Tuscaloosa

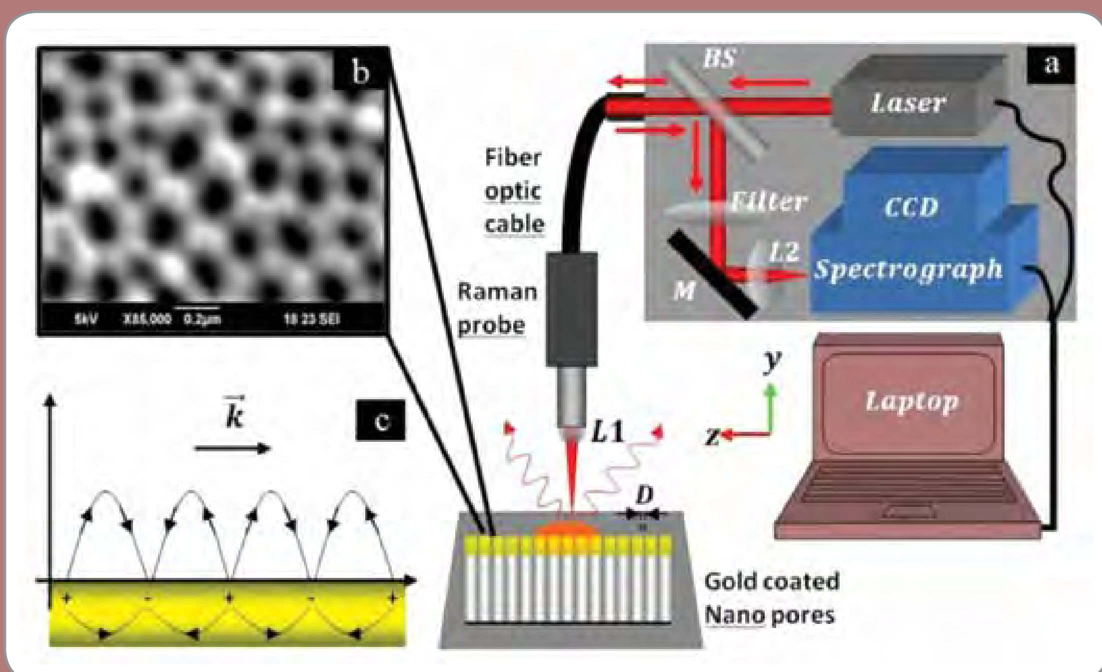
THE UNIVERSITY OF ALABAMA

NASA Technical Monitor:
Dr. Majid Babai,
Marshall Space Flight Center

MSI - On-Chip Nanostructure Surface Plasmon Enhanced Raman Spectroscopy Sensor for Space Applications

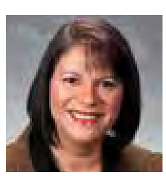
University of Alabama with Alabama A&M University

Miniaturized sensors with integrated functions are very desirable for NASA applications due to size and weight limitations faced by almost all space missions. In this program, faculty members from two Alabama universities investigated innovative new on-chip nanostructured surface enhanced Raman spectroscopy (SERS) sensor technology for space applications. The onchip SERS sensor can measure Raman scattering signals from target chemical analytes without using external and bulky Raman spectrometers.



A research group in the Alabama NASA EPSCoR program at The University of Alabama in Huntsville (UAH) collaborates with a research group at Alabama A&M University (AAMU), an HBCU, to explore a new frontier of nanophotonics sensor technology for potential NASA applications. An African American minority junior faculty member at AAMU is engaged in the proposed research program as a science co-investigator. The research program puts emphasis on this faculty member's research capability development and professional growth through the partnership and collaboration between the NASA EPSCoR research group and minority-serving institution (MSI). ✺

Dr. Junpeng Guo,
Science PI, Professor,
University of Alabama in Huntsville



Theresa Martinez, PMP,
NASA Technical Monitor,
Kennedy Space Center

The Alabama NASA Research Infrastructure Development (RID) Program

The goals of the Alabama RID program are to increase Alabama's success in earning competitive awards from a variety of sources and to build the strength of research groups at Alabama's research universities. The State EPSCoR Committee decided to concentrate the limited NASA funds on assisting faculty who are, as yet, largely unfunded in developing their research competitiveness, assisting them in getting new results and building external relationships. The State Committee requested a plan for a Seed Grant program that targets faculty who have been in their positions for less than 5 years. Alabama has won a RID Program grant from NASA each time the opportunity was offered. In the most recent program, after a rigorous competition, eleven PI's were chosen from 5 universities. Of these eleven, 6 have achieved significant success and are considered to have "graduated with honors".

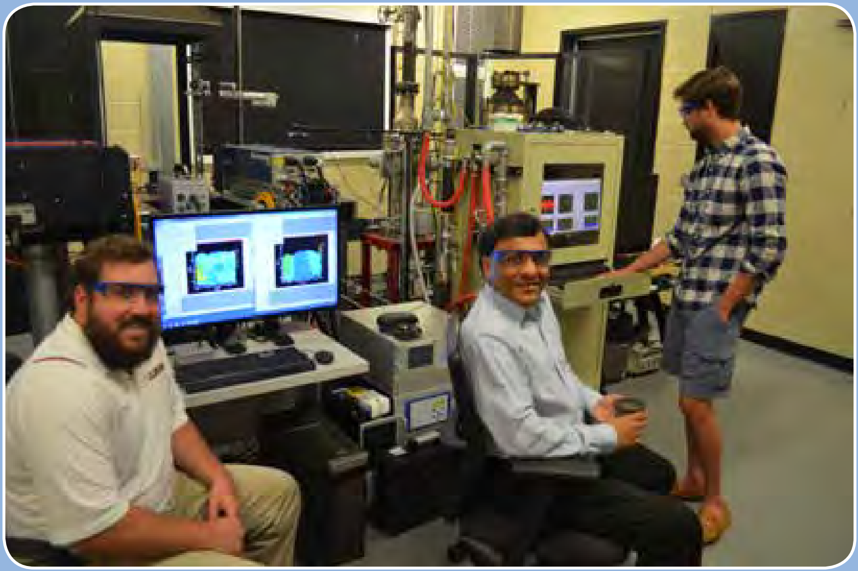
Dr. Amy Lang, University of Alabama;
Microgeometries for Boundary Layer Control

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

AL

University of Alabama/NASA Glenn Research Center, Langley Research Center, Marshall Space Flight Center, Aeronautics Mission Directorate

This research in the Department of Mechanical Engineering (ME) at the University of Alabama is producing innovative concepts, supplemented with experimental data, to enable lean direct 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 thermo-acoustic instabilities or large-amplitude pressure oscillation that can severely damage the engine. The UA team has developed and patented a porous insert concept to address these problems, and specifically in this project, we are exploring methods to create highly functional porous inserts from aviation grade materials using 3D additive manufacturing techniques. We are working with the Combustion Branch at NASA Glenn Research Center (GRC) where LDI combustion research has been extensively investigated. NASA's in-house experience is being utilized to define the hardware and operational challenges for the present study. The project is housed in UA's Engine and Combustion Laboratory (ECL), which has resulted in several systematic changes: (1) the facility is toured by prospective students and parents (including those from underrepresented groups) and has contributed to the largest enrollment in ME in 2015 (above 1400 students), (2) we hosted a technical workshop on "Sustainable Fuels; Production and Combustion" to invite and showcase the research facility to potential collaborators from industry, academia and government (over 70). Presently, we are working to transition the UA technology to gas turbine and/or power industry. The project is supporting two doctoral and one master's students, and a recent PhD graduate has joined the gas turbine industry. In response to these efforts, UA has created Alabama-Sustainable Energy Research Cluster (A-SERC), which will strategically hire several new faculty members to make sustainable energy as a premier research thrust on campus. ✺



James Allen (PhD candidate), Science PI Prof. Ajay K Agrawal, and John Kornegay (PhD Candidate)

John Kornegay (PhD Candidate) and Daniel Depperschmidt (MS Candidate)

NASA Technical Monitor: Dr. Chi-Ming Lee

ALASKA

Dr. Denise Thorsen,
AK EPSCoR Director,
University of Alaska Fairbanks

Alaska is a state of extremes. Much of the state is remote and/or inaccessible. While 2/3 of the state's population live clustered around its three urban centers Anchorage, Fairbanks, and Juneau, the remainder live distributed over nearly 300 remote communities that are inaccessible by road or ferry. The natural environment plays a major role in the economy of the state through natural resource extraction; shipping and transportation, often in a harsh climate; and maintaining a subsistence life in the face of global climate change. The Alaska NASA EPSCoR program has strengthened research in monitoring environmental change, hazard prediction and mitigation. The program has also allowed expansion into new areas of research in Technologies for Space and Extreme Environments and Aeronautics. Over the past five years we have been able to leverage EPSCoR funding to develop exciting new research in excess of $6,000,000.

Alaska TOC

Senator
Lisa Murkowski

Senator
Dan Sullivan

Representative
Don Young
(District At Large)

Photos by Todd Paris

Estimating Spatio-Temporal Variability in Evapotranspiration in Interior Alaska Using Field Measurements, Modeling and Remote Sensing

AK

University of Alaska Fairbanks, Geophysical Institute/NASA Science Mission Directorate

The magnitude and rapidity of ecological and hydrological changes due to climate warming are so dramatic in interior Alaska that the effects can be witnessed in a single lifetime! Alaska's NASA EPSCoR project to map and monitor evapotranspiration (ET), a critical component of Alaska's water cycle, is therefore strategically planned to capture these changes. What may seem like a simple change to human eye is in fact caused by many entwined processes. University of Alaska Fairbanks (UAF) faculty and students partnered with researchers from NASA Goddard Space Flight Center and the U. S. Department of Agriculture to understand the underlying processes causing these changes.

Project researcher, Dr. Jordi Cristóbal training undergraduate student Patrick Graham in setting up field equipment used to collect calibration and validation (CalVal) data. Airborne and satellite missions, as well as local and regional scale surface energy balance models that use input data from NASA satellite missions require such CalVal data for quality control and for quantitative studies. Photo by Meghan Murphy, UAF.

The project resulted in establishing two permanent field sites in Alaska's boreal forests with instrumented flux towers to measure essential climate data; hiring project post-doctoral fellow Dr. Jordi Cristóbal as a research faculty member at UAF; graduating Ph.D. student Derek Starkenburg who will continue as a post-doctoral fellow in educational research related to climate systems; training an undergraduate student, Patrick Graham, who will soon start graduate studies at UAF; disseminating new data and research findings through the project website and publications; fostering new research partnerships with federal and state agencies; supporting preparatory science for NASA satellite missions such as SMAP and HyspIRI; and facilitating new research funding, most significant of which is a major research instrumentation grant from the National Science Foundation that has helped to establish the only airborne hyperspectral facility in the State of Alaska that will further promote research in ecology and resource exploration in Alaska.

For more information check out www.et.alaska.edu and www.hyperspectral.alaska.edu ; or contact the Principal Investigators Denise Thorsen (dlthorsen@alaska.edu - managing PI) and Anupma Prakash (aprkash@alaska.edu - technical PI). ✺

Prof. Anupma Prakash,
Science PI,
University of Alaska Fairbanks,
Geophysical Institute

David L. Toll,
NASA Technical Monitor,
Goddard Space Flight Center

UAF UNIVERSITY OF ALASKA FAIRBANKS

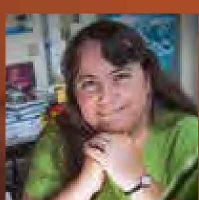
Quantifying Fuel Impacts on Wildfire Behavior and Emissions by Coupling Small Unmanned Aircraft In-situ Measurements with Satellite Observations

University of Alaska Fairbanks, Geophysical Institute/Science Mission Directorate

The major goals of this project were to use a combination of manned and unmanned aircraft systems (UAS) to quantify the optical properties of wildfire smoke, improve satellite retrievals of active wildfire smoke areas, and improve smoke transport and deposition modeling through the assimilation of multi-scale remote sensing data. Another goal was to gather insight into fire dynamic as a function of vegetation type, and evaluate the use of Synthetic Aperture Radar (SAR) at differentiating wildfire behavior such as the differences between fires burning in the canopy and fires burning close to the ground. Such information on burn location is expected to be of significant benefit for the quality of fire dynamic models and for correctly characterizing wildfire/weather interactions

This effort allowed us to develop a new light optical atmospheric counter (LOAC) for UAF's Alaska Center for UAS Integration (ACUASI), to be used for characterization of smoke plumes emanating from wildlands fires, as well as investigation of environmental factors (fuel, moisture, winds) on fire behavior. This asset was also used to support EPA investigation of plumes emanating from military ordnance explosions at Joint Base Elmendorf-Richardson (JBER) in February 2015. The LOAC project was developed by ACUASI and UAF engineering students.

In addition, this project allowed researchers to lease a Synthetic Aperture Radar (SAR) for use on manned aircraft and evaluate its applicability to future larger UAS planned for UAF. This capability will provide valuable insights into environmental conditions affecting fire line burn behavior. This asset will be used to measure fire line advancement during the 2015 fire season and measure burn regrowth for Alaska's Funny River fire of 2014. ✺



Dr. Catherine F. Cahill, Science PI, University of Alaska Fairbanks, Geophysical Institute

Dr. Lisa Huddleston, NASA Technical Monitor, Kennedy Space Center

ACUASI 'Ptarmigan' hexacopter with LOAC payload during EPA ordnance testing at JBER.

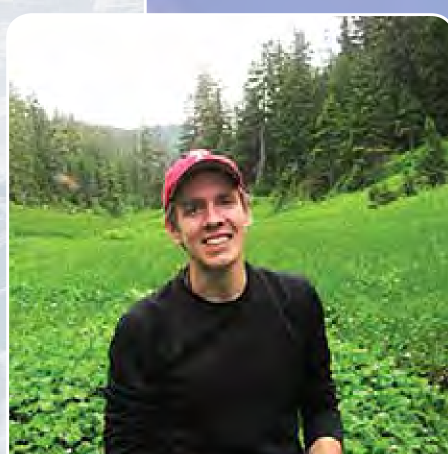
Alaska Research Infrastructure Development

Through an Alaska NASA EPSCoR seed grant, we utilized advanced remote sensing (LiDAR) methods to map forest characteristics, coupled those with measurements of streamwater chemistry, and then modeled chemistry from that remote sensing information. The result is a means to estimate streamwater concentrations of various nutrients from air or space, essential in the hard to traverse landscape of southeast Alaska. Future work will expand on these results by exploring options for scaling up to larger areas, potentially utilizing new NASA missions like the ICESAT-2 space-born LiDAR platform, and incorporating these results into other regional efforts like stream temperature modeling, important for salmon habitat and a key climate change dependent consideration.

The NASA EPSCoR RID project "Detecting sparse sea ice using SAR in the Chukchi Sea" is a collaborative project where researchers at the University of Alaska Fairbanks are using remote sensing tools to better understand how sparse sea ice influences walrus distributions in late summer. Using Synthetic Aperture Radar (SAR) the researchers at the University of Alaska Fairbanks are tracking the persistence of sea ice over productive offshore areas around Hanna Shoal to identify how diminishing sea ice affects the formation of large walrus haul outs along the Alaska coast.

As part of building collaborative relationships with NASA researchers the scientists at the University of Alaska Fairbanks are working with researchers at the NASA Jet Propulsion Laboratory to gain insight on the focal areas and availability of additional high resolution remote sensing data to ground truth low concentrations of sea ice. While this project focuses on the methods to detect sparse sea ice it is also helping to evaluate how NASA data products can be applied to ecological studies that track changes in sea ice at different scales.

Another NASA EPSCoR RID seed project, "Estimating year-round surface energy fluxes in Alaska Arctic and sub-Arctic watersheds through remote sensing and field measurements," Dr. Cristóbal established a strong interdisciplinary team with research partners from the University of Alaska Fairbanks (UAF), NASA Goddard Space Flight Center, the U. S. Department of Agriculture, and the University of Maryland. Dr. Cristóbal also provided mentorship and an exceptionally positive experience for undergraduate student, Patrick Graham, who was involved in all aspects of this research. The datasets and results from this project benefit a large application science community that uses data from current NASA missions such as Landsat, TERRA/AQUA, NPOESS for climate research. It also benefits the researchers involved in preparatory science for planned NASA satellite missions such as SMAP and HyspIRI. ✺



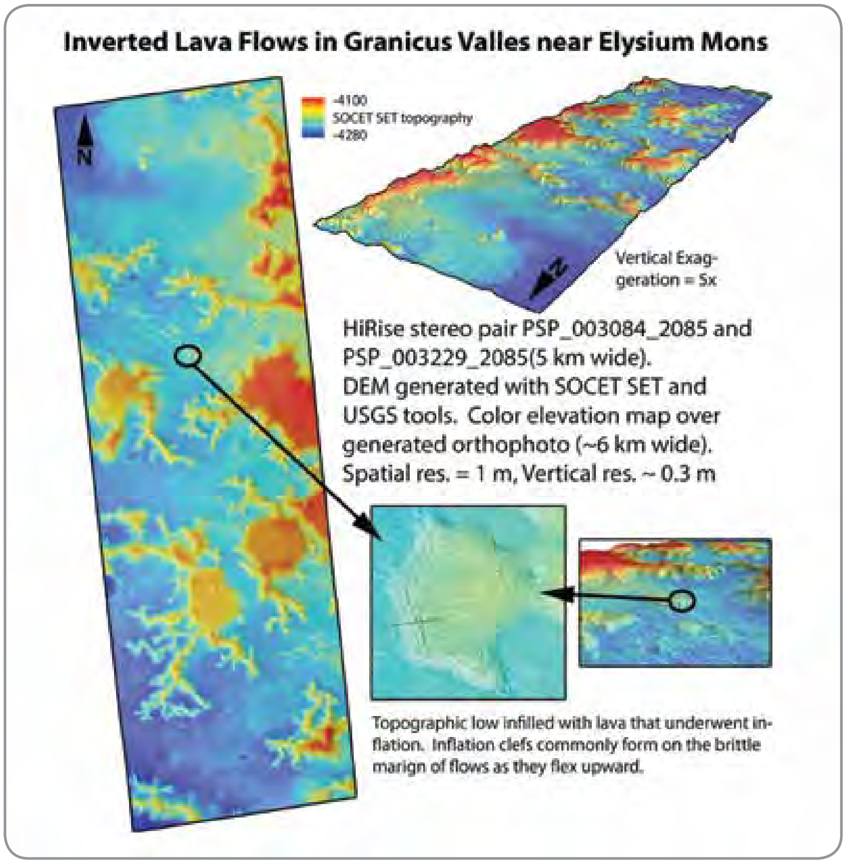
Top: Aerial photography is one of the tools used to ground truth SAR detections of sea ice used by Pacific walrus as a platform to stay close to offshore foraging areas in the Chukchi Sea.

Middle: Dr. Jordi Cristóbal atop a 24 m (~80 ft) tall observational tower in interior Alaska, installing a suite of instruments to measure essential climate variables. Maintaining such equipment in Alaska is difficult because of the remoteness and harsh winter conditions. Year-round measurements from this flux tower are used to calibrate and validate local and regional scale surface energy balance models that use input data from NASA satellite missions.

Bottom: John Krapek, Masters student at UAF, sampling streamwater chemistry high in the south fork of Cowee Creek. High resolution remote sensing is being used to predict stream chemistry and nutrient flows from forests and into the marine environment.

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

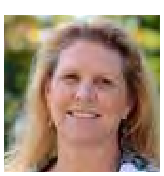
University of Alaska, Fairbanks/NASA Goddard Space Flight Center, Science Mission Directorate



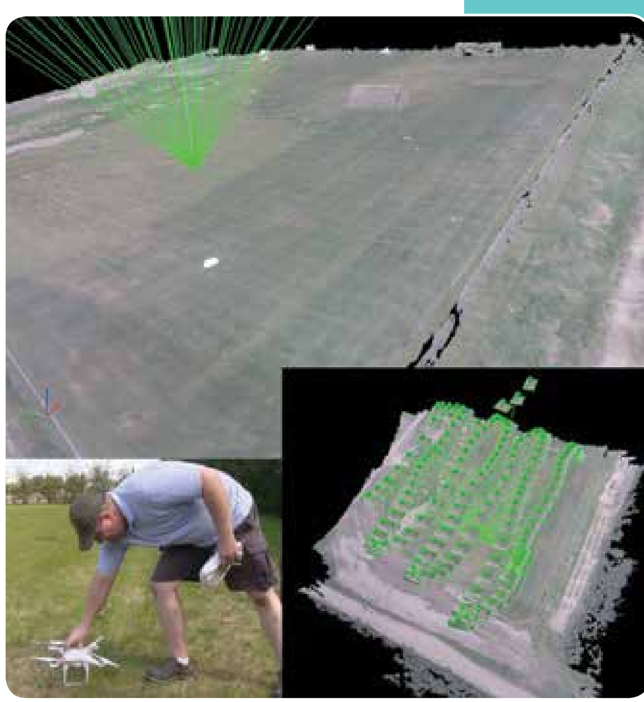
▲ *Stereo-derived topography of a volcanic inflation feature on Mars that was generated at the University of Alaska Fairbanks Photogrammetry Lab.*

Research goals of our CAN include developing the infrastructure to effectively generate topography from aerial photographs and integrating this capability into the research of local entities. We also have a goal of integrating these methods into the higher education of Alaskan geoscientists, particularly those from underserved populations. In summer, 2015, we provided two internships to undergraduates in the Alaska Native Science and Engineering Program. The internships are assisting a program for rural Alaskan high school students that trains them to collect images for local environmental research projects (e.g., students from one coastal village are examining the rate of shoreline erosion). The interns are doing proof-of-concept studies to show how the images can be used to derive valuable high-resolution topography. Below, a test site of a local soccer field was imaged using a UAV, and cm-scale topography was derived using “structure-from-motion” software. Structure-from-motion is a technique that uses ray-tracing algorithms to derive shape from multiple images of the same object acquired from different perspectives. The topography was generated at the UAF Photogrammetry Lab that was created through this NASA EPSCoR CAN. ✺

Dr. Robert Herrick,
Science PI,
Research Professor,
University of Alaska Fairbanks,
Geophysical Institute



Dr. Lori Glaze,
NASA Technical Monitor,
Planetary Studies



◄ *3D rendering of soccer field generated using structure-from-motion software and images collected from a small unmanned aerial vehicle (UAV). Left inset shows Alaska Native Science and Engineering Program intern Scott Taylor with UAV and right inset shows the flight plan for image collection.*

A Vertical Comet Assay for Measuring DNA Damage to Radiation

University of Alaska/NASA Glenn Research Center, Human Exploration and Operations Mission Directorate, International Space Station

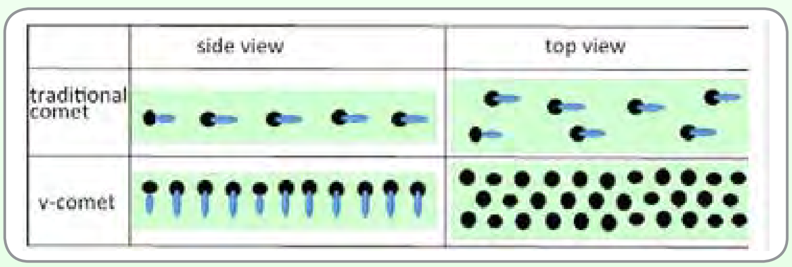
NASA needs a reliable and sensitive technique to collect data at ground and in-flight for assessing risk to astronauts from radiation exposure during spaceflight. We aim to develop such a technique to measure DNA damage, considered the first and foremost step in the malignant transformation of a normal cell into a cancerous one.

While Earth's magnetic field protects its inhabitants from space radiation, astronauts traveling beyond low Earth orbit are at greater risk of malignancies due to chronic, low-dose exposure to galactic cosmic rays, and random, short-term exposures to energetic particles from the Sun. Radiation exposure produces single and double strand-breaks in cellular DNA. The amount of strand-breaks can be correlated to the extent of damage to cells from radiation.

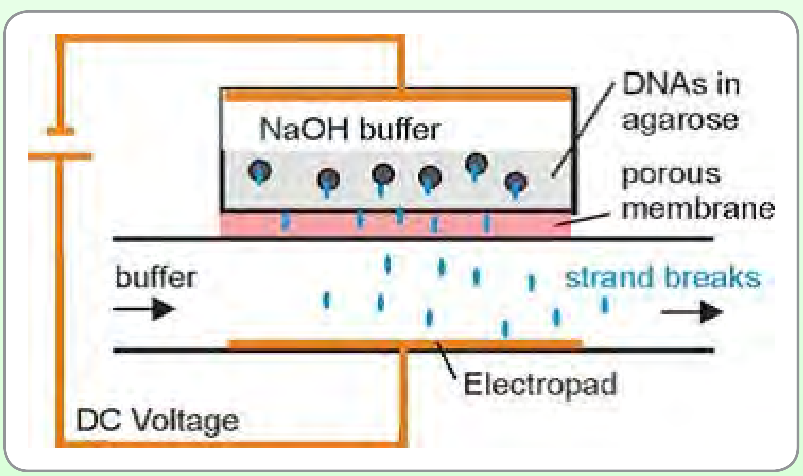
One of the most convenient models to study DNA damage and repair processes in live cells is the "comet assay," or single-cell gel electrophoresis. Unfortunately, this technique requires laboratory set-ups so, at present, we have no reliable techniques to measure DNA damage aboard spacecraft. (This concern is addressed in NASA's 2012 roadmap in the domain of Human Health, Life Support and Habitation Systems).

We will develop, prototype and test a new, "in the field" technique we call " vertical comet," or "v-comet." This new assay will use small scales of microchamber configuration in an integrated approach that combines the sensitivity of a traditional comet-assay technique with the versatility and subtle precision of a microfluidics technique.

Development of this simple, sensitive technique for use in-flight or at mission control should provide increased safety for our astronauts during short spaceflight or long-term interplanetary exploration. ✺



Schematic views of traditional and v-comet assays. Cellular density can be increased 5–10 times with the vcomet assay compared with the traditional comet assay. Because analysis is done after electrophoresis, in the traditional assay, each cell is analyzed separately from others, and the prior concentration of cells should be adjusted such that the extended tails do not cover/touch each other.



Cross-sectional schematic of the proposed v-comet assay.

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

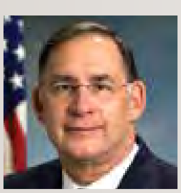
Dr. Yuri Griko,
NASA Technical Monitor,
Ames Research Center,
Life Science Division

ARKANSAS

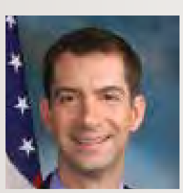
Dr. Mitchell Keith Hudson,
AR EPSCoR Director,
University of Arkansas at Little Rock

Since the first awards of the NASA EPSCoR program, Arkansas has participated with numerous projects ranging from studies on hybrid rocket propulsion, super-massive black holes, novel nanotech materials, to new robotic vision systems. In common, these projects all advance the aerospace arts in a state that until recently had little aerospace industry. NASA EPSCoR has trained a workforce and provided each region of the state with faculty members that have experience in aerospace activities, as we require each Arkansas award to have a substantially diverse human resource and geographic component. Since its founding, NASA EPSCoR has become the lead source of aerospace research in the state, as most non-EPSCoR projects have had their start directly or indirectly from these roots. Recently, Arkansas has become a major supplier of aircraft components and services. We believe that Arkansas NASA EPSCoR will continue to be a major contributor to research, a trained workforce, and aerospace economic impact in the state and region.

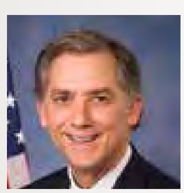
Arkansas TOC



Senator
John Boozman



Senator
Tom Cotton



Representative
J. French Hill
(2nd District)

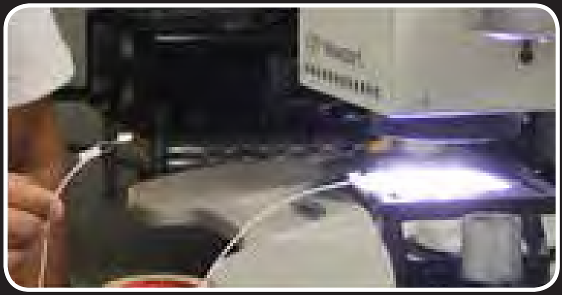
Functionalization of Nanomaterials for Photovoltaic Devices

University of Arkansas/NASA Ames Research Center, Space Technology Mission Directorate

AR

UNIVERSITY OF ARKANSAS

The project supported by NASA-EPSCoR was focused on establishing methods to enhance the performance of the photovoltaic devices fabricated from nanocrystals, such as $CuInSe_2$, FeS_2, InP/ZnS core shells and InAs quantum dots embedded into GaAs p-n junction. The properties of the devices investigated here are the power conversion efficiency, which is extracted from the I-V characteristics, the external quantum efficiency, and spectral response. The methods used to enhance the device performance are based on the plasmonic effect and antireflection coating layers. The study of plasmonic effect was performed by coupling the devices to gold nanoparticles and gold optical nanoantennas. The antireflection coating layers were nanomaterials grown by sol-gel techniques. These sol-gel grown materials including ZnO nanorods, Ta_2O_3, MgF, AZO thin films were used as single and bilayers antireflection coatings. The combination of both the plasmonic affect and antireflection coating were found to increase the power conversion efficiency, quantum efficiency, and the spectral response by at least 50%. Several technical papers were resulted from this funding. ✺



An LED powered by InAs quantum dots solar cells fabricated in the PI-Lab.

Omar Manasreh,
Science PI,
University of Arkansas,
Fayetteville

Meyya Meyyappan,
NASA Technical Monitor,
Ames Research Center

Research Infrastructure Development Program

The NASA EPSCoR Research Infrastructure Development Award Program in Arkansas involves two base activities designed to boost Arkansas academic researchers into serious aerospace projects, with the key idea being mission relevance to NASA. These activities are our RID Teaming Awards and RID Travel Awards. RID Teaming awards are made to beginning or intermediate level research teams made up of faculty and students from at least two Arkansas campuses. Since these $25,000 one year awards are developmental and require at a minimum a full-NASA EPSCoR proposal at their end, we require a PhD granting research campus be involved. Often, the partner campus is a comprehensive or even a small private college campus. AR NASA EPSCoR has found we can boost research at the four year institution via this type partnership, obtaining better geographic and often under-represented group diversity in the process. Our second area awards small travel awards to faculty in the jurisdiction to go to a NASA Center or other installation and meet scientists and/or engineers in their research areas. We make some of these awards to faculty already involved in our programs as well as to some faculty that have not previously identified with NASA and aerospace work. These work similarly to our Space Grant RI travel awards, but can be made to any faculty member at any campus in our state. These seed awards generate significant interest in NASA research and facilities.

AR RID has included projects in many different areas, including propulsion, nanotechnology, astronomy, and plant biology. Recent projects have included: "Effect of microgravity and GT3 on radiation-induced genomic instability in endothelial cells" with participants from University of Arkansas for Medical Sciences and Southern Arkansas (SAU); "Development of Intermediate Band Quantum Wire Solar Cell for NASA Space Exploration" at University of Arkansas at Pine Bluff (UAPB, our HBCU as lead) and University of Arkansas, Fayetteville (UA); and "Development of Critical Technologies for Formation and Proximity Flight with Nano-Satellites". AR RID brings together four to five aerospace research teams each year, most are newly formed teams, although a second year of funding may be applied for concurrently with a NASA EPSCoR Research Award proposal. Since RID was established, AR NASA EPSCoR has made about 45 RID teaming awards. ✺

Dr. Abdel Bachri's team of student researchers from Southern Arkansas University (SAU) investigate the effects of radiation on human cells for their NASA EPSCoR RID Award titled "Effect of microgravity and GT3 on radiation-induced genomic instability in endothelial cells". Human Umbilical Vein Endothelial Cells (HUVEC) are harvested from liquid nitrogen storage tank (1), HUVEC cells are examined following irradiation (2), and cells are loaded into the High Aspect Ratio Vessel (HARV) for microgravity treatment (3). The HARV bioreactor was designed by vNASA JSC scientists to freely suspend the cells and simulate near zero gravity on earth.

New Computer Vision Methods for NASA Robotic Planetary Exploration

University of Arkansas/NASA Jet Propulsion Laboratory, Human Exploration & Operations, Space Technology, and Science Mission Directorates

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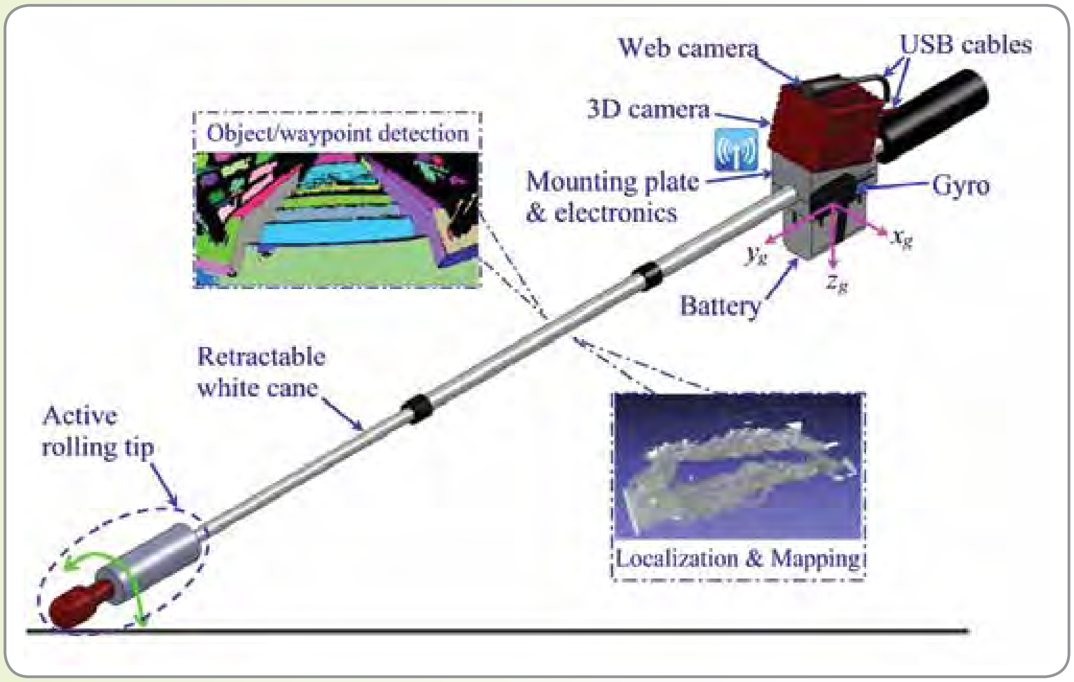


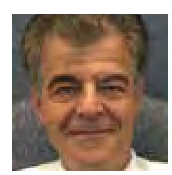
Concept image of the co-robot cane: the computer vision methods allow the robot cane to localize itself, map the environment in 3D, and detect objects and obstacles for wayfinding.

In future missions, the luxury of having constant human intervention may not be possible for deep space missions. Fully autonomous operations is key, however the current rover stereovision based navigation method is not reliable for fully autonomous operations. Therefore, Hudson and his University of Arkansas, Little Rock (UALR) team are developing and validating autonomous robot navigation methods based on a single imaging sensor-3D Flash LIDAR (Light Detection and Ranging) Camera (FLC). Along with devising innovative computer vision methods, new Graphics Processing Unit (GPU) computing techniques will be used to not only use for navigation purposes, but also for robot localization, terrain mapping, and path mapping.

A spin off of the research resulted in robotics technology being used to develop a co-robot cane for the visually impaired. As a navigation aid, the co-robot cane has two modes: co-robot mode and white cane mode. The cane may detect human intent by sensing the cane user's compliance to the robot motion and switch between the two modes automatically. The two computer vision components, 6-DOF (Degrees of Freedom) device pose estimation and 3D object detection, are the spin offs of the NASA EPSCoR research. The University of Arkansas, Little Rock (UALR) team received a research grant from the National Institutes of Health (NIH) through the National Robotics Initiatives Program to further develop the computer vision methods for reliable and real-time application in the co-robot cane for the visually impaired. ✺

UNIVERSITY OF ARKANSAS

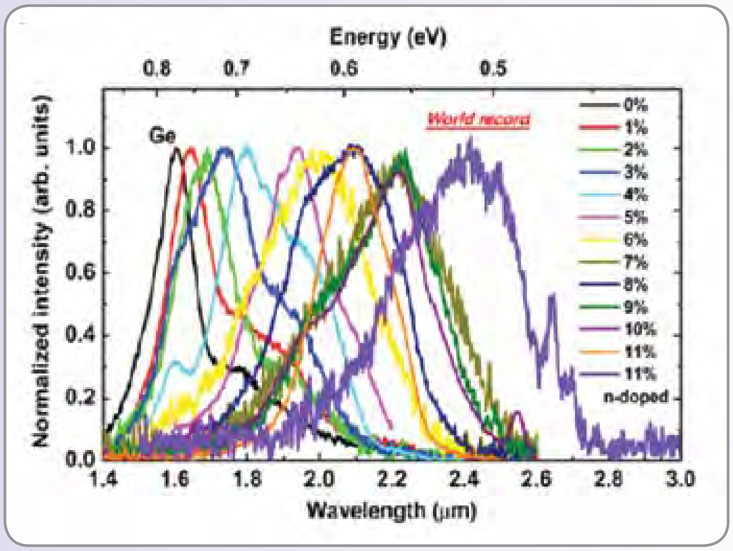
Dr. Cang Ye,
Science PI,
University of Arkansas,
Little Rock



Ali Shaykhian, Ph.D.,
NASA Technical Monitor,
Kennedy Space Center,
Information Technology (IT) Directorate

SiGeSn Based Photovoltaic Devices for Space Applications

University of Arkansas/NASA Glenn Research Center, Space Technology Mission Directorate



A summary of normalized room temperature Germanium-Tin (GeSn) Photoluminescence (PL) with Sn composition from 0 to 11%. (Note, the low signal noise ratio for samples with Sn composition higher than 8% is due to switching from liquid nitrogen cooled Indium-Gallium-Gallium (InGaAs) detector to a thermoelectrically cooled Lead-Sulfur (PbS) detector.

Future space science and human exploration missions will require solar power photovoltaic (PV) systems with significantly higher performance in efficiency and radiation tolerance, and at lower cost. Although the Space Power and Energy Storage Roadmap recently published by NASA has set an aggressive goal for space PV to be 35%, 40%, and 45% more efficient within 5, 10 and 15 years, respectively, the prevailing triple-junction PV technology has reached its maximum potential.

Our world-class team of researchers in the field of germanium-tin (GeSn) technology will develop the next generation, high-efficiency, four-junction solar cells for space applications. They'll design silicon-germanium-tin(SiGeSn)-based PV devices that can be monolithically integrated with existing triple-junction cells by providing an optimized 1eV bandgap cell. This approach provides both boosted performance and a low-cost manufacturing route. The additional benefit is the high radiation tolerance due to the use of a SiGeSn material system.

The team proposes to extend the concept of MJ solar cells to develop SiGeSn two-junction thermophotovoltaic devices which could provide radioisotope power systems with much higher energy conversion efficiency than thermoelectric converters.

The team includes four researchers from three Arkansas institutions and is supported by four experts from three NASA research centers and four industry partners, in which NASA Glenn Research center and SolAero (formerly Emcore) are the key research and manufacture sites for space PV in the U.S. Team members are world-leading researchers and currently hold most "world records" on GeSn material growth and device performance. ✺

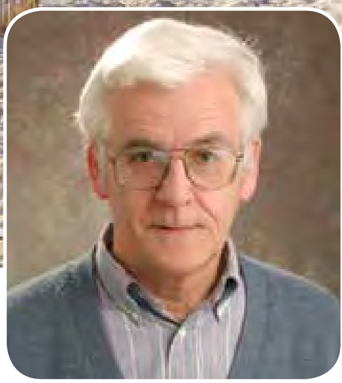
Dr. Shui-Qing (Fisher) Yu,
Science PI,
Associate Prof. of Electrical Engineering,
University of Arkansas

Dr. Sang H. Choi,
NASA Technical Monitor,
Senior Scientist,
NASA Langley Research Center

UNIVERSITY OF ARKANSAS

Langley Research Center (LaRC) is the oldest of NASA's field centers, located in Hampton, Virginia, United States. It directly borders Poquoson, Virginia and Langley Field. LaRC focuses primarily on aeronautical research, though the Apollo lunar lander was flight-tested at the facility and a number of high-profile space missions have been planned and designed on-site.

DELAWARE



D. J. Mullan, PhD,
DE EPSCoR Director

In addition to the our major research agreements, the first NASA/EPSCoR funds for Research Infrastructure Development (RID) grants became available in Delaware in 2007. Three awards are made annually to junior researchers in the state. Up to 14 applications have been received each year from the academic research institutions in the state: Delaware State University, University of Delaware, and Wesley College. The successful applicants have come from Departments as varied as Biology, Marine Studies, Electrical and Mechanical Engineering, Plant Science, Astrobiology, Geology, Physics, and Environmental Studies. The faculty awardees typically go on to obtain promotion and tenure. NASA/EPSCoR Research awards, competed at the national level, have also been won by four teams from Delaware, in Marine Studies, Physics, and Chemical Engineering. In the latter case, the PI has recently been elected to the National Academy of Engineering and will conduct experiments on the International Space Station.

Delaware TOC

Senator
Tom Carper

Senator
Christopher Coons

Representative
John Carney
(District at Large)

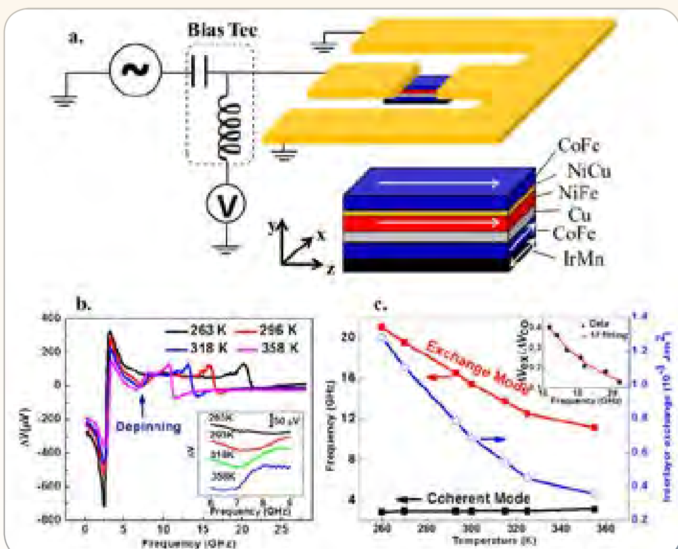
First State National Historic Park, Ft. Christina

DE

Subwavelength Structures Based on Metamaterials and Spintronic Devices for Microwave Detection and Imaging

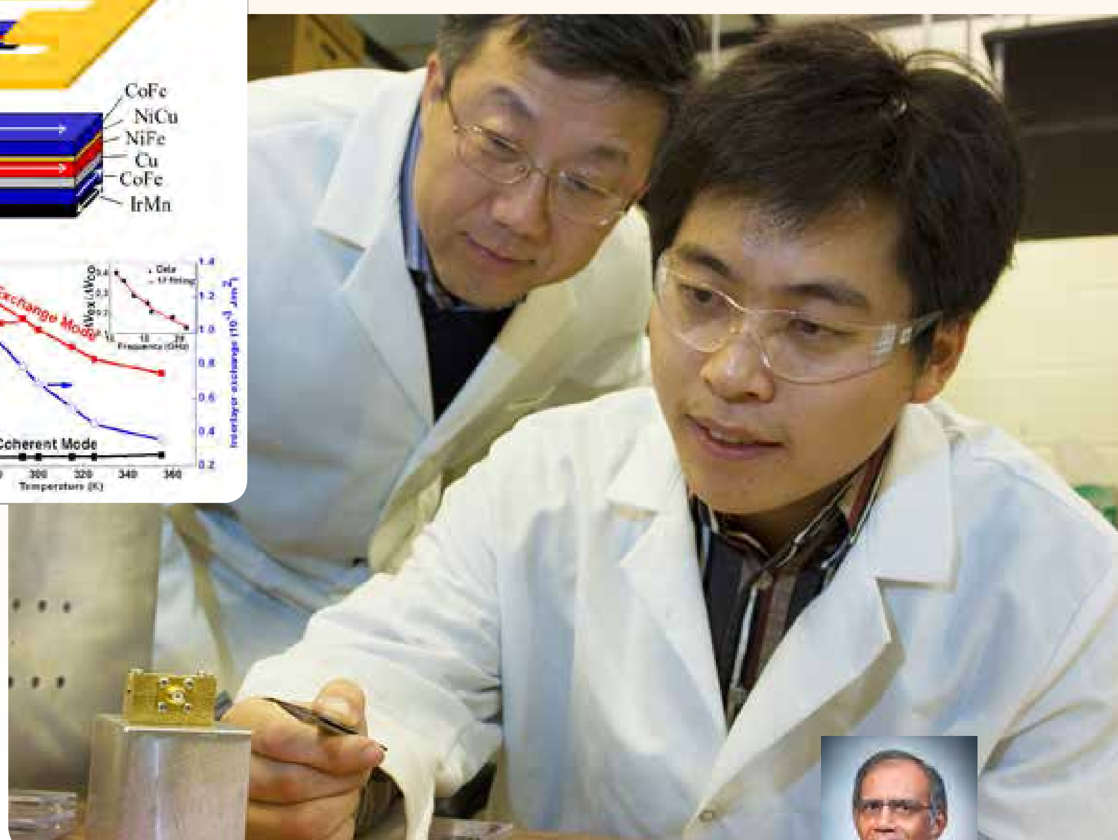
University of Delaware/NASA Glenn Research Center, Space Technology Mission Directorate

This NASA EPSCoR program aims to develop novel microwave devices based on metamaterial concepts and spintronic devices. Metamaterials refer to a class of materials that do not occur naturally and are characterized with unique electromagnetic (EM) properties. The field of spintronics explores the magnetic properties (spin) of electronics, in addition to and sometimes in place of electronic properties (charge) of electronics. Two major advances have been achieved in this research. First, a microwave imaging device has been developed which is characterized with subwavelength pixel size and near perfect efficiency. Besides the microwave imaging applications, the concept can also be extended to construct a universal energy adaptor that converts EM wave energy into other forms of energy with negligible losses. Second, a new mechanism to significantly enhance and tune ferromagnetic resonance frequency (FMR) has been proposed and demonstrated. The enhancement and tunability of FMR is much larger than any existing methods. FMR phenomenon has been widely used in many microwave devices and is an important parameter used in computer harddisks and magnetic memory. A spintronic microwave device with tunable frequency has been demonstrated. The device is capable of detecting microwave frequency, intensity, and phase. Consequently, such a device can be used to construct an on-ship network analyzer and spectrum analyzer. These significant advances have been achieved with an interdisciplinary team of physicists, material scientists, and engineers and the close interaction between the university and a NASA research center. The program has also trained undergraduate and graduate students as future generations of scientists in critical areas. ✺



▲ *Experiment setup of the spin valve-based (SV) microwave detector. (b) The SV response at different temperatures. The resonant frequencies of the exchange mode decreases with increasing temperature. The inset shows the gradual increase of the resonance magnitude and decrease of frequency with increasing temperature. (c) The resonant frequency for coherent and exchange modes and extracted interlayer coupling strength as a function of the temperature. The inset shows that the voltage sensitivity is inversely proportional to the frequency.*

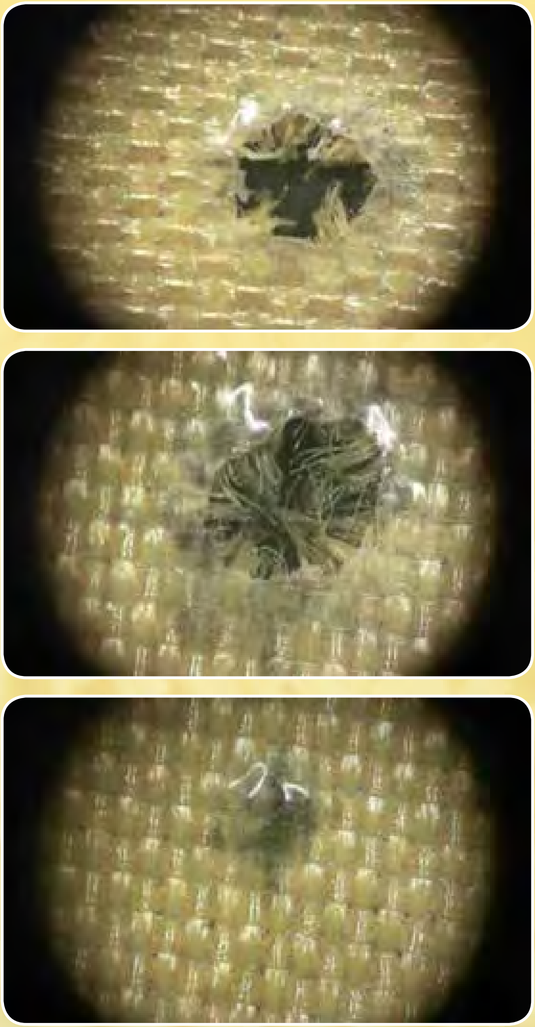
▼ *Prof. John Q. Xiao (Science PI, University of Delaware), and a graduate student working on microwave experiments.*



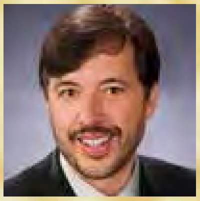
Dr. Rainee N. Simons, PhD, NASA Technical Monitor, Glenn Research Center, SMD

Flexible, MMOD- and Puncture-Resistant Shear Thickening Fluid/Textile Composites for EVA Suits

University of Delaware/NASA Marshall Space Flight Center and Johnson Space Center, Human Exploration & Operations Mission Directorate



Backside view of bladder cloth in lay-ups containing Neoprene-coated nylon (top), STF-treated Kevlar® 1025 (middle), and STF-treated Kevlar® 1148 (bottom) as an active Layer.



Prof. Norman J. Wagner, Science PI, University of Delaware

Richard W. Russell, NASA Technical Monitor, Marshall Space Flight Center

Astronauts are exposed to potential micrometeoroid and orbital debris (MMOD) threats during extravehicular activities. Puncture damage to space suits may also arise from other physical hazards such as tools, sharp edges on handrails or surface elements. Backup suits and gloves can be used to support missions in near-Earth space, but such redundancy and increased mass is not practical for longer missions or deeper explorations. Flexible, lightweight, multi-threat protective materials are needed to provide the durability and protection that will be required in future space suits. This includes adding both puncture resistance and MMOD resistance, as well as self-healing functionality. The former is provided by incorporation of the recently commercialized STF-Armor™ nanocomposite textile developed by the University of Delaware and the US Army Research Laboratory that has proven to be a highly effective protective puncture and ballistic resistant material in soft body armor applications. NASA funded research in our laboratory has the goal of developing STF-Armor™ specifically tailored for application in EVA suits. Furthermore self-healing materials under development at UD also have tremendous potential to further improve astronaut survivability should the TMG be compromised.

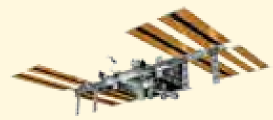
Ground-based UD research on advanced nanocomposite materials for astronaut and spacecraft protection, conducted under a current NASA EPSCoR award, proved the concept that high strength-to-weight textiles impregnated with shear thickening fluids (STF) can improve the micrometeoroid and orbital debris (MMOD) and enhanced puncture resistance for the thermal micrometeoroid garment (TMG) of extra-vehicular activity (EVA) suits. Further research on self-healing materials based on the reversible addition-fragmentation transfer (RAFT) mechanism is further proposed as a means to repair damage and restore pressure bladder integrity should the TMG be compromised.

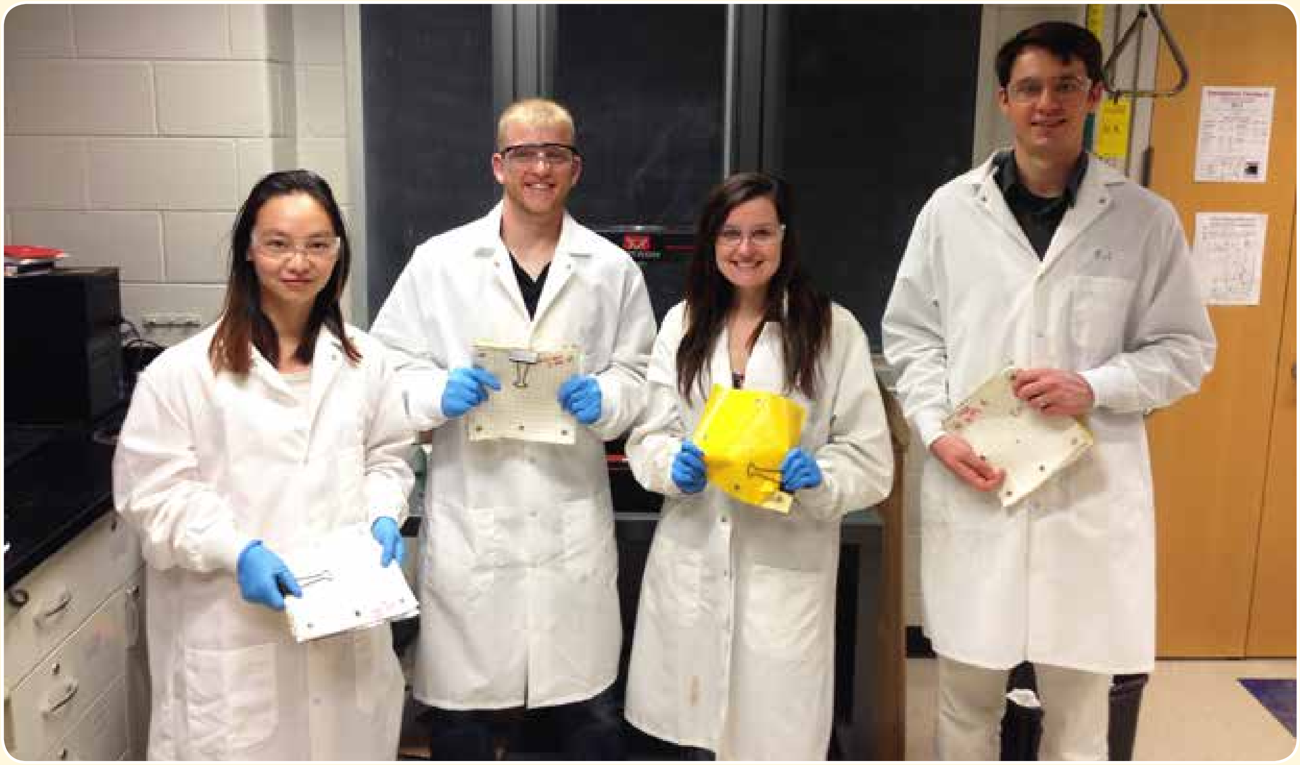
Based on the success of this ground-based research, the UD research team has been selected for an ISS experiment. In this experiment we propose to evaluate the stability and efficacy of advanced TMG suit lay-ups containing advanced nanocomposite textiles and self-healing materials in the extreme thermal, vacuum, atomic oxygen and radiation environment of low-earth orbit (LEO). The proposed material testing using the Materials on the International Space Station Experiment (MISSE) test station planned for the ISS is aimed at advancing the technology readiness level (TRL) of MMOD-resistant and self-healing materials developed and tested on Earth. Proof-of-concept and prototype testing (TRL 3 to 4) has been performed on MMOD-resistant STF-textiles in the full EVA suit lay-ups using hypervelocity testing at NASA Marshall Space Flight Center and most currently, at White Sands Test Facility with the assistance of the NASA Johnson Space Center's Hypervelocity Impact Technology (HVIT) Group. ✺

UNIVERSITY OF DELAWARE

ISS Flight Op - Improved EVA Suit MMOD Protection Using STF-Armor ™ and Self-healing Polymers

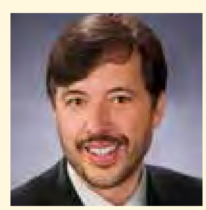
University of Delaware/NASA Johnson Space Center, Human Exploration & Operations and Space Technology Mission Directorates



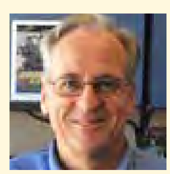


▲ *NASA funded research team at the University of Delaware working on improved EVA Suit MMOD protection using STF-Armor and self-healing polymers: from left to right: Jingsi Gao (PhD candidate), Colin Cwalina (PhD candidate and Delaware Space Grant Consortium Fellowship Awardee), Melissa Gordon (PhD candidate) and Dr. Richard Dombrowski (research scientist).*

We are evaluating the stability and efficacy of advanced thermal meteoroid garments (TMG), for use in the extra-vehicular activity (EVA) suit lay-ups, which contain advanced nanocomposite textiles and self-healing materials. This work is being conducted under a NASA EPSCoR award. The goal of the flight experiment on the International Space Station (ISS) is to test the TMGs in the extreme thermal, vacuum, chemical (atomic oxygen) and radiation environment of low-earth orbit (LEO). The proposed material testing is to be conducted on the ISS and is aimed at advancing the technology readiness level (TRL) of MMOD-resistant and self-healing materials that have been developed and tested on Earth. Proof-of-concept and prototype testing has been successfully performed on MMOD-resistant STF-textiles in the TMG lay-ups using hypervelocity testing at NASA Marshall Space Flight Center and White Sands Test Facility with the assistance of the NASA Johnson Space Flight Center's Hypervelocity Impact Technology (HVIT) Group. These results were presented at the 2015 HVI conference and are published in the proceedings. In addition, we are developing self-healing polymers for use in providing additional protection whereby a compromised bladder layer can self-heal through a mechanochemical mechanism. Further earth-based testing under simulated low earth orbit conditions at Marshall Space Flight Center is proposed to validate these concepts. A flight experiment on the ISS is planned for 2017, which will expose these TMG lay-ups containing both STF-textiles and self-healing polymers to the conditions of LEO using the MISSE test facility on the ISS. ✺



Prof. Norman J. Wagner,
Science PI,
University of Delaware



Steve Huning,
ISS RIM,
Johnson Space Center

Delaware RID Research

One of the goals of NASA EPSCoR is to help young researchers establish themselves in order to be considered for larger federal grants. A recent highlight of the Delaware jurisdiction is the research of Dr. Christopher Kloxin, an Assistant Professor in the departments of Materials Science & Engineering and Chemical & Biomolecular Engineering at the University of Delaware. To follow is a summary from the final report of his project entitled, “Smart and Healing Materials for Inflatable Habitats and EVA Suits in Space”:

The principal goal of this NASA-RID Seed grant is to develop barrier materials for habitats and EVAs that are capable of self-healing. Repair or replacement of damaged or fractured materials in space presents a significant challenge, especially those materials that act as an environmental barrier, which must be lightweight, flexible, and durable.

The RID funds made available have been utilized to sponsor our research efforts to create a new generation of self-healing materials. The initial phase of our research has focused on the organic synthesis of the base monomers that constitute the self-healing polymer networks. We have recruited two new students to work on this project: a PhD student, Melissa Gordon, and an undergraduate student, Jonathon Galarraga (both of which are part of under-represented groups in STEM research). These students were able to develop their materials synthesis and characterization skills throughout the timeframe of the sponsored work. Additionally, they were able to identify and synthesize a novel monomer that will be the fundamental self-healing unit within the polymerized networks.

We have synthesized and scaled up the materials, polymerized the monomers into films, and are now in the process of characterizing self-healing properties of this material. Once this work is finished it will be the basis of a publication that is in preparation. ✷

Christopher J. Kloxin, Ph.D., University of Delaware

Melissa Gordon (PhD candidate) and Jonathan Galarraga (undergraduate researcher), show Prof. Kloxin their new elastomer that is capable of self-healing. This self-healing elastomer utilizes a microscopic repair mechanism that is triggered in response to damaged chemical bonds. This mechanism is proposed to dramatically increase the service lifetime of the material. This research was made possible through a University of Delaware NASA EPSCoR seed grant.

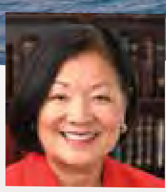
Johnson Space Center, where human spaceflight training, research, and flight control activities are conducted, is renamed in honor of the late U.S. president and Texas native, Lyndon B. Johnson

HAWAI'I

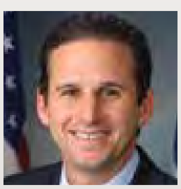
The goal of the Hawai'i NASA EPSCoR Program is to develop an academic research enterprise that is directed toward long-term, self-sustaining, nationally-competitive capabilities in aerospace and aerospace-related research. The Hawai'i NASA EPSCoR Program supports a series of collaborative projects that will strengthen ties between the University of Hawai'i system, NASA Centers in closest proximity to Hawai'i, State and Federal agencies, and private industry. The Hawai'i NASA EPSCoR Program works with other EPSCoR Programs and similar programs in the State of Hawai'i to accomplish these goals.

Dr. Flynn will be working closely with Dr. John Peterson, the POC of the newest EPSCoR jurisdiction, Quam, and has recently been awarded addition Research Infrastructure Development to assist with Guam's onboarding to the NASA EPSCoR program.

Dr. Luke Flynn,
HI EPSCoR Director,
University of Hawai'i at Manoa



Senator
Mazie Hirono



Senator
Brian Schatz

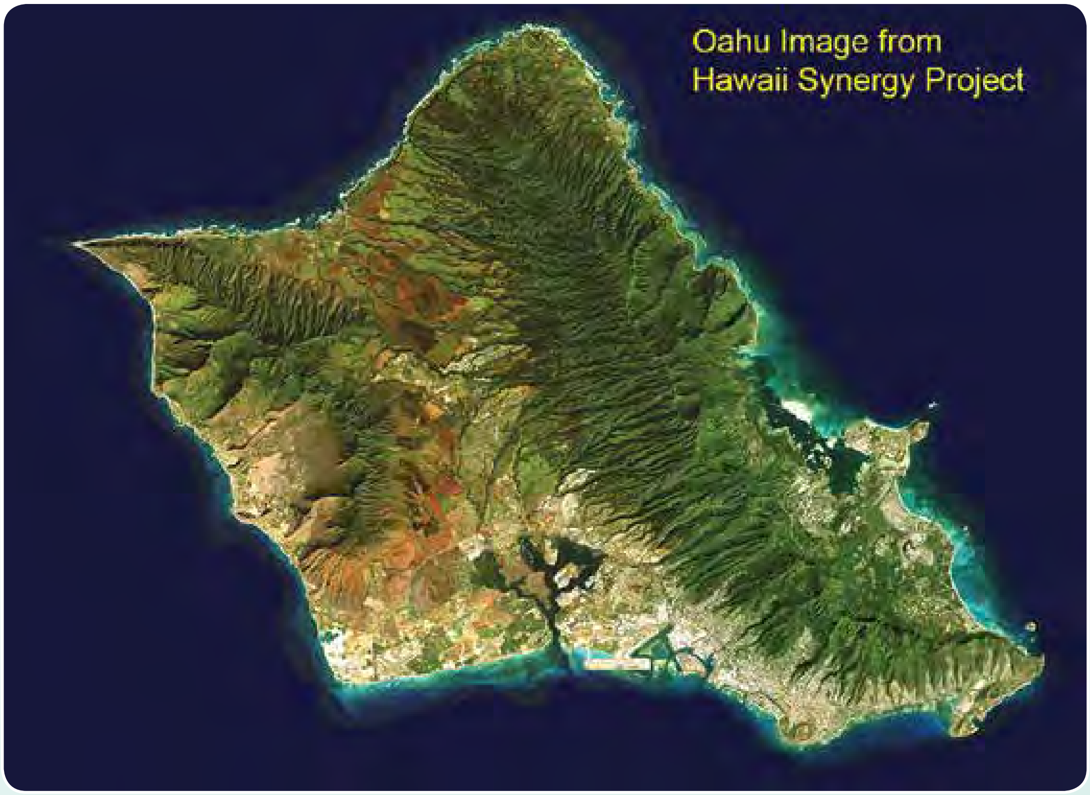
Representative
Mark Takai
(1st District)

Representative
Tulsi Gabbard
(2nd District)

Hawai'i TOC

Development Of An Open-architecture Mission Operations System to Support Multiple Small Spacecraft Missions

University of Hawai'i/NASA Ames Research Center, Goddard Space Flight Center, and Kennedy Space Center/ Human Exploration & Operations Mission Directorate



The primary goal of this EPSCoR project is to develop a comprehensive, "open" set of software tools and hardware to support the operations of one or more small spacecraft missions; it can also perform an important role in the design, development, and testing phases of these missions. These tools operate within an "open architecture" named COSMOS (Comprehensive Open-architecture Space Mission Operations Support), a project performed with the collaboration of the NASA Ames Research Center (ARC). Other applications for their use have been identified and, in some cases, prototyped. These include lunar missions with monitoring and control of both the lander and rover, and remote monitor and control of space-related facilities - even non-space applications. COSMOS will particularly be suited for small operations teams with a very limited development and operations budget, such as universities.

Since they use an "open architecture," COSMOS's major tool components for visualization, support and production and manipulation of its base data program can be adopted for use by future spacecraft missions.

The project's results should benefit NASA's Space Mission Directorate. HSFL, in partnership with the NASA ARC, will use COSMOS to create a functional mission operations test bed, capable of evaluating evolutionary techniques and technologies. Also, COSMOS is currently being modified in collaboration with the Space Dynamics Laboratory, to support the DICE mission, and with the NASA ARC, to support PhoneSat and other missions.

While none have yet been granted, patents for this promising spacecraft "tool kit" will likely have been applied for by year's end. ✺

Trevor Sorensen,
Science PI,
University of Hawai'i, Honolulu

Barbara L. Brown,
NASA Technical Monitor,
Kennedy Space Center

Hawai'i Research Infrastructure Development

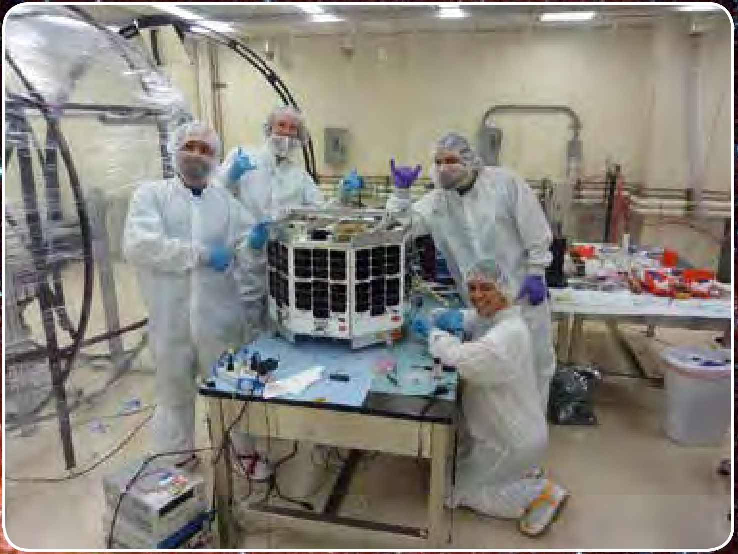
When the U.S. military's ORS-4 mission makes it to space, it will not only demonstrate a new, low-cost launch capability to deliver 300 kilograms to low-earth orbit; it'll also be the first orbital launch from the U.S. Navy's Pacific Missile Range Facility on Kaua'i, Hawai'i and will carry a satellite designed and built by University of Hawai'i faculty and students.

The 110-pound Hyperspectral Imaging, Aeronautical Kinematic Analysis satellite, or HiakaSat, will be ORS-4's primary payload, accompanied by 12 CubeSats aboard a Super-Strypi rocket. "Hiaka", meaning "to recite legends or fabulous stories" in Hawaiian, is the latest cooperative effort of the EPSCoR-funded Hawai'i Space Flight Laboratory.

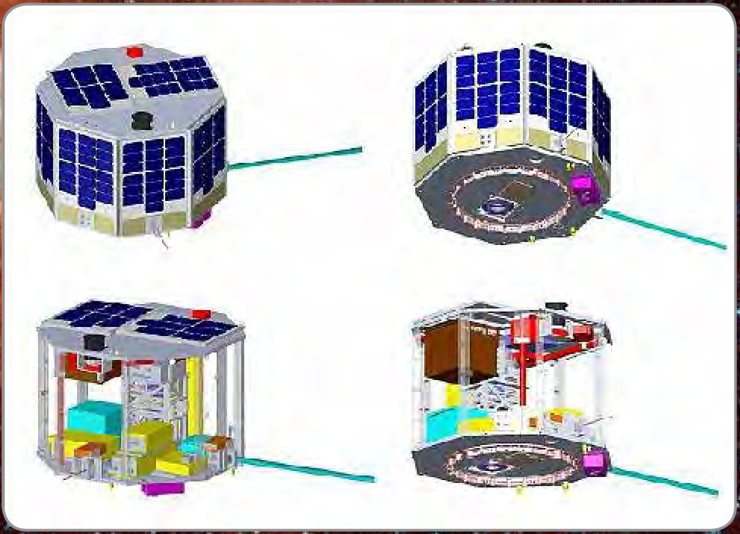
HSFL was established in 2007 within the University of Hawai'i at Mānoa's School of Ocean and Earth Science and Technology and the College of Engineering. Its goal is to design, build, launch, and operate small spacecraft from the Hawaiian Islands while promoting economic growth opportunities for the state in those markets. HSFL has attracted more than $35 million in government funding for HiakaSat.

For this mission, Kaua'i Community College will be the primary communications link for the satellite. A Honolulu Community College-built payload with a camera will photograph the separation of HiakaSat from its rocket's third stage; HCC electronics will provide backup memory to HiakaSat and operate a receiving station. HSFL personnel will operate the rocket's 135-foot rail launcher, the largest sounding rocket launcher in the world. Windward Community College and UH Hilo are also assisting with the mission.

Interim UH President David Lassner said, "The University of Hawai'i is pleased to support the state in becoming a low-cost gateway to space and to provide our students with real-world experience that will be invaluable as we train Hawai'i's aerospace workforce." ✺



HiakaSat (HawaiiSat-1 mission) in the HSFL I&T clean room. (image credit: UH/HSFL)



Various views of the HiakaSat microsatellite. (image credit: HU/HSFL)

Development of a Large Area Standoff Bio-Finder and Chemical Analyzer for Planetary Exploration

HI

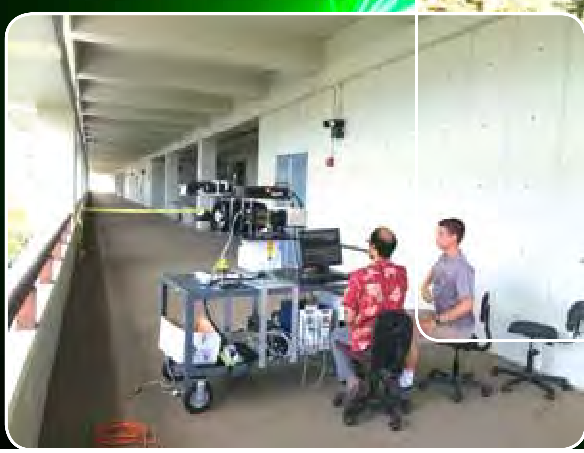
University of Hawai'i/NASA Goddard Space Flight Center, Ames Research Center, Jet Propulsion Laboratory, Science Mission Directorate, Space Technology Mission Directorate

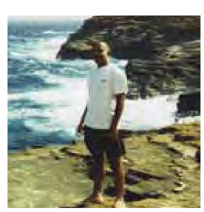
University of Hawai'i researchers are developing a compact laser based system for remote chemical analysis of minerals with funding from the NASA EPSCoR program. The researchers are a building compact system which can perform chemical analysis of a target from a distance of 10m using remote Raman, LIBS and fluorescence spectroscopies in daytime with fast detection time of 1s using a green 532nm pulsed laser. The University of Hawai'i has collaborated with NASA AMES and NASA Langley Research Centers, and the Los Alamos National Laboratory for this effort. Two of the researchers funded by this EPSCoR program were selected to be team member for upcoming NASAs Mars 2020 mission for developing the "SuperCam" instrument in collaboration with LANL. This achievement made local news highlighting the research capabilities available at University of Hawai'i. The Hawai'i researchers are also collaborating with USA-based laser company Q-Peak, Inc., from Bedford, Massachusetts, under the NASA Small Business Technology Transfer (STTR) program, to develop a compact laser for space applications. The State of Hawai'i, typically known for its tourism industry, is systematically changing to open doors for space science and high tech industry. Hawai'i Space Flight Laboratory (HSFL) is looking forward to its first satellite launch in October 2015. With a successful launch, Hawai'i will be the first state in the world to train students to build their own small satellites and launch them in space. Educating and training new students in space science and technology and developing new instruments is one of the goals of the EPSCoR program. http://www.kitv.com/news/uh-scientists-to-have-input-on-2020-mars-mission/27676572 ✺

http://www.manoa.Hawaii.edu/news/article.php?aId=6685

The laser based instrument developed under this EPSCoR program.

Training of an undergraduate student by a doctoral student during a field testing for remote chemical sensing.



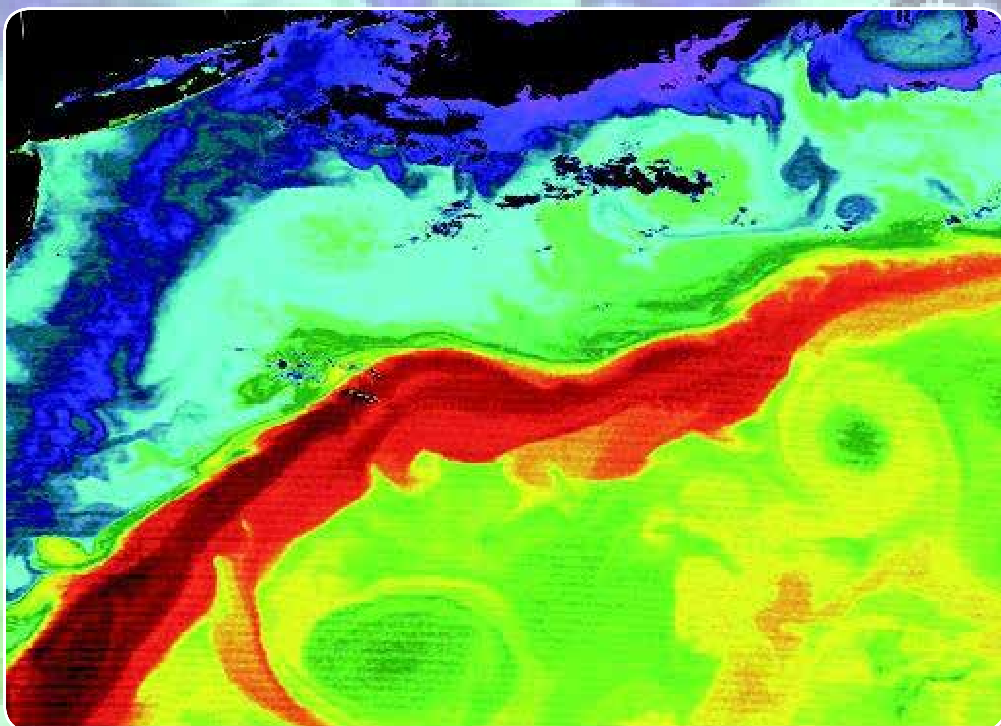


Dr. Anupam Misra, University of Hawai'i, Honolulu

Dr. Chris McKay, NASA Technical Monitor, Ames Research Center

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

University of Hawai'i, Honolulu/NASA Ames Research Center, Science Mission Directorate



The Miniaturized Infrared Detector for Atmospheric Species, or MIDAS, is a small, low-cost infrared instrument designed to detect greenhouse gases, such as carbon dioxide and methane, from remote platforms such as UAVs and high altitude balloons here on Earth to cubesats and planetary missions to Mars, Titan, and beyond.

Current, state-of-the-art technologies for remote detection of trace gases are accurate but limited in range, resolution and how their data can be displayed. These systems are not miniaturizable due to physical and power constraints or are not powerful at large working distances. They are also too expensive for smaller missions and their platforms.

With miniaturization, MIDAS has significant advantages: from UAVs and, ultimately, cubesats, this low-cost, adaptable infrared system can make higher spatial resolution measurements and classification of these gases for climatological and hazard studies, such as from leaks in gas pipelines.

The proposal team has a great deal of experience in developing instruments for thermal infrared remote sensing of solid and gaseous targets such as CO_2 and CH_4. MIDAS builds on previous EPSCoR- and NASA R&D-funded developments of space-born microbolometers to produce a miniaturized solution suitable for deployment on a large number of future mission architectures. ✺

Dr. Brendan Hermalyn,
Science PI,
University of Hawai'i, Honolulu

Dr. Anthony Colaprete,
NASA Technical Monitor,
Ames Research Center

HI

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

Hawai'i Institute of Geophysics and Planetology/NASA Jet Propulsion Laboratory, Science Mission Directorate

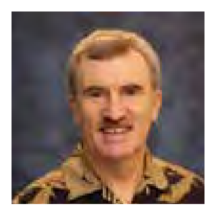
Aerial image acquired by UH Hilo UAV on 10/29/2014 of the then-active lava flow approaching the town of Pahoa on the Big Island. Direction of flow is to the right. This image was obtained with a simple "point-and-shoot" camera. This proposal intends to not only extend the range of instruments that could be flown, but also to develop techniques to have coordinated flying with multiple UAVs.

This NASA EPSCoR project will show University of Hawai'i (UH) faculty and research staff how to utilize unmanned aerial vehicles (UAVs) for science projects, with a specific focus on analyzing the active Kilauea volcano. NASA has long studied the volcanoes in Hawai'i using different remote sensing techniques that include satellites, aircraft and, more recently, unmanned aerial vehicles such as the UAVSAR.

Although Hawai'i was selected in 2013 (along with Alaska and Oregon) to be part of one of six national Federal Aviation Authority (FAA) UAV Test Sites, the UH is poorly prepared to take advantage of this opportunity for new research. Learning how to conduct research under formal Federal flight rules, including the flight certification of sensors, training the UAV operators, and meeting FAA range safety rules will be an important part of this project. In addition, novel techniques, such as UAV formation-flying for "stereo viewing" of volcanic plumes, will open up many new science research opportunities.

This specific project, to be mentored by Dr. Dave Pieri at NASA's Jet Propulsion Laboratory, will investigate the connection between the thermal properties of active lava flows and the changes in flow topography at Kilauea on an hour-by-hour basis. The team also wants to estimate the gas flux from the volcanic plumes associated with these flows. To accomplish these science objectives, they will use multiple UAVs to make simultaneous measurements of Kilauea's active lava flows and volcanic plumes.

These concurrent measurements will be coordinated through the adaptation of the UH COSMOS small-satellite software to control UAVs. Through mentoring by Dr. Matt Fladeland (NASA Ames), the team will learn the operational aspects of UAV research and how they relate to NASA's broader research objectives. Thus, the Team will become more competitive with our future research proposals to be submitted to NASA. ✺



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

Dr. Matthew Fladeland, NASA Ames Research Center, Earth Science Division

HIGP Hawai'i Institute of Geophysics & Planetology

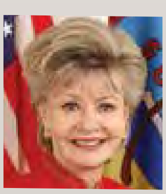
GUAM

Guam first became eligible for NASA EPSCoR in 2013. Because of its size and remote location, Guam is aligned with the Hawai'i jurisdiction until it can get its NASA EPSCoR program fully staffed.

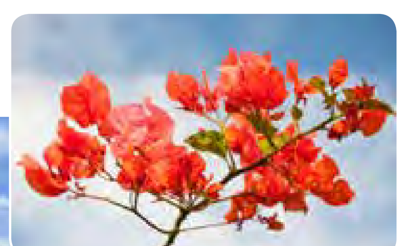
To accomplish this, Guam will be executing their 2015 Research Infrastructure Development (RID) activity through Hawai'i. Once their RID processes are established they may apply for a $400,000 RID grant (new jurisdictions receive and extra $25,000 the first year of their first RID award to help get the program established). The NASA EPSCoR program office has made contact with Dr. John Peterson from the University of Guam and put him in contact with the Hawai'i NASA EPSCoR director. In addition, Hawai'i was awarded extra RID funding to assist Guam in the near term in preparing any research proposals and to submit those proposals through Hawai'i. The EPSCoR project office is looking forward to Guam's participation and wish them good luck with their first research proposal.

Dr. John Peterson,
GU EPSCoR POC,
Asst. Vice President of Graduate Studies,
Research & Sponsored Programs,
University of Guam

Dr. Luke Flynn,
HI EPSCoR Director,
University of Hawai'i at Manoa



Representative
Madeleine Z. Bordallo,
Guam

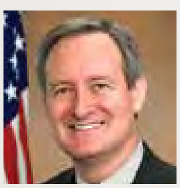


Wallops Flight Facility (WFF), located on the Eastern Shore of Virginia is operated by Goddard Space Flight Center primarily as a rocket launch site to support science and exploration missions for NASA and other Federal agencies.

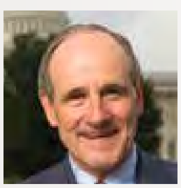
IDAHO

NASA EPSCoR has provided a solid foundation for enhancing the skills and capabilities of Idaho's researchers. The research initiation grant program funded by the NASA EPSCoR Research Infrastructure Development program has enabled Idaho's researchers to gain critical experience necessary to win and execute new research projects. Through NASA EPSCoR, Idaho is gaining a solid reputation for cutting edge research in many areas including water resource management, fire ecology, energy storage, and the effects of space on biological processes.

Dr. Joseph Law,
ID EPSCoR Director,
University of Idaho

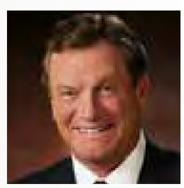


Senator
Mike Crapo



Senator
James E. Risch

Representative
Raúl Labrador
(1st District)



Representative
Mike Simpson
(2nd District)

The University of Idaho, in Moscow.

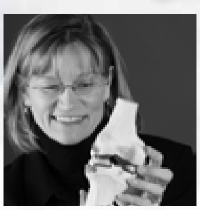
Idaho TOC

Molecular Mechanisms of Cellular Mechanoreception in Bone

Boise State University/NASA Human Exploration & Operations Mission Directorate

Boise State University Microgravity University students fly on the Weightless Wonder - an aircraft that flies extreme parabolic maneuvers over the Gulf of Mexico, simulating hyper gravity (two times Earth gravity) and microgravity (very little gravity that results in weightlessness). In 2014, the team's project, "Gravitational Effects on Cerebrospinal Fluid Pressure and Flow in an Anatomical Model" focused on examining the aftereffects of microgravity in astronauts' cerebrospinal fluid following return to normal gravity. Dr. Julia Oxford advised the team on their research.

Establish the cell culture system in which to evaluate how changes in the ECM influence cellular response to simulated microgravity. Investigate intermediates of signaling pathways that influence osteoblast differentiation under conditions of simulated microgravity in a defined extracellular matrix. Investigate novel intermediates in the mechanism of mechanotransduction. This work is being conducted through a collaboration involving NASA Johnson Space Center, Microgravity University, Sapidyne, Inc., and University of Texas Health Science Center at San Antonio. ✺



Dr. Julia Thom Oxford,
Science PI,
Boise State University

Dr. Jean D. Sibonga,
NASA Technical Monitor,
Johnson Space Center

BOISE STATE UNIVERSITY

Remote Sensing of the Cryosphere: Calibration and Validation

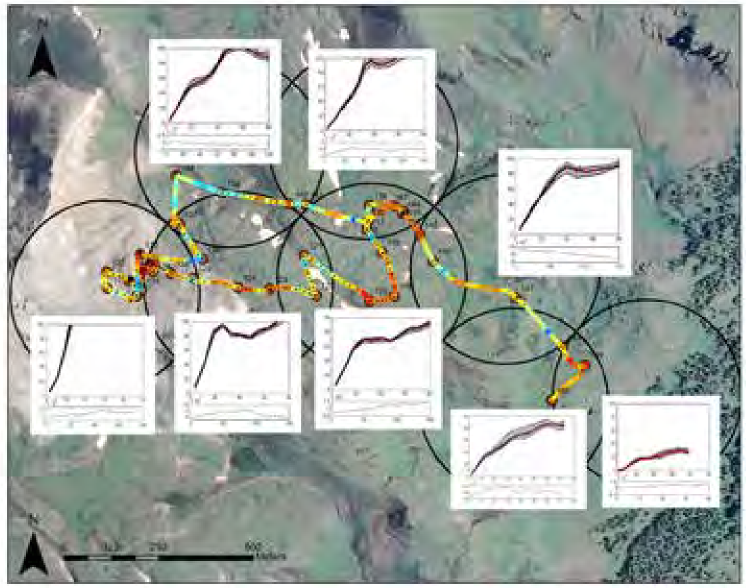
Boise State University/NASA Goddard Space Center, Science Mission Directorate

The two primary goals of this project were to improve our ability to monitor snow properties from space, and to develop a research group within Idaho, which will become a leader in remote sensing of the Cryosphere.

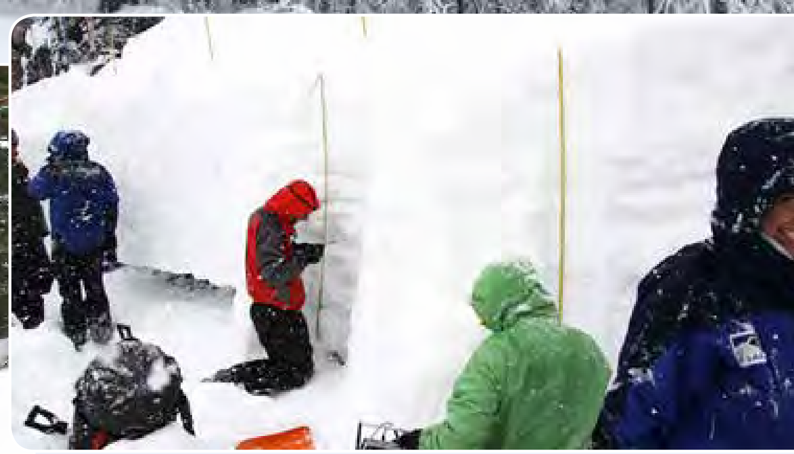
New methods that can exceed the maximum spatial and temporal resolution and extent over which snow can be currently measured were develop. This includes new remote sensing techniques, as well as methods that allow higher resolution snow characterization for calibration and validation of remote sensing observations. ✺

For additional material, please see http://earth.boisestate.edu/cryogars/cryogars-in-the-media/

Dr. Lora Koenig, NASA Technical Monitor, Acting Project Scientist, Operation Ice Bridge, Goddard Space Flight Center



Changes in spatial variability as measured by variogram analysis along a radar profile in Silverton, Colorado.



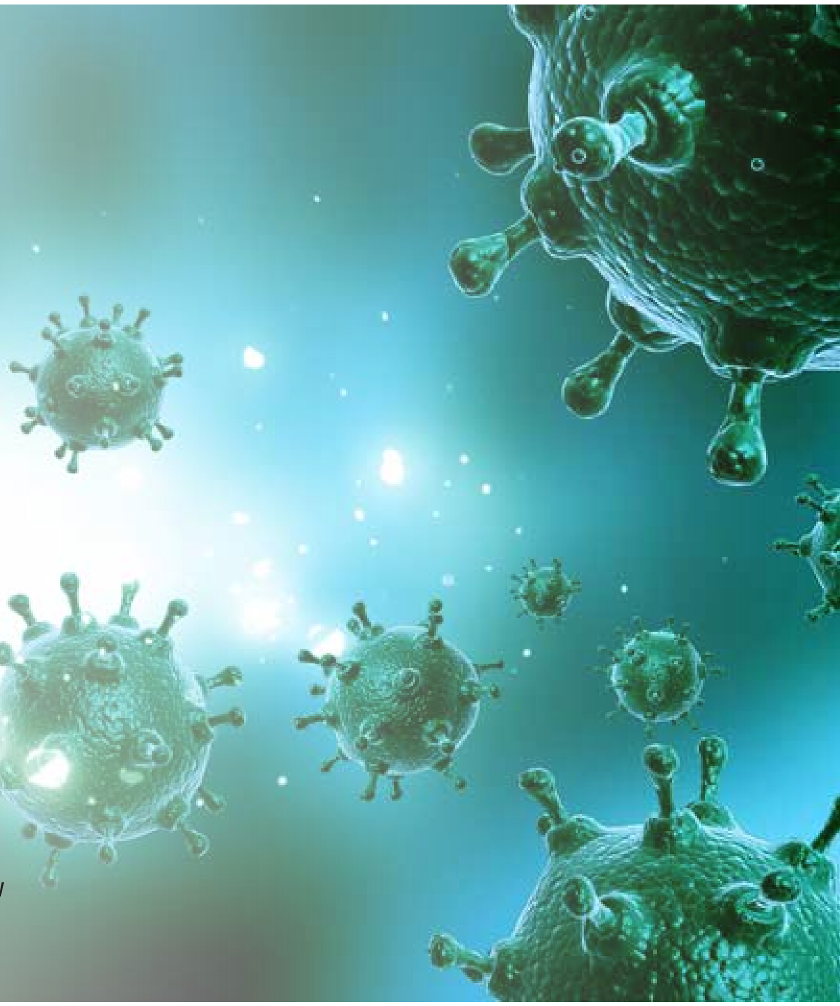
Students work with NASA EPSCoR researcher, Dr. HP Marshall, Science PI, Boise State University, to perform in-situ snow measurements for calibration and validation of ground-based and satellite radar measurements in support of the “Remote Sensing of the Cryosphere: Calibration and Validation” grant.

Radar measurements from aerial tramway, which allowed weekly non-destructive measurements throughout the winter.

BOISE STATE

Investigations of the Potential for Microorganisms Residing on Mars-Based Spacecraft to Inhabit Mars and Pose Planetary Protection Challenges

University of Idaho/NASA Ames Research Center, Science Mission Directorate



Results from our studies have provided the basic beginnings of understanding microorganisms that reside on pre-launch spacecraft and their potential impact on space exploration of possible habitable worlds. The search for extraterrestrial life is bolstered by our long-standing quest to determine if we are alone in the universe or if there are other planetary bodies which may also support life. However, the search for life on these planetary bodies introduces another challenge; microbes from Earth hitch-hiking on the spacecraft. This is a challenge that must be addressed when exploring potentially habitable planetary bodies. Studies conducted at the University of Idaho in Moscow, Idaho have begun to answer important questions regarding the microorganisms collected directly from the Mars Curiosity rover and Viking spacecraft landers prior to launch. What our research has shown is that the microorganisms remaining on the spacecraft, after numerous attempts to eradicate them, are very resistant to extreme environmental conditions. They are some of the hardiest of microorganisms, being able to survive desiccation for extended periods of time then grow again when conditions are favorable. These organisms grow after simulated exposure to the space environment, such as intense UV-C radiation and low temperatures, and can grow under extreme environmental conditions including elevated salt or pH. Many of these bacteria grow under anaerobic conditions using sources known to be available on Mars, such as sulfate, perchlorate, and iron, to conserve energy. Further studies will provide additional insight as to whether these organisms can truly inhabit other worlds, ways to mitigate their initial contamination of spacecraft, and provide additional knowledge as to the limits of life as we know it. Over the last year our research has been featured in Nature News, Popular Science and Discover Magazine, among other media outlets. Dr. Smith was also interviewed on CBC Radio's Science show "Quirks and Quarks". ✺

University of Idaho

Dr. Andrzej Paszczynski, Science PI, University of Idaho

Dr. David J. Smith, NASA Technical Monitor, Ames Research Center

Idaho NASA EPSCoR Research Infrastructure Development

NORTHWEST NAZARENE UNIVERSITY

Development of a Fire Monitoring and Assessment Platform (Fire-MAP):
Utilization of Multi-Spectral Cameras on Unmanned Aerial Vehicles for Mapping Wildland Fire Extent and Severity.

The Northwest Nazarene University (NNU) FireMAP team initiated collaboration with Vallivue High School's Engineering class taught by Tegan Byerly. This collaboration started with an attempt to promote STEM education in a local high school, but resulted in a significant collaboration where Vallivue and NNU built a "Giant Ruler" on the soccer field, which a DJI Phantom 2 Vision+ was used to take imagery of at various altitudes. Vallivue analyzed the imagery to calculate the spatial resolution of imagery taken at each of those altitudes. The Computer Programing 1 (COMP2220) class at NNU is starting on their semester project which is a program that will take the latitude and longitude off a geotagged image taken by a DJI Phantom 2 Vision+ and calculate the yaw and altitude for the image based on the readings in a GPS log file of the flight on which the image was taken. This program will use the altitude and yaw to create a control point file at will be used by ArcGIS to georeference the image, translating the image coordinate system into the WGS84 coordinate system. One of the student researchers on FireMAP team has written a program which will georeference and mosaic images from a DJI Phantom using ArcGIS. The python script will use the program being written by the students in COMP2220 to create the necessary control point file for an image which ArcGIS will use to georeference the images. ✺

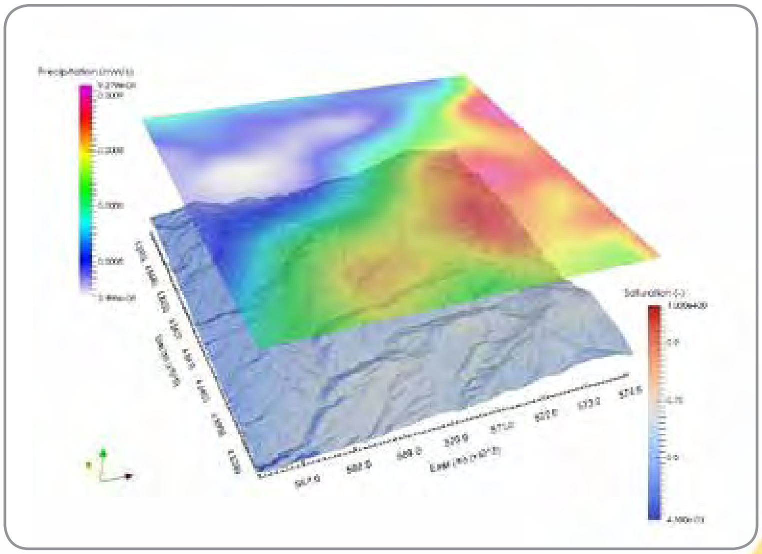
NNU's Dale Hamilton leveraged the fire-related research he is currently conducting with unmanned aerial vehicles (UAVs) to engage and inspire local Idaho students to pursue STEM careers. In these images, students from Vallivue High Schools work together with NNU researchers to create a giant ruler to be imaged from a UAV.

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

Boise State University/NASA Goddard Space Flight Center, Jet Propulsion Laboratory, Science Mission Directorate

Rain or Snow? Researchers at Boise State seek to improve predictions of mountain water storage in a warming world. Recent and ongoing drought throughout the world and in the western US have underscored the importance of monitoring and predicting regional water storage, particularly in light of the challenged posed by climate change. In mountainous regions throughout the world climate change is expected to increase the fraction of precipitation arriving as rainfall rather than snow, relative to historic conditions. Mountain snowpacks serve as an important natural reservoir, storing winter precipitation for use in the warmer, often drier, summer months. In testbed watersheds in Idaho, researchers at Boise State University are using advanced tools to simulate atmospheric conditions in these complex, mountain landscapes. They are seeking to address questions like to what degree do weather and climate models have to resolve and represent the spatial heterogeneity in these landscapes to capture the transition between rain and snow? And how can remote sensing observations of snow cover or soil moisture be used to correct for errors in model predictions? Preliminary results show that finer resolution in the atmospheric models leads to demonstrable improvement in the accuracy of precipitation phase. This is seen in the simulated soil moisture. Coarser resolution simulations deliver precipitation to the watershed as rain, leading to an immediate increase in soil moisture. Finer resolution simulations, on the other hand, deliver the precipitation as snow, which (correctly) melts several days later producing a delayed response in soil moisture. The research project is aimed at improving the conjunctive use of models and remote sensing data, from satellites like the recently launched SMAP and the forthcoming ICESAT-2, to make better predictions about the dynamics of water storage in these mountainous regions. ✷

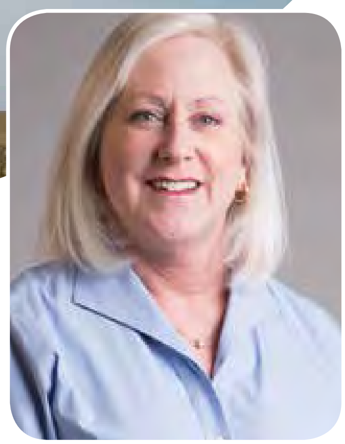
BOISE STATE UNIVERSITY



Dr. Alejandro N. Flores, Science PI, Boise State University

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

IOWA

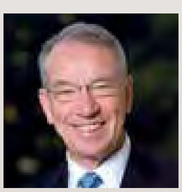


Dr. Charisse Buising, Director Iowa NASA EPSCoR

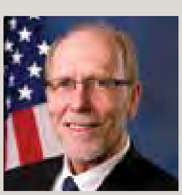
Funding to the Iowa NASA EPSCoR program improved capacity to do quality research. The Iowa program helped build a base of NASA-literate and connected researchers who are developing new technologies and successfully securing support for projects beyond seed funding. The Iowa program improved connections between Iowa and NASA researchers by funding travel to NASA centers to establish collaborations. NASA EPSCoR funding increased the number of researchers in Iowa working on NASA technical issues by providing seed grants. Finally, the program helped build partnerships through intra-state research collaborations in NASA relevant areas by funding networking meetings to exchange ideas, explore emerging research areas, and work more effectively.

This NASA EPSCoR Jurisdiction is one of EPSCoR's success stories. In 2013 Iowa "graduated" from EPSCoR by exceeding the National Science Foundation's research funding percentage eligibility line as shown on their FY 2013 and subsequent eligibility tables.

Senator Joni Ernst

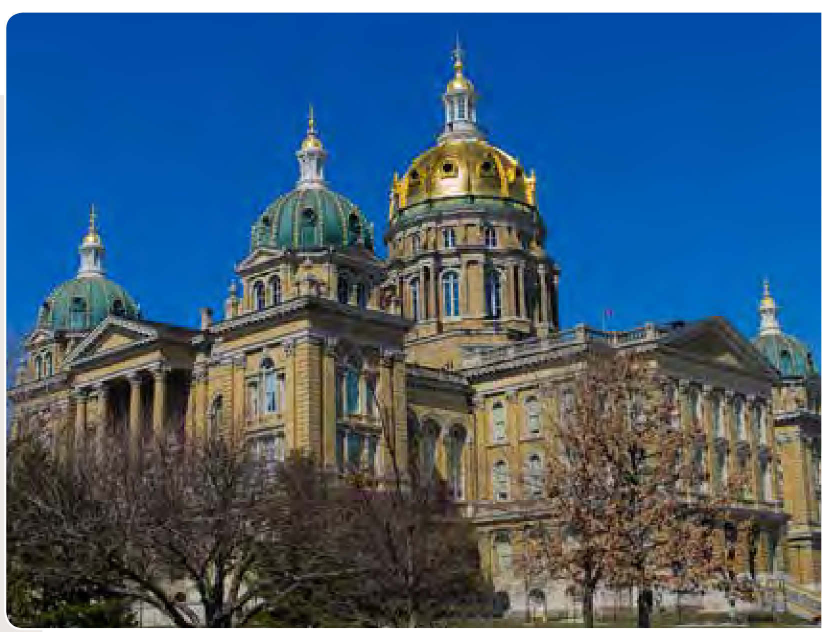


Senator Chuck Grassley



Representative Dave Loebsack (2nd District)

Iowa TOC



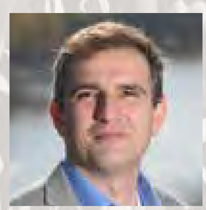
IA

Agricultural Soil Erosion and Carbon Cycle Observations in Iowa: Gaps Threaten Climate Mitigating Policies

University of Iowa/NASA Science Mission Directorate

In Iowa and most of the Midwest, increased variability between climate extremes (e.g., floods and droughts) coupled with intense agricultural activities to support our food and fuel needs are significantly shaping the carbon budget in the region. Most large-scale carbon budgets suggest that the Midwest can be a significant carbon sink, if the right management is practiced, but the full extent of this potential is unknown. The implications of agriculture management (till vs. no-till) on carbon fluxes are not well understood. Also, the role of tiles on carbon losses remains open. This work addresses this specific issue. In addition, it provides some unique data for calibrating NASA's global models for intensively managed eco -systems. These data are lacking. To our knowledge this is one of the few projects that systematically examines the collective role of runoff and tillage induced erosion on SOC redistribution and CO_2 fluxes using different scaling approaches (bottom up and top down) combined with direct in-situ flux and biogeochemical observations.

To help address these needs, our NASA EPSCoR team is investigating the impact of land-use change and associated agricultural practices on soil organic carbon (SOC) sequestration potential to provide better estimates of future CO_2 trends within the region. In collaboration with NASA and USDA researchers, our team has developed a two-pronged approach (bottom-up, top-down). The bottom-up approach explores the relationship between land-use change and CO_2 so we can model better the effects of soil erosion on the SOC movement across the landscape and improve carbon budgets in Iowa. The top-down approach lets us look at the carbon cycle at multiple scales to see how sensitive the larger, regional scale carbon observations and predictions are to the carbon emissions from different land management practices under variable climate conditions. The comparison between the bottom-up and top-down model will lead to a more holistic approach allowing us to identify areas of improvement for the larger scale models. To complete this work, we are incorporating information from the NSF-supported Intensively Managed Landscape Critical Zone Observatory, the recently installed NOAA tall tower observatory in West Branch, IA, and the long-term, field observations at USDA sites. NASA benefits from this EPSCoR research program are ample as we are providing improved understanding of how soil and atmospheric measurements taken at local and regional scale can be used to improve the biogeochemical models critical to NASA's forecasts of atmospheric composition, land cover, and climate at decade-to-century time scales. ✺



Thanos Papanicolaou, Science PI, formerly of University of Iowa, now at University of Tennessee

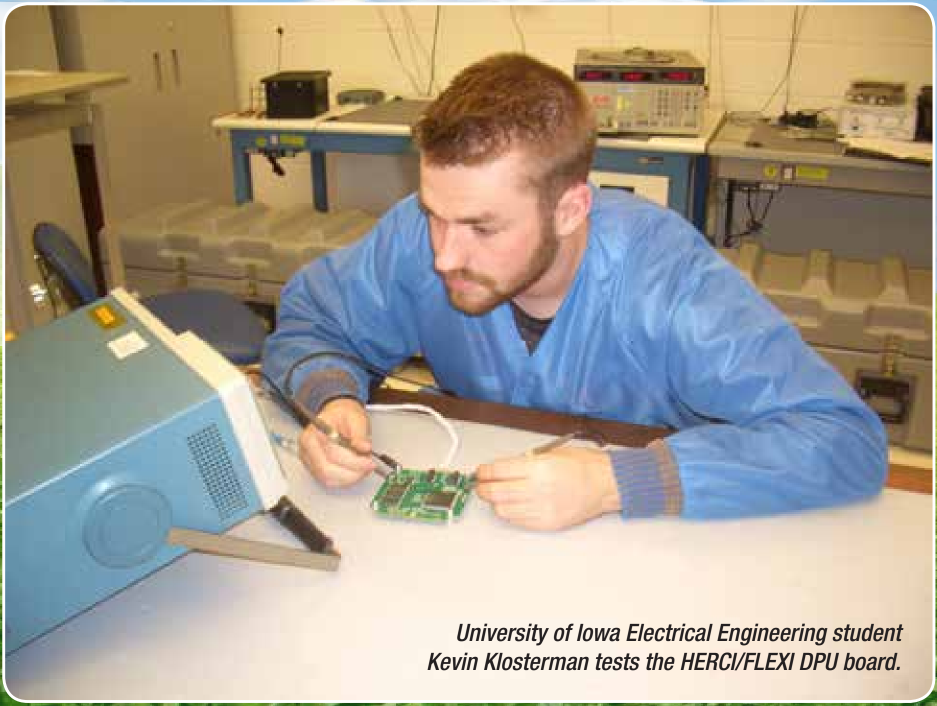
NASA Technical Monitor: Ransook C. Evanina, Glenn Research Center

Iowa NASA EPSCoR Research Infrastructure Development

University of Iowa Department of Physics and Astronomy engineers William Robison and Steven Remington install the Juno Digital Processing Unit on a test fixture prior to environmental testing.

A research grant from Iowa NASA EPSCoR was received by The University of Iowa to develop a digital signal processor that could be used to process plasma wave data onboard spacecraft. This allows digital processing to replace analog circuits and provide higher science return for less mass and power. Under this seed grant funding, the technology was developed to a level where it was successfully proposed on two NASA missions, and is currently on the way to Jupiter on the Juno spacecraft and orbiting the Earth on the two Van Allen Probes spacecraft.

The University of Iowa received another grant to develop the Juno Digital Processing Unit pictured above into a CubeSat form factor. The resulting board is being readied for flight on the AMSAT Fox-1D CubeSat as the processor for the High Energy Radiation Cubesat Instrument (HERCI) and has been proposed for a payload on the SLS EM-1 flight. ✺



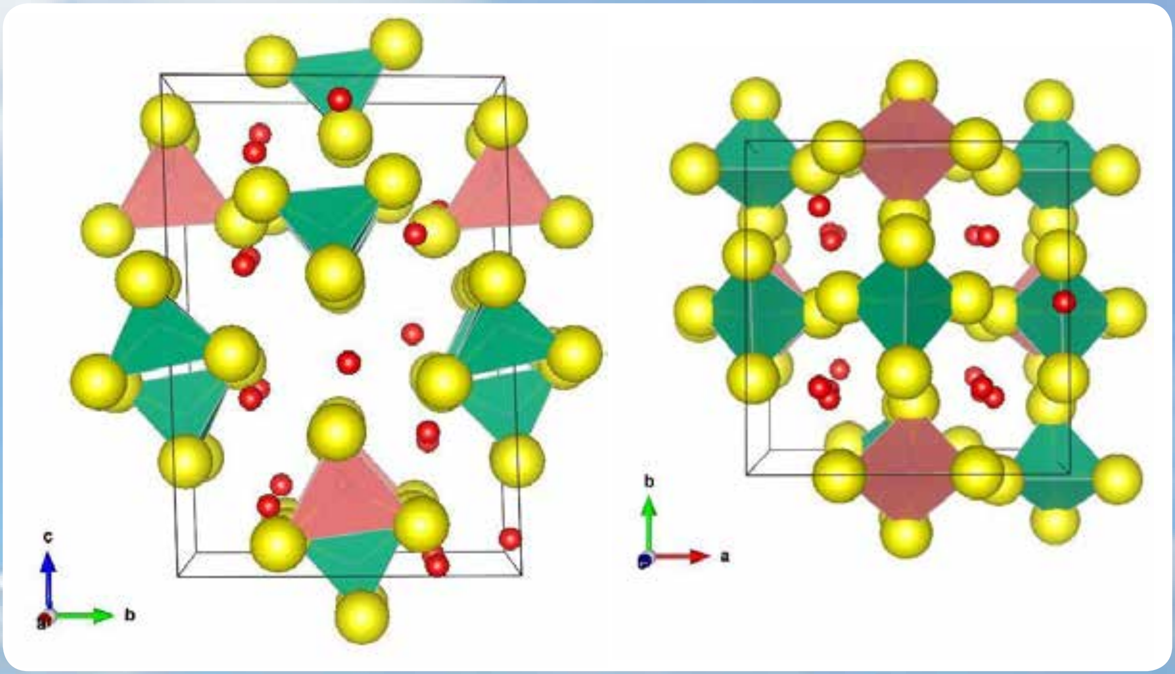
University of Iowa Electrical Engineering student Kevin Klosterman tests the HERCI/FLEXI DPU board.

IA

Next Generation Lithium Sulfur Batteries for Mission Enabling Energy Storage Systems

Iowa State University/NASA Glenn Research Center, Johnson Space Center & Jet Propulsion Laboratory/Human Exploration & Operations Mission Directorate, Space Technology Mission Directorate, Science Mission Directorate

Lithium batteries have enabled tremendous advancements in the use of portable electronics, in the use of hybrid and plug-in electric vehicles, and in the exploration of space. For the latter, their combined light weight and high energy and power densities make them the battery of choice by NASA for many of its space exploration systems and are currently being baselined for a number of upcoming robotic and human missions. However, the demands of space exploration are significantly more critical than those of terrestrial use and NASA continues to seek increases in the energy density that can be stored in and retrieved from its batteries to enable greater capability from its manned and unmanned space exploration systems. NASA also seeks safer batteries that do not suffer from the spontaneous ignition problems of present day lithium-ion batteries and to develop new batteries that have higher current rates so that they can be used in more power intensive applications such as explorer and rover vehicles. Finally, NASA seeks to develop new higher energy density batteries that can significantly extend the Human EVA time, yet at the same time increase the safety of these energy dense power systems to protect its astronauts during use. Specifically, the PIs seek to apply and expand their expertise in solid electrolytes, anodes, and cathodes to build research capacity and competitiveness in Iowa through the study, design, development and characterization of next generation lithium sulfur batteries (LSBs). This effort has enhanced the ongoing collaborations between the PIs, NASA Glenn and JPL, local industrial collaborators, and Iowa educational institutions. ✷



University of Northern Iowa

Iowa State University

Dr. Steve Martin,
Science PI,
Iowa State University

Dr. Vadim Lvovich,
NASA Technical Monitor,
Glenn Research Center

KANSAS

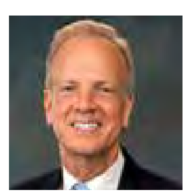
NASA IN KANSAS

The NASA EPSCoR Program helps to develop long-term, self-sustaining, nationally competitive research capabilities and infrastructure in Kansas. State universities, government agencies, and industry work together to establish expertise and new abilities in areas that are important to both NASA and Kansas (e.g., aerospace and related). Project funds competitively support selected investigators who make lasting contributions to Kansas' research infrastructure, academic programs, and economic development. Over the last three years more than a dozen university researchers, twenty-five university students, nine government researchers, and seven companies have been involved in the NASA EPSCoR sponsored efforts. Perhaps most important, significant research infrastructure enhancements in aeronautics, unmanned aircraft related technologies, materials, and astronautics have been established in Kansas. Additional investigator grants, totaling over $2M, have been obtained as a result of the work.

Dr. L. Scott Miller, KS EPSCoR Director, Wichita State University

Grant Hall, the symbol of Fort Leavenworth and headquarters of the U.S. Army Combined Arms Center. It is the oldest active United States Army post west of Washington, D.C.

Kansas TOC



Senator Jerry Moran

Senator Pat Roberts

Representative Mike Pompeo (4th District)

KS

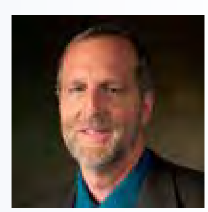
Aeroelastic Modeling Effects and Flight Test Demonstration of Resilient Adaptive Flight Controls on a General Aviation

Wichita State University/NASA Aeronautics Research Mission Directorate

In this project, Wichita State University and Hawker Beechcraft Corporation are investigating resilient aircraft flight control systems that adapt to unanticipated failures occurring during flight. Wichita State University's unique role has been to investigate applying this DOD and NASA technology to general aviation. The investigators of this project have, in prior work, demonstrated the usefulness to general aviation of adaptive flight control methods developed by Calise (dynamic inverse) and by Ferrari and Stengel and Balakrishnan (adaptive critic) through theoretical studies, MATLAB and piloted simulation. Yet, Calise's dynamic inverse flight control methods have only recently been tested in flight in any form on any aircraft – NASA-Ames with promising success on an F-15 in 2006-2007 and a partial test by Wichita State University in early 2007. This project significantly expands the general aviation research into a full flight test demonstration of Calise's methods on the Hawker Beechcraft Corporation CJ-144 NASA SATS fly-by-wire testbed, and an exploration of the real-time capabilities of Balakrishnan's adaptive critic methods. This project addresses the following topics in the Integrated Resilient Aircraft Control project of the NASA Aviation Safety Program within the NASA Aeronautics Research Mission Directorate; IRAC-1.1: Adaptive Control Methods and IRAC-1.5: Flight Validation of Metrics-Driven Adaptive Control, and an additional task 6) addresses VSST1-8 project topic: Integrated Flight Safety Assurance under Multiple LOC Precursor Conditions. ✺

Goodflight, LLC, Georg Schirmer CEO and AE MS and PhD student who was associated with this project in a general way, won $14,000 in startup funding from the WSU Ventures "Shock Tank" new ventures competition for his pilot training ios and android app development and commercialization.

Wichita State doctoral graduate Georg Schirmer shows student Kiran Rajaram a flight-tracking application for smartphones called "CFItrack."



Dr. Nhan Nguyen,
NASA Technical Monitor,
Ames Research Center

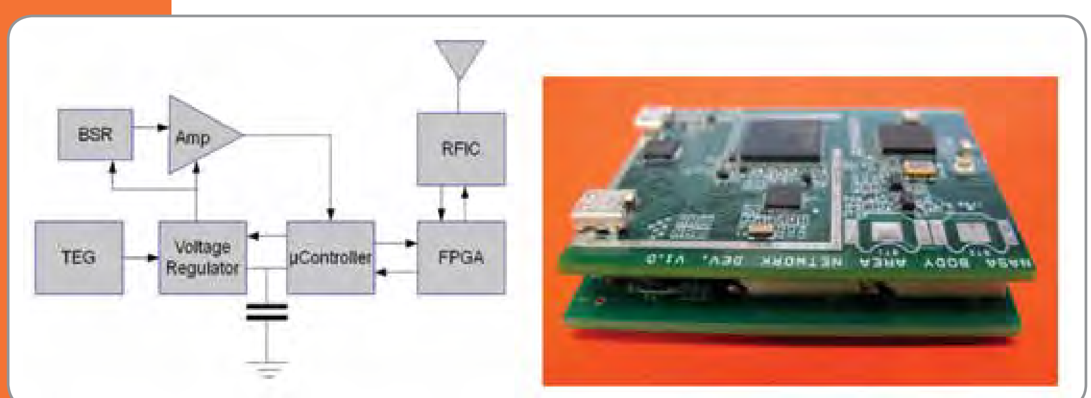
Dr. James Edward Steck,
Science PI,
Wichita State University

Biosensor Networks and Telecommunication Subsystems for Long-Duration Missions, EVA Suits, and Robotic Precursor Scout Missions

Kansas State University/NASA Jet Propulsion Laboratory, Human Exploration & Operations Mission Directorate

This project focuses on bio-medical technologies applicable to NASA's human spaceflight research program (coordinated with Johnson Space Center in Houston TX) and on wireless telecommunications technologies suitable for a variety of mission scenarios (interfacing with NASA/JPL and with private industry in the state of Kansas). The primary objectives are to improve astronaut safety and extravehicular activity efficiencies in future lunar, asteroid, and planetary exploration by understanding the body's responses to the on-set of physical fatigue, and to develop new electronics capable of sensing and communicating the astronaut's condition. These technologies include wearable bio-sensors and low-power wireless networks – research areas with broad application both within and outside the space program. Research into radio-wave propagation and energy harvesting also played a key role in the designs and prototype demonstrations completed during the project. The EPSCoR grant under which this research was funded has helped to support and educate over 20 graduate students and 16 undergraduate students in key science, technology, and engineering methods they will use throughout their future careers. During the three year performance period, the spaceflight theme on which the research vision was centered has motivated students, teachers, and the general public alike, and resulted in extensive technical publications and presentations as well as print, web, and television coverage. ✺

Kansas State University students performing Kinesiology-focused research on fatigue assessment and prediction. Predicting fatigue can allow EVA activities to be re-ordered to maximize astronaut work efficiencies when outside their planetary habitat.



Prototype biosensor electronics developed at K-State, including thermal energy-harvesting power source and associated radio and antenna. Energy harvesting replaces the need for batteries within a space suit, which could be dangerous because of the oxygen-rich suit atmosphere.

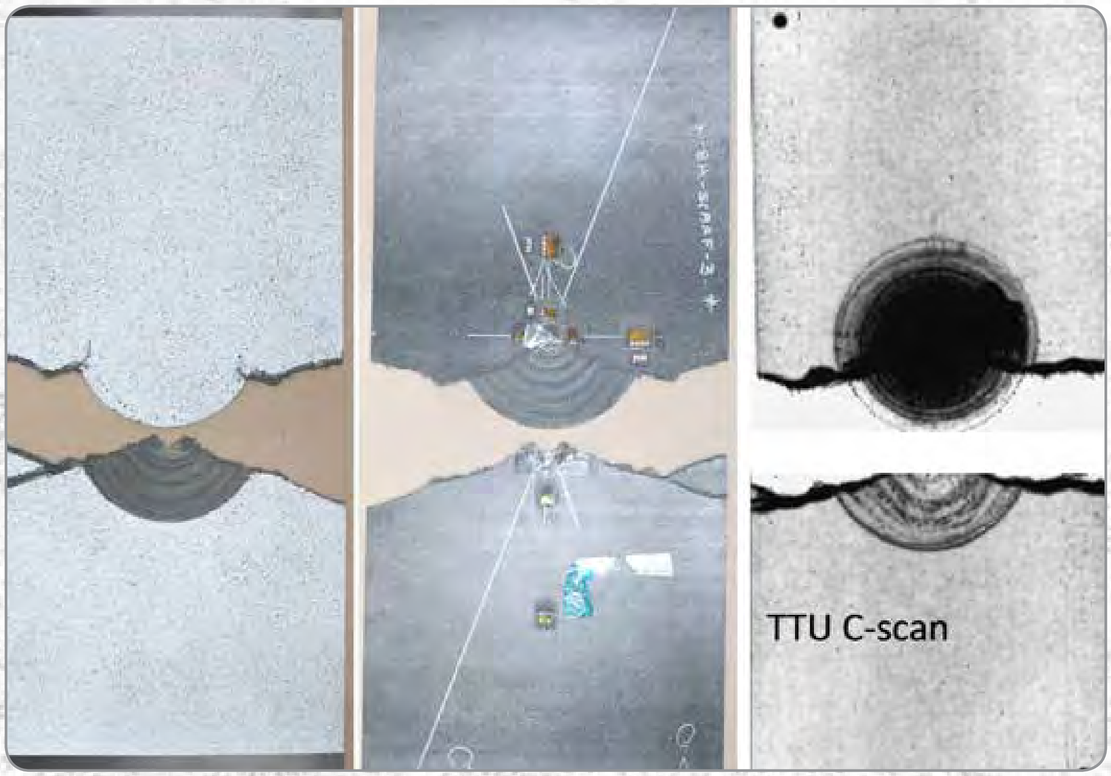
William Kuhn, Science PI, Kansas State University

Dr. Norman Lay, NASA Technical Monitor, Jet Propulsion Laboratory

Cure Management for Bonded Composite Repair

Wichita State University/NASA Human Exploration and Operation Mission Directorate

Bonded composite patch repairs are widely employed to repair flaws/damage resulting from manufacturing processes, fatigue, impact loading, etc., in metallic as well as composite structures. The repair process involves the removal of the flawed or damaged region from the parent structure, followed by surface preparation and bonding of the repair patch. The heat for curing the patch is typically applied using a heating pad which is controlled based on feedback from one or more surface mounted thermocouples. The temperature measurements on the surface of the parent structure and/or the repair patch do not accurately represent the temperature prevailing at the bondline or interior plies. The relatively poor thermal conductivity of the uncured prepreg coupled with heat losses due to conduction through adjoining structure (e.g., parent laminate, core, frames, etc.), convection and radiation to the surrounding ambience, results in spatial variation of temperature within the repair patch and the adhesive layer. Therefore, the repair patch and adhesive bondline may be under-cured and could be detrimental to the performance of the repaired structure under service loading. In spite of the availability of out-of-autoclave prepreg materials which are suited for field repair, the tight tolerances on the repair process often result in rejection of repairs and no mechanisms exist for mapping the temperature measurements to the mechanical properties of the adhesive bondline and the repair plies. In this program, several aspects of the repair process were investigated to integrate a 'cure management system' to control the repair process and assign a quality index to the repair patch. The activities were carried out as a multi-institution effort involving Wichita State University (WSU), Kansas State University (KSU) and University of Kansas (KU). A new cure management approach has been investigated and implemented for bonded composite repair in an effort to alleviate the risks associated with current repair practices and to improve the accuracy of post cure repair assessment. ✺



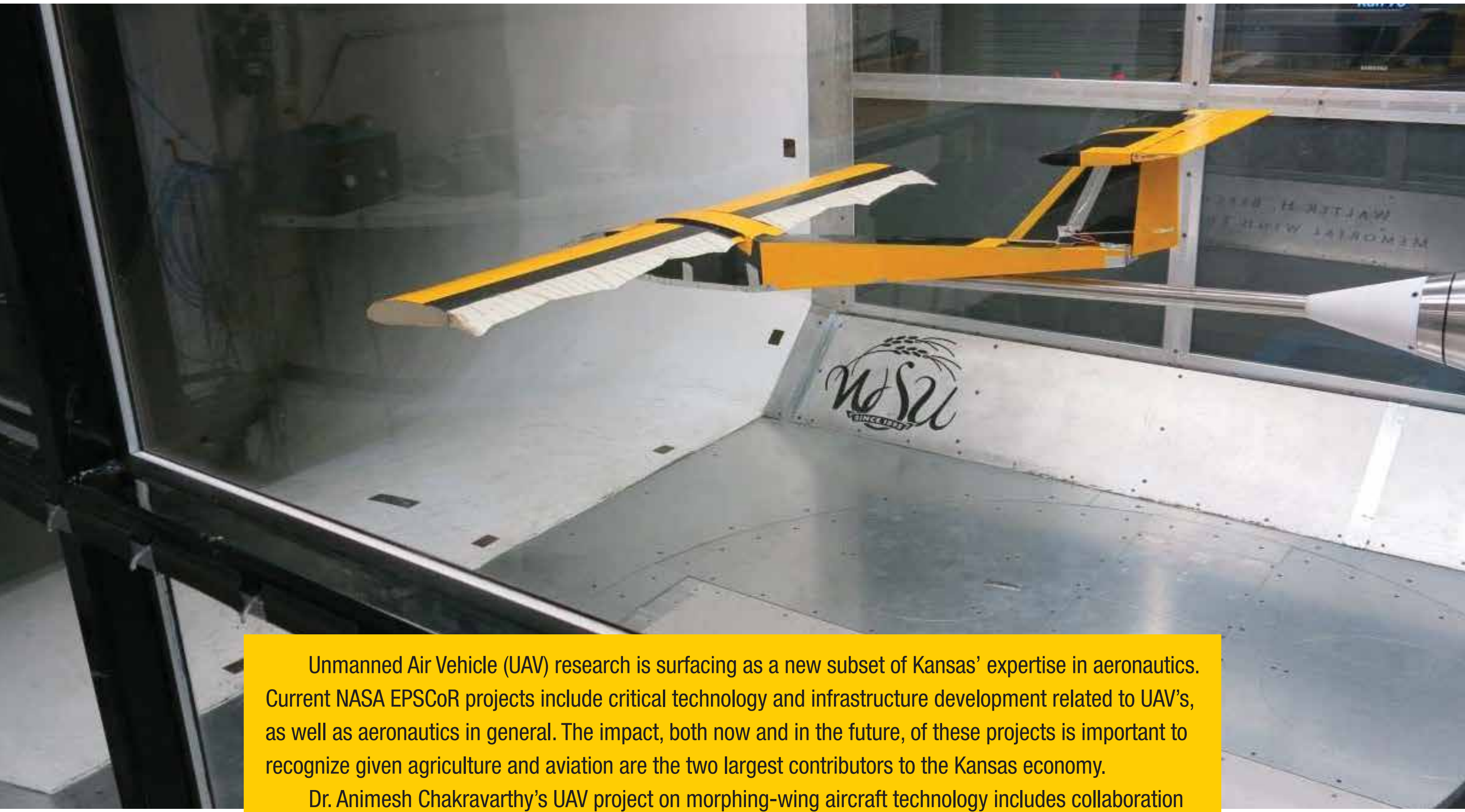
➤ Pictures and TTU C-scan image of failed test panel #1.

Dr. Bob Minaie and Dr. S. Keshavanarayana,
Science PI's, Wichita State University

Sarah Cox,
NASA Technical Monitor,
Kennedy Space Center, STMD

Kansas Research Infrastructure Development

Wichita State University



➤ *Morphing-wing UAV in the WSU 7x10-foot wind tunnel.*

Unmanned Air Vehicle (UAV) research is surfacing as a new subset of Kansas' expertise in aeronautics. Current NASA EPSCoR projects include critical technology and infrastructure development related to UAV's, as well as aeronautics in general. The impact, both now and in the future, of these projects is important to recognize given agriculture and aviation are the two largest contributors to the Kansas economy.

Dr. Animesh Chakravarthy's UAV project on morphing-wing aircraft technology includes collaboration with NASA, Beechcraft, and Boeing. The work is contributing to next-generation aircraft control methodologies, with Technology Readiness Level 6 systems, and includes a prototype UAV demonstration.

A five-foot span morphing UAV model, that shares several features with NASA's Variable Continuous Camber Trailing Edge and Flaps (VCCTEF) morphing aircraft design, has been designed and built. Uniquely, the UAV has an adjustable wing shape capability.

The UAV's wing incorporates a flexible aft portion covered by a latex membrane. Placed within the flexible portion of the wing (i.e., under the latex surface) are ten equally spaced servo-actuators, each capable changing the wing's trailing edge shape. A simple microcontroller is used to monitor and control the shape to yield improved aircraft performance over a wide range of flight conditions.

The prototype UAV was recently tested in the Wichita State University 7x10-foot wind tunnel. A first flight and continued testing is planned as the research progresses. Along with developing the related infrastructure, systems, and collaborations there is strong potential for related patents.

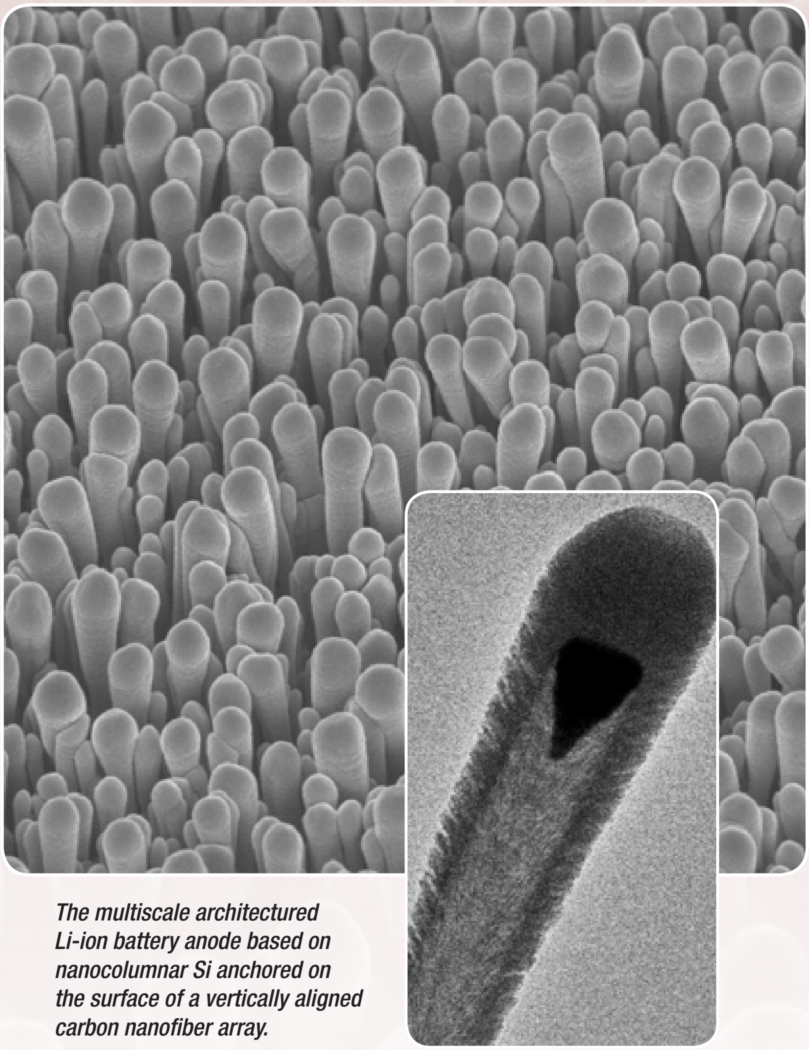
Interestingly, due in large part to his EPSCoR work, Dr. Chakravarthy recently received a National Science Foundation CAREER award. This prestigious award will allow Kansas to further establish and strengthen its expertise in aeronautics. ✺

Wichita State University

KS

Nanostructured Solid-State Energy Storage Devices for Wide-Temperature Applications in Space Exploration

Wichita State University/NASA Ames Research Center, Human Exploration & Operations Mission Directorate, Space Technology Mission Directorate



The multiscale architectured Li-ion battery anode based on nanocolumnar Si anchored on the surface of a vertically aligned carbon nanofiber array.

A multiscale hierarchical lithium-ion battery (LIB) anode composed of Si shells coaxially coated on vertically aligned carbon nanofibers (VACNFs) has been explored. A high Li storage capacity of ~3,000-3,500 mAh (gSi)-1 and 99.8% Coulombic efficiency have been obtained. Remarkable stability over 500 charge-discharge cycles have been demonstrated. Particularly, this electrode presents a high-rate capability that the capacity remains within ~7% as the C-rate is increased by 80 times from ~C/10 to ~8C. Electron microscopy, Raman spectroscopy and electrochemical impedance spectroscopy revealed that the electrode structure remains stable during long cycling. This high-rate property has been attributed to the unique nanocolumnar structure of Si in the shell. It reveals an exciting potential to develop high-performance LIBs by improving the electron and ion transport across solid electrode materials through the multiscale architecture hybrid materials. See the article by S. Klankowski et al in *J. Power Sources* (http://dx.doi.org/10.1016/j.jpowsour.2014.11.094). ✺

Meyya Meyyappan, Ph.D,
NASA Technical Monitor,
Ames Research Center, STMD

Dr. Jun Li,
Science PI,
Wichita State University

Wichita State University

Active Wing Shaping Control for Morphing Aircraft

Wichita State University/NASA Ames Research Center, Aeronautics Research Mission Directorate

This EPSCoR-funded project will be to design, develop and test certifiable control laws for active wing shaping of the Variable Camber Continuous Trailing Edge Flap (VCCTEF) aircraft. This morphing aircraft has been conceptualized by NASA and is a high priority for the NASA ARMD Fixed Wing Project.

The VCCTEF's control laws are of increased complexity. To achieve enhanced performance (higher lift-to-drag ratio) on a traditional flight path, the aircraft's active wing shaping control will sense and, in real time, continuously adjust the camber across multiple sections of the wings for optimal performance in every flight condition.

The research tasks outlined in this proposal are:

(1) Development of certifiable adaptive decentralized control laws for active wing shaping,

(2) Optimal number and placement of sensors on the wing to measure the wing shape,

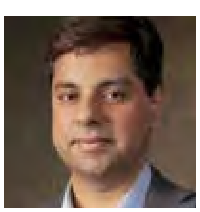
(3) Distributed sensing system for real-time wing shape monitoring and feedback of the wing shape to the control laws, and

(4) Development of a testbed morphing UAV for testing the wing shaping control laws in the wind tunnel and in flight.

Morphing and the use of low-weight elastic aircraft is an enabling technology that could lead to reduced drag, less fuel consumption and, thus, more affordable and greener air transportation.

Broader impacts of the proposed research include helping establish the Kansas and Missouri aviation industry as global leaders in morphing control technology on civil aviation aircraft, and contributing to the development of a technologically-advanced workforce by educating Kansas and Missouri students in advanced nonlinear robust flight control systems and morphing aircraft. ✷

The focal point for UAS flight research is the Garrison Flight Research Center (GFRC), located at the Lawrence Airport, 15 minutes from main campus.



Dr. Animesh Chakravarthy, Science PI, Wichita State University

WICHITA STATE UNIVERSITY

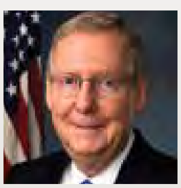
Dr. Nhan T. Nguyen, NASA Technical Monitor, NASA Ames Research Center

Ames Research Center (ARC), commonly known as NASA Ames, is a major NASA research center at Moffett Federal Airfield in California's Silicon Valley.

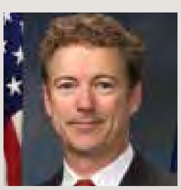
KENTUCKY

Dr. Suzanne Weaver Smith, KY NASA EPSCoR Director, University of Kentucky

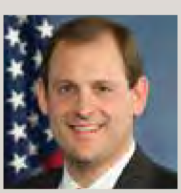
The NASA Kentucky EPSCoR program provides research awards statewide through competitive research initiation startup grants, workshop/conference organization awards, and travel support for faculty to meet with NASA researchers and establish collaboration. Kentucky research specialties include biomedical, materials, energy and space technology, as well as astronomy, space science, environmental science and remote sensing. Early-career faculty are a specific focus of the NASA Kentucky programs, with critical investment at key times for young researchers to help build their careers, expand research capacity and initiate productive national and international professional relationships. Results of these efforts are seen for faculty and their students when researchers funded by NASA Kentucky find follow on success with nationally competitive proposal awards, such as the NASA EPSCoR Research Awards or NSF CAREER Awards, publications and professional recognition. These research investments benefit the state as a whole as well as the universities and their industry partners, supporting essential work that drives innovation forward at NASA and advances technology-based industries in Kentucky.



Senator Mitch McConnell



Senator Rand Paul



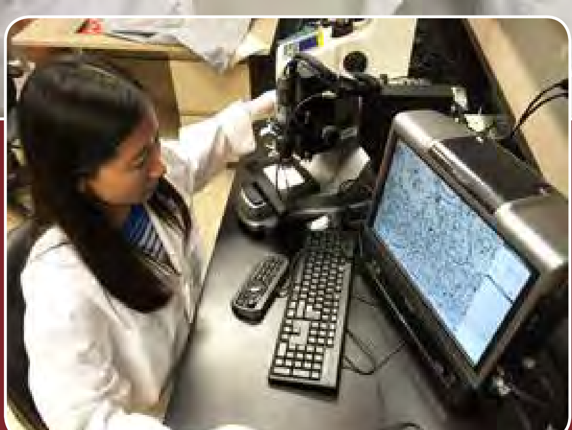
Representative Andy Barr (6th District)

Kentucky TOC

Memorial Hall on the University of Kentucky campus.

Shape Memory Alloys for High Temperature and Surface Morphing Applications in the Aerospace Industry

University of Kentucky/NASA Glenn Research Center, Aeronautics Research Mission Directorate



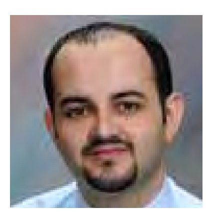
Top: University of Kentucky PhD candidates Sayed Saghaian and Peizhen Li use Dynamic Mechanical Analysis (DMA) equipment to perform testing of Nickel powder mixed with polymer.

Bottom: University of Kentucky PhD candidate Peizhen Li uses a digital microscope to analyze Nickel-Titanium shape-memory alloy samples.

Demand for aircraft with better fuel efficiency, lower emissions and quieter operation continues to grow. University of Kentucky faculty and graduate students along with industry partners and NASA researchers are collaborating to develop advanced high-temperature shape memory alloys (SMAs) that will enable better, "greener," and more versatile air vehicles in response to a crossagency initiative called the Next Generation Air Transportation System (NextGen). SMAs have the ability to change shape depending on applied temperature, stress or magnetic field, representing an important new class of materials that offers increased versatility and drag reduction compared to today's aircraft that have fixed aerodynamic surfaces and structures.

The primary goal of this research is to bridge the gap between the astonishing properties of SMAs and the challenging requirements of the aerospace industry. This research is also strongly aligned with one of Kentucky's five priority research areas: Materials and Advanced Manufacturing.

Research conducted for this project, both in Kentucky as well as at NASA Glenn Research Center, has actively pursued SMAs with higher transformation temperatures and strength than previously developed. Dozens of alloys were investigated for performance characteristics suitable for application in the aerospace industry, resulting in many joint publications and conference presentations. This project has built the infrastructure to further characterize and research SMAs at the University of Kentucky, leading to additional shape memory alloy study. ✺



Dr. Haluk Ersin Karaca, Science PI, University of Kentucky

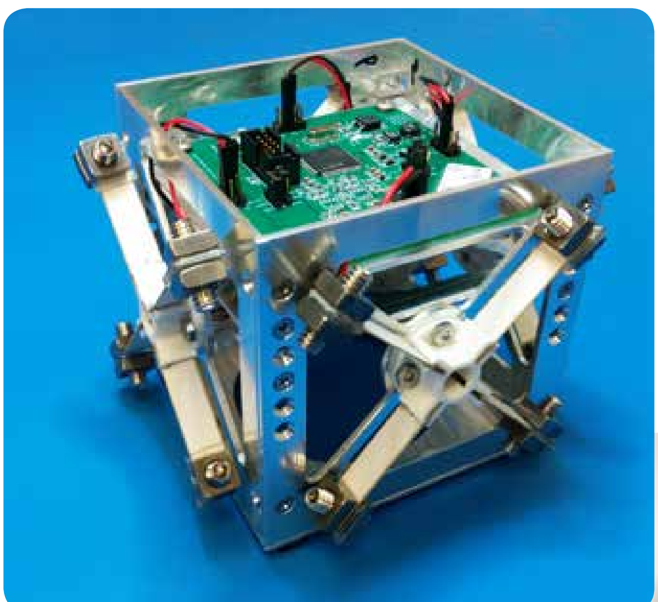
Dr. Ronald Noebe, NASA Technical Monitor, Kennedy Space Center

Kentucky Research Infrastructure Development

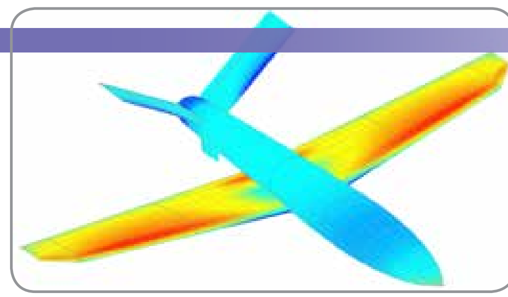
Dr. Marcelo Guzman leads an award-winning research laboratory at the University of Kentucky, benefiting from two successive NASA Kentucky EPSCoR Research Infrastructure Development Grants to initiate projects in atmospheric science.

Two of Dr. Guzman's graduate students recently won national awards. PhD candidate Liz Pillar received the Outstanding Student Paper Award in the Atmospheric Sciences Section of the American Geophysical Union Fall 2013 conference for her work on the chemistry of ozone. PhD candidate Alexis Eugene received the Graduate Student Award from the American Chemical Society Environmental Chemistry Division in 2014 recognizing her research productivity investigating the formation of atmospheric aerosols. The National Science Foundation recently recognized Dr. Guzman himself with a CAREER award for his exceptional work as an early-career faculty member in the UK Department of Chemistry.

Dr. Guzman, along with students Pillar and Eugene, utilized NASA Kentucky Space Grant support to attend a high-altitude scientific ballooning workshop at NASA Marshall Space Flight Center in early 2015 and have now incorporated scientific ballooning into the lab's research assets, providing lab scientists the capability to select instrumentation, gather sensor data directly, and formulate studies specifically to local areas. Dr. Guzman also established a partnership with faculty in the Environmental Science Technology program of nearby Bluegrass Community and Technical College to share resources and expertise related to scientific ballooning and atmospheric chemistry. ✺



University of Kentucky researchers developed an attitude control system for nanosatellites, using piezoelectric reaction beams to generate internal torques. A prototype CubeSat actuation system was developed and single-axis attitude control was demonstrated.



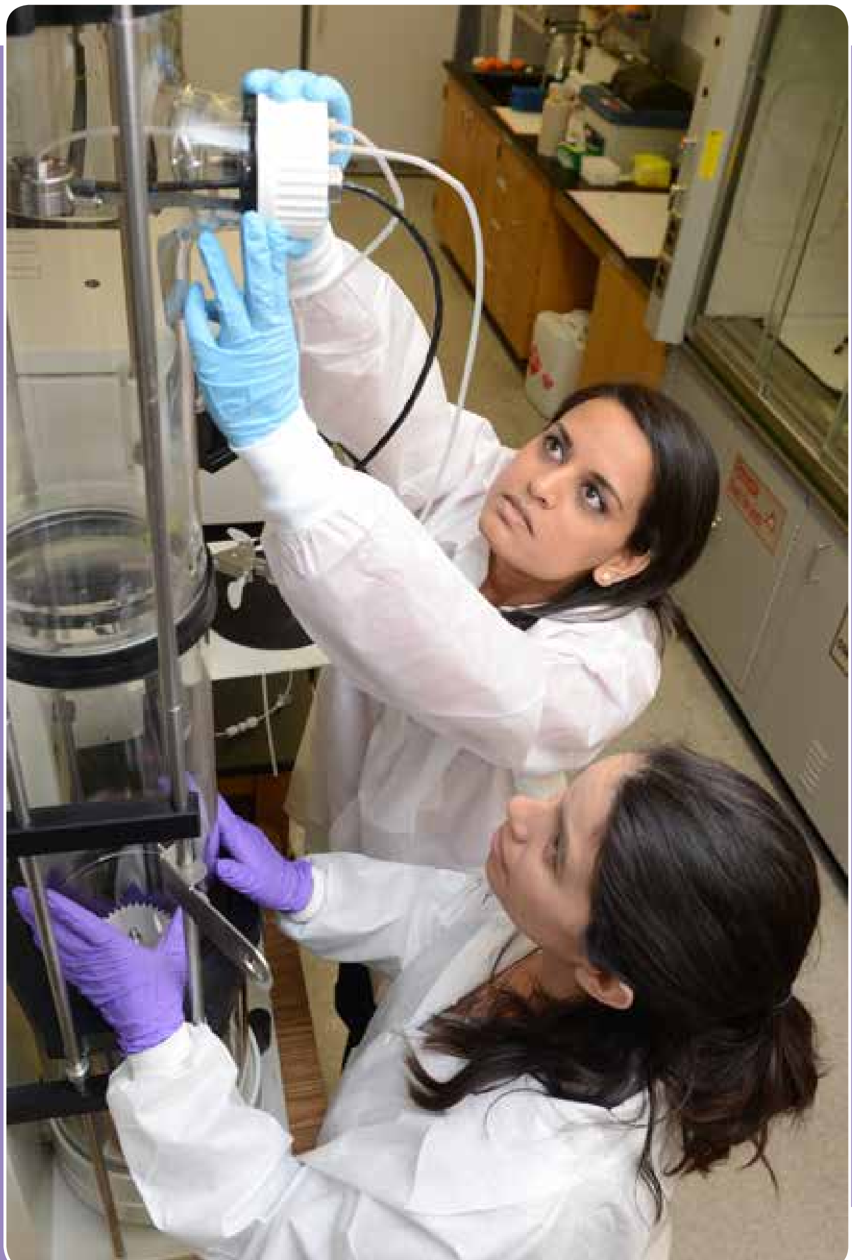
Aerodynamic simulation results for the first generation of BLUECAT aircraft. BLUECAT is an acronym for Boundary Layer Unmanned Experiment for Characterizing Atmospheric Turbulence, and is a project at the University of Kentucky which utilizes UAS aircraft to conduct measurements of atmospheric turbulence near the ground.

PhD candidate Liz Pillar performs analysis of atmospheric chemistry experiments at the University of Kentucky. The American Geophysical Union has acknowledged Pillar's research with their Outstanding Student Paper Award.

KY

A Paradigm-Shifting Therapy for Mitigating Cellular and Tissue Damage in Humans Exposed to Radiation

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



Dr. Patricia Soucy, Primary Science Investigator, Assistant Professor, and graduate student Ishita Jain of the University of Louisville use a Spray Dryer to prepare nanoparticles for a NASA EPSCoR research project investigating new therapies to treat human exposure to radiation, such as the exposure astronauts may experience during long-term space travel.

The impact of the NASA EPSCoR research investments in Kentucky is substantial and increasing each year to benefit NASA and to increase Kentucky's research competitiveness. Since 2007, Kentucky has received seven EPSCoR Research Awards involving 5 Kentucky academic institutions (including Kentucky's only MSI) and 5 Kentucky plus 2 US industry partners. Investment in over half a million dollars of equipment has added to Kentucky's research infrastructure, with more than $6.5M in reported follow-on-funding. Researchers at 6 NASA centers and 1 additional US federal agency (DoE) are partners in the research efforts which are delivering results for NASA's human spaceflight, ISS microgravity research and aeronautics missions, along with building research infrastructure, industry and faculty expertise.

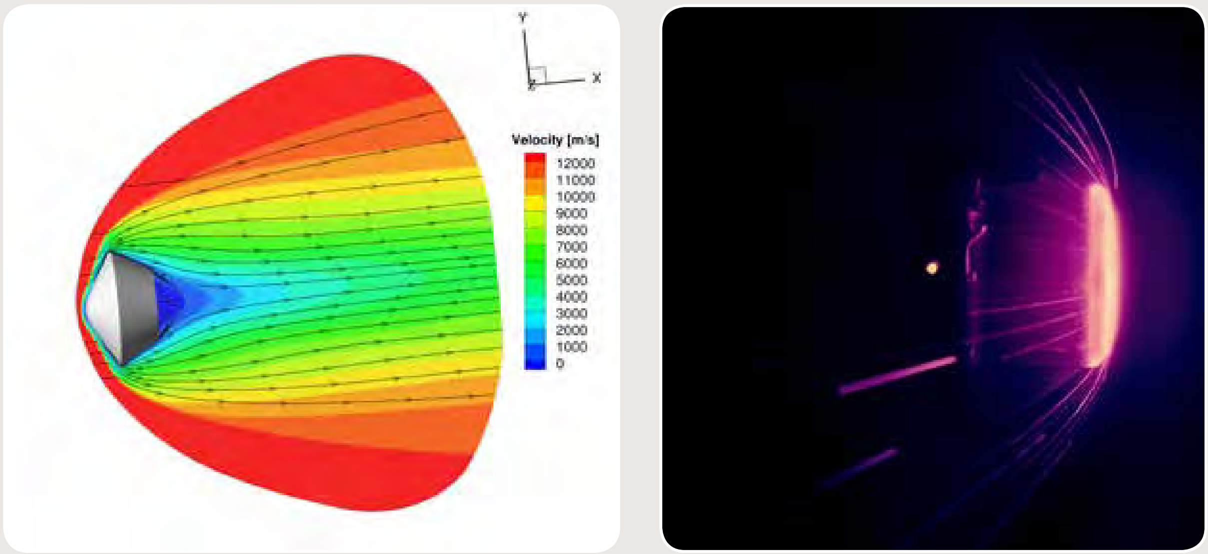
Major research accomplishments for year two of this grant include production and characterization of the 3 drug delivery vehicles for the different antioxidants proposed. Developments from this grant have been presented at local, regional, and national conferences throughout the past year. This work was presented at NASA's HRP workshop in February 2014 and has been invited back for another oral presentation in 2015. Other conference presentations include Biomedical Engineering Society (October 2014), Southeastern Regional Meeting of American Chemical Society (October 2014), as well as research presentations at local meetings within the University of Louisville. In addition, there are 3 papers in preparation that are expected to be submitted by the end of the year. ✺

UNIVERSITY OF LOUISVILLE.

Dr. Thomas Goodwin, Ph.D, NASA Technical Monitor, Johnson Space Center

Improving Heat Shields for Atmospheric Entry: Numerical and Experimental Investigations for Modeling Ablative Thermal Protection System Surface Degradation Effects on Near-Wall Flow

HEOMD, SMD, STMD/LaRC, GSFC, MSFC, ARC, JSC, University of Kentucky and Kentucky State University

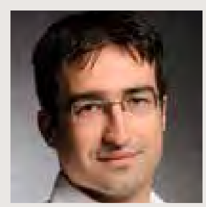


University of Kentucky heat shield researchers modeled atmospheric re-entry and material response characteristics of the Stardust Return Sample Capsule, a NASA spacecraft that returned samples from comet Wild 2 to Earth after a seven-year mission. The re-entry of Stardust is to this day the fastest man-made object to ever enter Earth's atmosphere, at roughly 12 km/s. Credit: Huaibao Zhang and Alexandre Martin

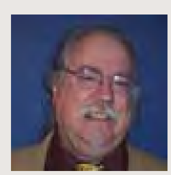
Research is underway at two Kentucky universities to study and improve the performance of heat shield materials that enable spacecraft to survive extreme temperatures of atmospheric entry. The project titled Improving Heat Shields for Atmospheric Entry: Numerical and Experimental tInvestigations for Modeling Ablative Thermal Protection System Surface Degradation Effects on Near-Wall Flow is uncovering knowledge of fluid dynamics needed to advance technology of thermal protection systems, also known as heat shields, for spacecraft that travel from Earth and enter the atmosphere of other planets, like Mars, or that go to space and return to Earth, such as astronaut crew vehicles.

This project uses an approach of numerical modeling combined with experimentation to develop computer simulation capability that is optimized and validated with heat shield performance measurements conducted under simulated atmospheric entry conditions in a high-temperature arc-jet facility. Researchers at the University of Kentucky and Kentucky State University collaborating with multiple NASA Centers (Ames, Langley, and Johnson) have conducted test campaigns with the NASA Langley HYMETS (Hypersonic Materials Environmental Test System) arc-jet facility in which FiberForm heat shield materials were subjected to high temperature heat flux in a Mach 5 airflow. Multiple journal and conference publications have resulted.

The material response (MR) code developed as part of this project is being used to investigate NASA test articles and performance of full-scale thermal protection systems, including for NASA's new crew vehicle Orion. GPU-processing techniques developed to run the code are advancing computer science programs at both participating Kentucky universities. Kentucky students who have completed or are on track to complete bachelor and graduate degrees have benefitted from technical skills gained in this research program and opportunities to conduct unique research in-state as well as at NASA facilities, such as Ames Research Center in California's Silicon Valley. ✺



Dr. Alexandre Martin, Science PI



Dr. David J. Chato, NASA Technical Monitor

Influence of Gravity on Electrokinetic and Electrochemical Colloidal Self-Assembly for Future Materials

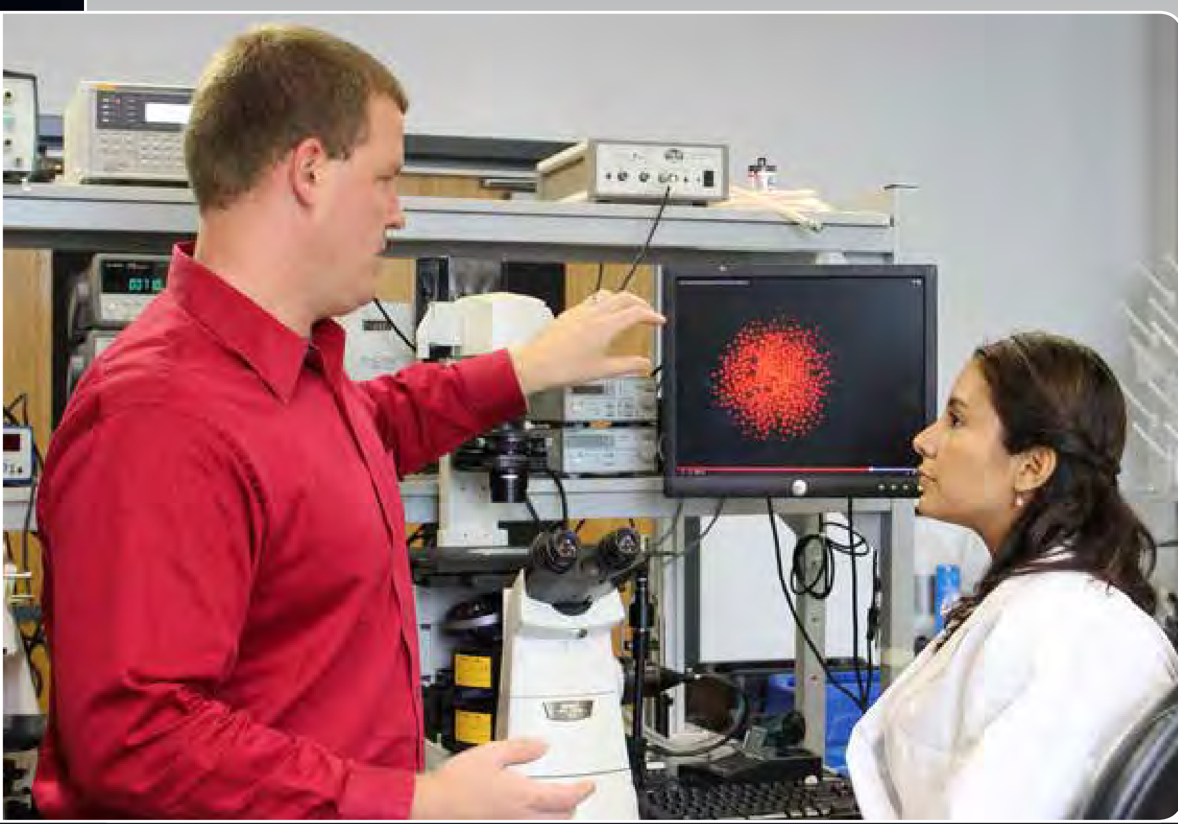
KY

University of Louisville/Western Kentucky University/NASA Glenn Research Center, Marshall Space Flight Center, Human Exploration & Operations and Space Technology Mission Directorates

Early in this project, Kentucky researchers creating microfluidic experiments for the International Space Station received an opportunity to send experiments to space. The team from the University of Louisville and Western Kentucky University quickly prepared experimental samples that were delivered to NASA Glenn Research Center. Those samples now await a ride to orbit on an ISS re-supply mission later this year and will provide initial results to guide associated research tasks for control experiments on the ground in labs at UofL and WKU.

This project is designed to investigate the fundamental physics of colloids – liquids like milk that contain suspended particles – by isolating them from the force of gravity on Earth. Understanding how to precisely control colloids will result in the development of materials with enhanced energy, thermal, optical, chemical, and mechanical properties.

New equipment acquired for this research complements existing infrastructure at the U of L Micro/Nano Technology Center, providing specialized multidisciplinary laboratory tools for Kentucky researchers and regional industrial partners who can also benefit from this research aligned with the Kentucky Science & Innovation Strategy. With partners including a space industry startup and a multinational corporation interested in their work, this research team is positioned to take advantage of the unique opportunity to conduct experiments in the microgravity environment onboard the ISS National Laboratory. ✺



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

UNIVERSITY OF LOUISVILLE.

WKU

Researchers at the University of Louisville and Western Kentucky University are developing specialized fluid experiments for the International Space Station. Research of colloids onboard ISS offers the potential for development of more efficient solar-electric propulsion and lighter, stronger aerospace materials. Dr. Stuart Joseph Williams, Science PI, University of Louisville and PhD candidate Vanessa Velasco in photo above.

CubeLab Standard for Improved Access to the International Space Station for Scientific Payloads

University of Kentucky, Moorehead State University/NASA Ames Research Center

The design and development of the CubeLab Bus is complete. Several versions of the enclosure and connectors have been tested and a final design supporting floating Universal Serial Bus (USB) connectors and mount points for NASA Ames Payloads has been designed. Thermal analysis and testing has been performed and models have been produced with 3D printers and have been machined in aluminum. Several iterations of the electronics have been developed and tested, with the Command and Data Handling (C&DH) components and software libraries and the External Power Supply (EPS) subsystem evolving to a very mature design. The mission control software has been tested and software for mission scripting and commanding have been developed and tested. Finally, a fully Space Plug-and-Play Architecture (SPA)-1-compliant Applique Sensor Interface Module (ASIM) has been tested with the CubeLab Bus. The bus will support a wide variety of mission profiles and is ready for integration with payloads.

Infrastructure was established at the University of Kentucky consisting of test equipment and procedures that were used to flight qualify several payloads flown to the ISS in the CubeSat form-factor. Currently a CubeSat is being qualified for delivery to the ISS for launch under the NASA EPSCoR ISS Flight Opportunity program.

Several technologies that were developed as part of the CubeLab Bus design are being adapted to small satellites. The battery charging technologies developed for the CubeLab is being adapted into a generic modular EPS system for small satellites. Also, the communications libraries developed to interface with the Ames payload are being leveraged for communications and data handling on two CubeSats that flew in 2013 (KySat-2 and Trailblazer) to demonstrate control and data transfer from a novel stellar gyroscope and flight demonstrations of the US Air Force Space Plug-and-Play Architecture (SPA).

Dr. James Lumpp, University of Kentucky professor, led the UK College of Engineering Space Systems Lab in design and implementation of the CubeLab Bus for standardized lab access to the International Space Station. This project utilized a ground operations station at UK, pictured here, with live video and communications links to ISS.

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

Douglas Gruendel, Ph.D.,
NASA Technical Monitor,
Kennedy Space Center

ISS Flight Op - Validation of a CubeSat Stellar Gyroscope System

KY

University of Kentucky/NASA Johnson and Kennedy Space Center/Human Exploration and Operations and Space Technology Mission Directorates

Researchers at the University of Kentucky have developed a method to control the orientation of a satellite in space using an onboard visual gyroscope system that captures images of stars. Integrated into a small satellite called a CubeSat, the gyroscope system has a camera that images the background star field from the satellite's position and then estimates the satellite's orientation based on the relative motion of stars between successive images. The advantage of this approach, once demonstrated, is the potential for lower-cost attitude determination and control systems for all small satellites with limited computing and power resources. The University of Kentucky Space Systems Lab will test their stellar gyroscope system in low-Earth orbit as a follow-on project to the Kentucky Space, UK, and Morehead State University KySat-2 CubeSat launched in 2013 as part of the ELaNa IV mission. A student and faculty team at UK will upgrade an existing CubeSat built for the KySat-2 project and, along with their NASA partners, prepare it for launch into orbital trajectory from the International Space Station. This project gives researchers in the University of Kentucky College of Engineering access to space to test their concepts and hardware, while also providing UK students firsthand experience with spacecraft testing and operations. ✷

University of Kentucky students Timothy Lim and Zachary Porter perform subsystem upgrade testing for a CubeSat that will be launched into orbit from the International Space Station to test an experimental stellar gyroscope method for small spacecraft attitude determination developed by the UK Space Systems Lab.

UK UNIVERSITY OF KENTUCKY

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

Steve Huning,
NASA ISS RIM,
Johnson Space Center

LOUISIANA

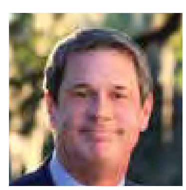
LOUISIANA NASA EPSCoR

Louisiana participates in all of the agency EPSCoR programs and is committed to enhancing its R & D capacity both for educational and economic development. Louisiana has a long history of involvement with the NASA space program including use of the Michoud Assembly Facility in New Orleans for fabrication of the Apollo Saturn V, the Shuttle External Tank, and now Orion and SLS. The NASA EPSCoR program enables Louisiana to foster development of academic / government / industry partnerships directed toward nationally-competitive capabilities in aerospace related research, further the education of students to develop the next generation workforce, and foster new infrastructure with the potential to contribute to state economic development goals. NASA EPSCoR is funding a wide array of Louisiana research projects in these areas: Astrophysics, Self-Healing Composites, Aircraft Safety, Genetic Assessment, Human-Machine Interface, Advanced Sensors and Combustion, Biotechnology with Nanoparticles, Energy Storage, Advanced Materials, and Additive Manufacturing.

Greg Guzik,
LA EPSCoR Director,
Louisiana State University

Louisiana TOC

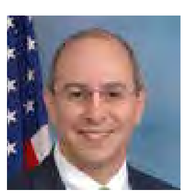
Senator
Bill Cassidy



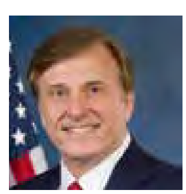
Senator
David Vitter

Representative
Steve Scalise
(1st District)

Representative
Cedric Richmond
(2nd District)



Representative
Charles Boustany Jr.
(3rd District)



Representative
John Fleming
(4th District)

Representative
Ralph Abraham
(5th District)

Representative
Garret Graves
(6th District)

Bio-Mimetic Self-Healing Composite Sandwich for Impact Tolerant NextGen Aerospace Structures (Self-Healing Structures)

Louisiana State University/Southern University/NASA DRC, Aeronautics Research Mission Directorate

LA

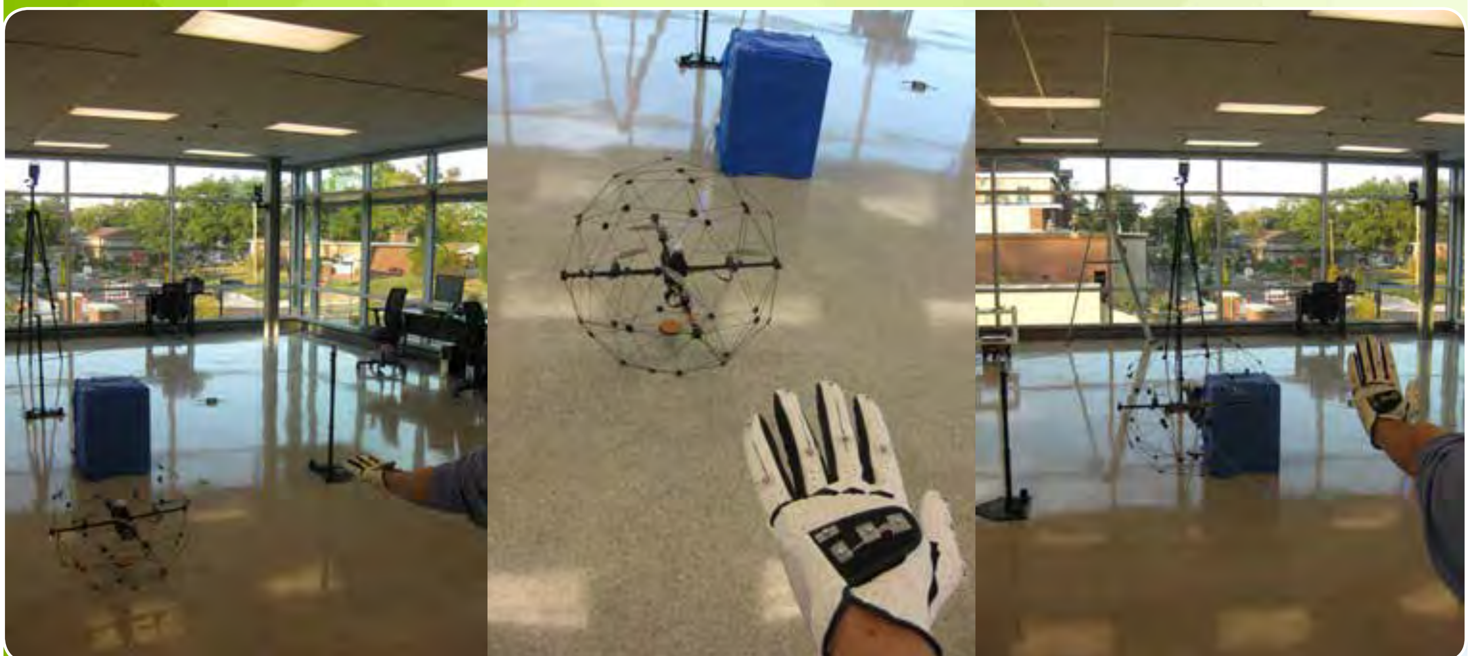
Dr. Guoqiang Li,
Science PI,
Louisiana State University

Sarah Cox,
NASA Technical Monitor,
Kennedy Space Center, STMD

Mr. Ukeamezhim Ayaugbokor, a M.S. student at Southern University Mechanical Engineering and participant of this project, is preparing his DSC test of a SMP in LSU Composite Materials and Structures Lab.

In the last year of the project, several advancements have been made, including (1) A multi-mechanism phenomenological model is developed within the finite deformation framework for capturing the thermomechanical behavior of shape memory polymers (SMPs) both during programming and in service. Particularly, the damage mechanisms in SMPs, including mechanical damage and functional damage, are studied within the continuum damage mechanics framework. Statistical mechanics is incorporated to describe the initiation and saturation of these damage mechanisms. The main advantage of the model, compared to the existing counterparts, is its simplicity by minimizing the need for curve fitting, and capability in simulating the non-linear stress-strain behavior of SMPs with various morphologies. (2) A new healing-on-demand composite made of fishing-line artificial muscle, thermoset matrix, and thermoplastic healing agent, was fabricated and tested. The artificial muscles were arranged in either unidirectional or orthogrid pattern. Repeated fracture/healing cycles by low velocity impact and/or three-point bending of beam specimens were conducted. It is found that artificial muscles can achieve a healing efficiency as high as 100% with a volume fraction as low as 3.5%. It is also found that the muscles behave similarly to SMP fibers in terms of closing wide-opened cracks, but are stronger and stiffer, respond faster with larger actuation force, and cost less. (3) A computationally efficient phenomenological constitutive model is developed for polymeric muscles made of fishing-lines or sewing threads. Two types of molecular chains are considered in micro-scale level that controls training and actuation processes - helically oriented chains and entropic chains. The performance of the model is validated by available experiments in the literature. The model may provide a design platform for the use of low-cost artificial muscles in self-healing composites. ✺

Louisiana Research Infrastructure Development



"System for Classification of 3D Dynamic Hand Gestures," Rastko R. Selmic, AT&T Professor of Electrical Engineering, Louisiana Tech University

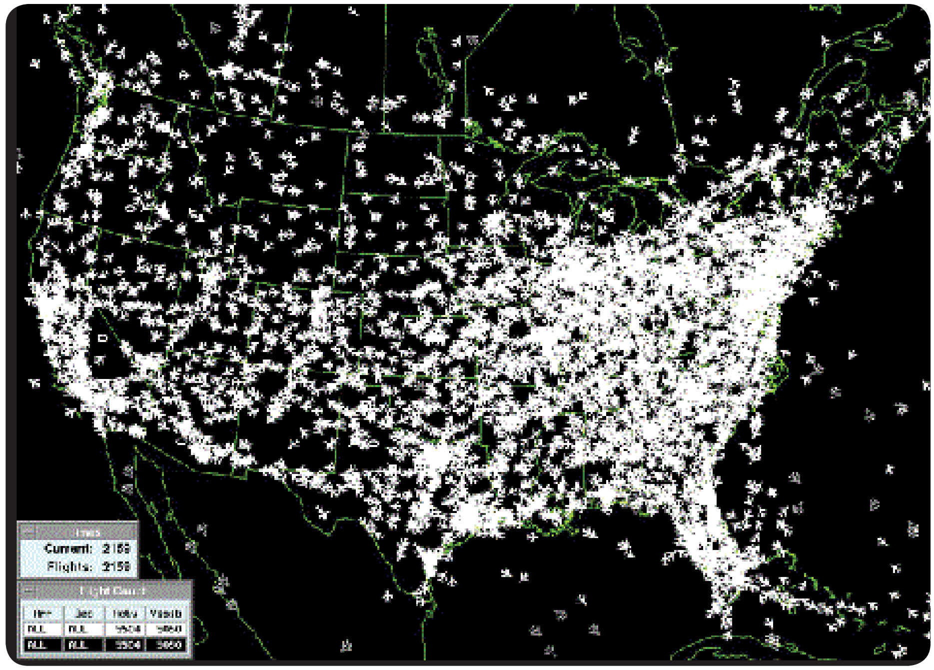
The project objectives are to develop an accurate and efficient classifier with a diverse vocabulary of dynamic gestures and apply this technology to gesture recognition and controls. Studies related to dynamic gesture recognitions as an extension of static gesture (posture) recognition algorithms have begun, and neural network-based and Kalman filter-based classifiers for dynamic gesture recognition are being studied. Dr. Selmic's group, including Dr. Jinko Kanno, Dr. Christian Duncan, and Ph.D. student Andrew Gardner, uses a smart glove for both static and dynamic gesture detection and classification. Fifteen markers are distributed over the glove. Each finger has two markers except for the thumb, which has three markers. A special rigid pattern on the back of the hand is used to establish local coordinate systems invariant under translation and rotation. Once the team theoretically develops dynamic gesture detection and classification, they will work next on producing the software based on those algorithms.

Dr. Selmic's team has been developing a laboratory testbed for dynamic gesture recognition and control. The testbed consists of a Vicon camera system with ten Vicon MX T-40 cameras. The system provides a full resolution maximum capture rate of 370 frames-per-second (fps) for each camera. This enables the system to provide high precision tracking motion data. Mr. Andrew Gardner, a Ph.D. student on the team, has developed an interactive demo that allows a user to interact with a virtual environment by employing five static gestures. Pointing allows the user to control the camera like a joystick with pitch, yaw, and roll. The user may also grab and move or throw objects, while a stop gesture pauses the animation.

Potential future applications of this technology include gesture-based control of robots, vehicles, and home appliances, gesture-based (body language-based) authentication and recognition, and development of 3D user interfaces. ✷

Integrated Trajectory Information Processing and Management for Aircraft Safety (ITIPS)

University of New Orleans/Louisiana State University/Southern University/NASA DRC, Aeronautics Research Mission Directorate



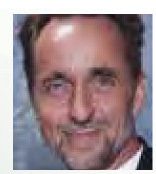
The goal of the Louisiana Board of Regents' EPSCoR-funded research effort is to develop and securely integrate algorithms that better process real-time data about aircraft in our skies. Many will have practical impact upon our nation's NextGen air traffic management system: algorithms that predict the trajectories of aircraft; how much space between aircraft is needed for safe flight; how to predict and avoid collisions, etc.

The team met the goals and objectives set for this second year of the project. Accomplishments include: (a) theory and algorithm development for the joint decision and estimation (JDE) approach to integrated trajectory prediction (TP) and intent inference and verification (IIV), and for variable-structure multiple-model estimation for trajectory prediction; (b) methodological development for a multiple-model based statistical approach for conflict detection (CD) and alerts as well as collision avoidance; (c) theory and algorithm development for consensus and networked control of heterogeneous multi-agent systems for air traffic management; and (d) methodology and algorithm development for diagnostics, prognostics, and monitoring of aircraft conformance and health management.

Our research also focused on the security of NextGen's data networks. We have investigated fast adaptive sequential methods for early detection of network intrusions aimed at preventing or lowering their potential damage. We proposed analytic and computational methods for designing multistage, multi-hypothesis testing schemes for detecting network intrusions such as ``portscans" and "denial of service" (DoS) attacks. Our techniques focus on reducing detection times for wide variations of traffic parameters while guaranteeing fewer false alarms.

We continue collaborations with several small companies for technology transfer, including ARCON Corporation (Waltham, MA), FORSUGO Hi-cell (Marrero, LA), Intelligent Fusion Technology (Germantown, MD), ObjectVideo (Reston, VA), and Propagation Research Associates (Marietta, GA). Several joint proposals for collaboration have been submitted, based partially on this NASA project. ✺

Dr. X. Rong Li,
Science PI,
Research Professor,
University of New Orleans



Dr. Kai Goebel, Ph.D,
NASA Technical Monitor,
Ames Research Center

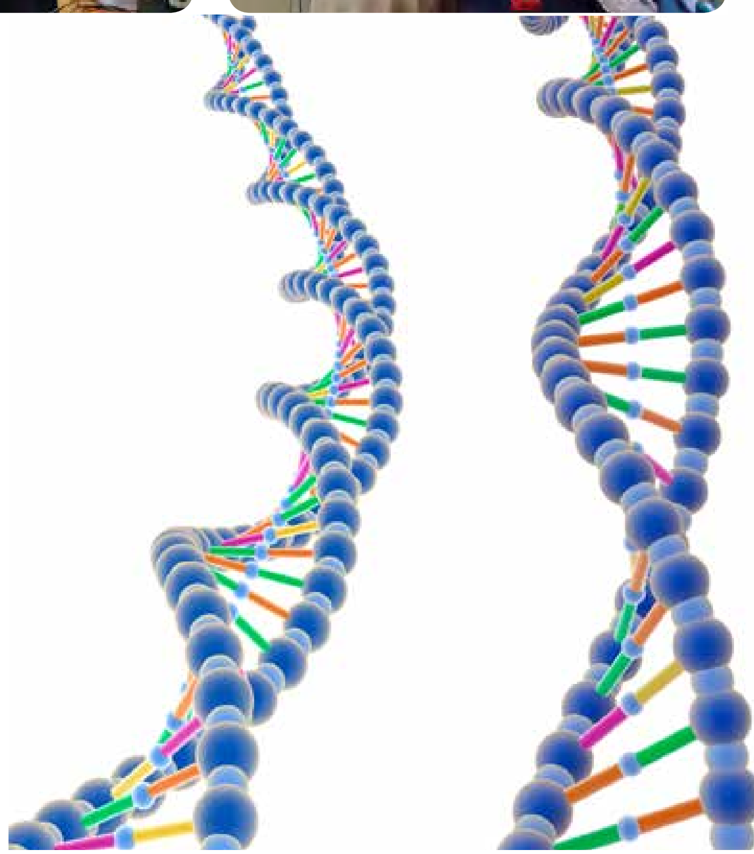
Genetic Assessment of the Space Environment Using MEMS Technologies

Louisiana Tech University/Grambling State University/University of Louisiana at Lafayette/NASA Kennedy Space Center, Ames Research Center, Johnson Space Center, Human Exploration & Operations Mission Directorate, Space Technology Mission Directorate

Three universities from across the state of Louisiana are working to create an instrument that can be used by space biologists and other researchers to examine the effect of space radiation on living things. The focus of this project is to make the system completely autonomous, so that continuous biological testing can be performed from within hazardous environments without subjecting the scientists to harmful conditions. This requires the seamless integration of several technologies, an important element of which has been recently demonstrated. The research team has developed a way to automatically collect genetic material from a biological sample, and then transfer that material safely, quickly, and automatically into a process reactor for analysis. This achievement required the close collaboration of a biologists, physicists, and engineers. Graduate and Post-Graduate students working on various aspects of the project are shown in the pictures to the left. ✺

Dr. Niel Crews,
Science PI,
Louisiana Tech University

NASA Technical Monitor:
Dr. Ralph F. Fritsche



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

Louisiana State University/Southern University/Xavier University of Louisiana/NASA Glenn Research Center, Science Mission Directorate, International Space Station

TETRA detector unit: 19 cm x 19 cm x 0.56 cm NaI (Tl) scintillator viewed by Lucite light pipe and 12.7 cm diameter photomultiplier tube. The TETRA-I array of gamma ray detectors have operated in Baton Rouge, Louisiana since July 2010. TETRA-I consists of an array of twelve 19 cm x 19 cm x 5 mm NaI (Tl) scintillators in four separate detector boxes deployed on rooftops on the LSU campus. TETRA-I has observed thirty-six TGF-like events, mainly during spring and summer thunderstorms, in which 50 keV – 2 MeV gamma rays are observed at ground level in shorter than 5 msec bursts associated with nearby (< 5 km) negative polarity lightning.

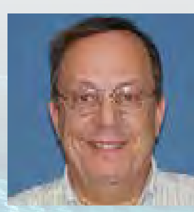
The goal of this EPSCoR-funded project is to better understand a component of lightning-producing storms called terrestrial gamma flashes, or TGFs. The project also will build research infrastructure at three minority institutions in two EPSCoR jurisdictions and train underserved minority students.

TGFs are a significant but not yet completely understood component of the electric structure of thunderstorms. They're intense, millisecond-scale fluxes of gamma rays associated with terrestrial lightning that were discovered by NASA's Compton Gamma Ray Observatory and have been observed, as well, by detectors on the AGILE and Fermi spacecraft. These observations indicate that electrons are accelerated to very high energies by the electric fields in lightning, producing showers that radiate high fluxes of x-rays and gamma rays.

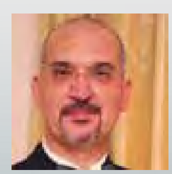
The TGF and Energetic Thunderstorm Rooftop Array II, or TETRA-II, will collect important data complementary to Fermi's observations of the currents associated with these electromagnetic showers. In collaboration with the University of Puerto Rico "Bayamón" using seed support from the Louisiana Board of Regents and Louisiana Space Grant Consortium, TETRA-II's expanded, higher resolution, detector arrays will be deployed in Puerto Rico and Jamaica where lightning activity is extremely high and where the prime orbiting TGF detector (the Gamma ray Burst Monitor on NASA's Fermi mission "" GBM) indicates that the rate of TGFs is also high.

Two HBCUs, Southern University and Xavier University, will commission/operate the new arrays as well as analyze data for climate models and weather-predictive systems.

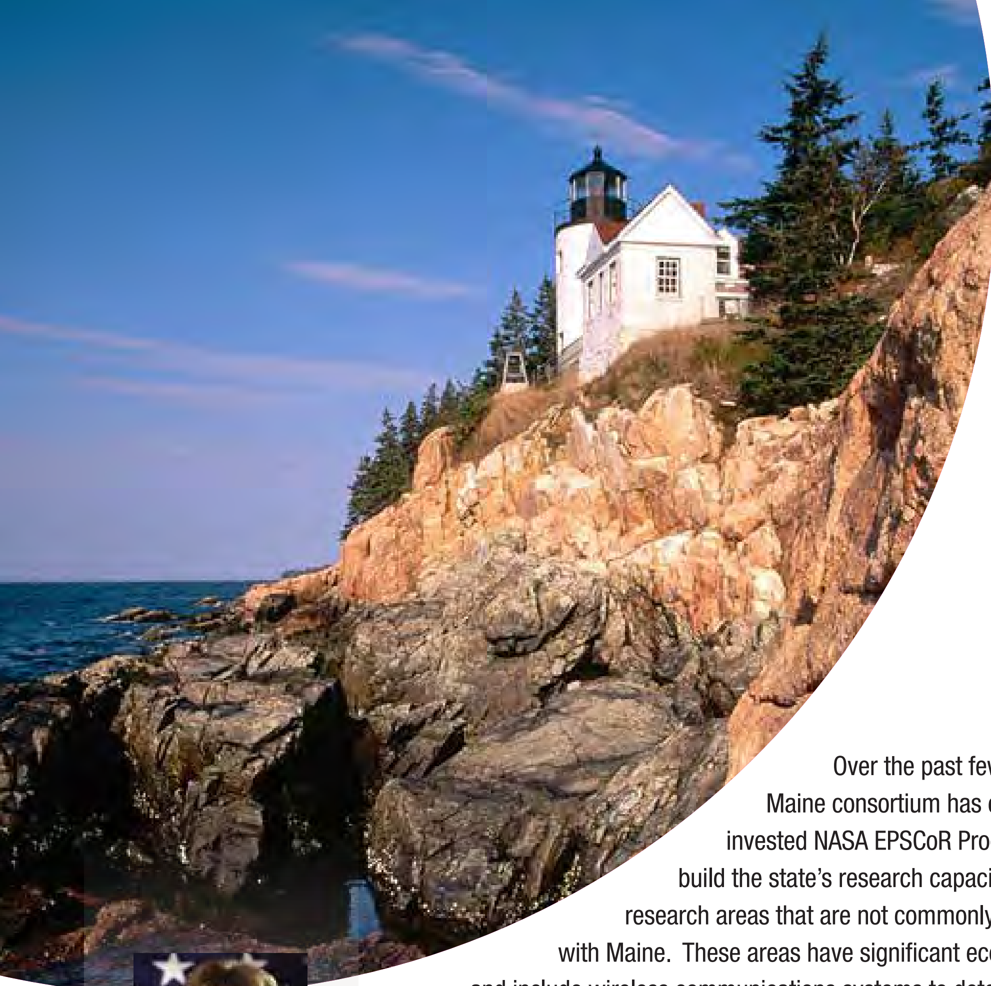
Lightning is a major concern for NASA due to potential damage from strikes to space vehicles at launch and launch and assembly infrastructure. Lightning is also the focus of NASA's space-based Lightning Imaging Sensor (LIS) aboard the EOS TRMM satellite and an LIS instrument scheduled for launch to the International Space Station in 2016. ✷



Dr. Michael L. Cherry,
Science PI,
Professor, Louisiana State University



Nasser Barghouty,
NASA Technical Monitor,
Manager, Astrophysics Office
at NASA-Marshall Space Flight Center

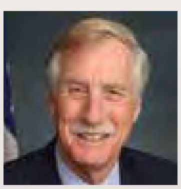


MAINE

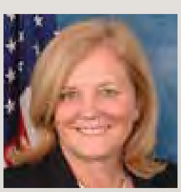
Terry Shehata, Ph.D.,
ME EPSCoR Director

Over the past few years the Maine consortium has competitively invested NASA EPSCoR Program funds to build the state's research capacity in emerging research areas that are not commonly associated with Maine. These areas have significant economic potential and include wireless communications systems to detect leaks in deployable space structures; testing and evaluating hypersonic inflatable atmospheric decelerator devices that protect spacecraft during re-entry intro earth's atmosphere; development of green (oil-free) two-stroke piston engine for unmanned air vehicles; and the development of high-speed air-breathing propulsion that could significantly reduce the size, weight, and cost of launch vehicles for access to space, and address the fast growing nanosatellite market. Without a doubt, NASA EPSCoR has generated enthusiasm among Maine researchers and students to explore research opportunities with economic and workforce development opportunities in the aerospace research and education sector that otherwise would not have been available from mainstream federal funding.

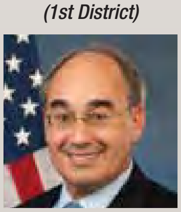
Senator Susan Collins



Senator Angus King



Representative Chellie Pingree (1st District)



Representative Bruce Poliquin (2nd District)

Maine TOC

ME

Learning How to Breathe: What Can We Learn About Antiquity, Biological Iron Oxidation, and Respiration on Oxygen from Modern Fe-Oxidizing Bacteria

Bigelow Laboratory For Ocean Sciences/NASA Science Mission Directorate

Bigelow | Laboratory for Ocean Sciences

This project's goals are aimed at better understanding a group of microbes of interest to NASA from an exobiology standpoint, and developing single cell genomics techniques as a tool of use to NASA researchers working on extremophilic bacteria, as well as the larger scientific community.

Nearly five million dollars in external funding from federal and private funders has been acquired during the course of this work by the PIs. In addition, Bigelow Laboratory has received significant philanthropic funding during the course of this project, the success of this project has been touted to potential philanthropic donors as well.

The Bigelow PIs have close scientific collaborations with researchers at University of Delaware, Harvard University, Western Washington University, DOE JGI, Princeton University, Woods Hole Oceanographic Institution, and other institutions. Emerson has recently been consulting and doing contract work for water treatment division of the Cargill and Kraft Corporations related to technology transfer of Fe-oxidizing bacteria studies. ✺

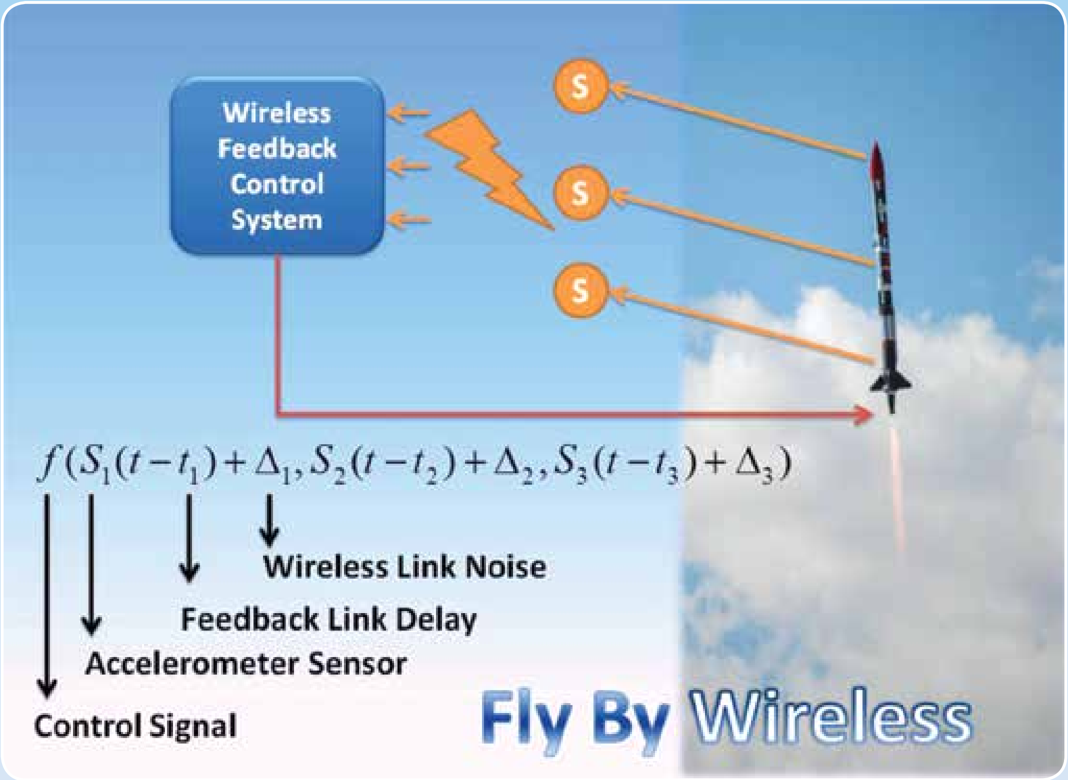
David Emerson and microbiologists sampling iron-oxidizing bacteria. Photo credit: Ari Daniel Shapiro

⮝ *David Emerson, Science PI,*
Bigelow Laboratory For Ocean Sciences

Jennifer L. Eigenbrode, Ph.D.,
NASA Technical Monitor,
Goddard Space Flight Center, HEOMD

Minority Serving Institution

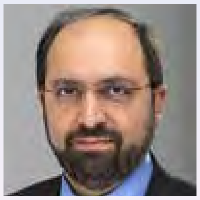
UMaine and Cal State Long Beach collaborated on eliminating wires in aerospace control systems to save on weight, cost, and accuracy of guidance and navigation. The challenges addressed in this project included real-time modeling of vibration model of the vehicle using wireless sensors. Delay and noise in the control loop calls for advanced signal processing and new control techniques to provide a robust and reliable system. ✺



Eliminating wires from aerospace control systems significantly reduces weight, while posing challenges dealing with delay and noise in sensor data.

Theresa Martinez, PMP, NASA Technical Monitor, Kennedy Space Center

University of Maine, WiSe-Net team



Dr. Ali Abedi, Science PI, University of Maine

Research Infrastructure Development

MAINE

Wireless Sensing of Space Structures, a state of the art Wireless Sensing laboratory, has been established at the University of Maine, which hosting NASA JSC'S Inflatable Lunar Habitat instrumented with multiple wireless sensors monitoring the structural integrity, shape, impact, leak, temperature, and humidity. An iPad app has been designed by VEMI Laboratory to visualize the data in the form of a heat map, making the interaction with the test-bed more accessible by other researchers. Several new distributed in network coding and computing algorithms were developed as part of this project. Some of the wireless sensors developed in this laboratory were tested on board rockets in Mojave, CA in collaboration with California State University (Long Beach) CALVEIN program. New courses in Wireless Communications area in both undergraduate and graduate levels are attracting more students into wireless sensing field and enabling a myriad of new applied research directions in biomedical sensing, structural monitoring, and environmental sensing benefiting more researchers outside of Engineering. ✷

This project was funded by a NASA EPSCoR RID award.

Employees of Applied Thermal Sciences prepare a prototype high-speed air-breathing propulsion-based rocket for launch in Cherryfield, Maine.

Applied Thermal Sciences' prototype high-speed air-breathing propulsion-based rocket in flight. The rocket successful achieved a high of 20,000 feet which allowed the ground crew to test the rocket's efficiency and associated vibrations.

Photos Courtesy of Applied Thermal Sciences, Inc

Behavior and Optimization of Hypersonic Inflatable Atmospheric Decelerator Devices for Spacecraft Re-Entry

University of Maine/NASA Langley Research Center, Human Exploration & Operations Mission Directorate, Space Technology Mission Directorate

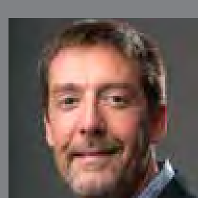
Hypersonic Inflatable Aerodynamic Decelerators or HIADs are one of the key technologies supported by the NASA Game Changing Development Program to mature innovative, high-impact new approaches to meet future space mission objectives and provide solutions to national needs. The purpose of this research project is to advance the basic understanding of the load-deformation behavior of HIADs.

HIADs show great promise for use in space mission applications. They permit the landing of larger payloads due to their large frontal area relative to their stowed volume and total weight, and are also ideal for thin atmospheres. A Hypersonic Inflatable Aerodynamic Decelerator is a nose-cone-mounted inflatable structure consisting of multiple, concentric, nitrogenfilled tori that is designed to decelerate and protect spacecraft during atmospheric re-entry.

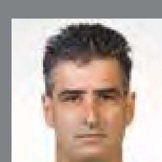
A tension-torsion machine was purchased for this project. The goal of the tension-torsion testing is to quantify the mechanical properties of the HIAD shell consisting of Technora braided fabric and a urethane bladder. These properties can then be used to generate input for FE models of inflatable structures. ✺

A tension-torsion machine was purchased for this project.

UMaine students in front of one of the tori that make up the cone-shaped HIAD. The UMaine testing facility is determining the constitutive properties of the braided fabric shell that make up each tori.



Dr. William Davids, University of Maine, Advanced Structures and Composites Center



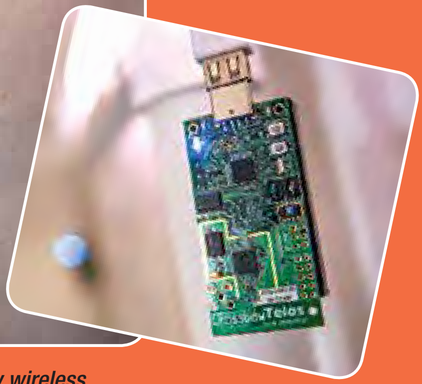
Dr. Anthony Calomino, PhD, NASA Technical Monitor, Langley Research Center

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

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

A view of inside the lunar habitat, a 42 ft diameter concentric torus built by NASA JSC and instrumented by wireless sensing laboratory at UMaine examining the sensors and the collected data on a tablet PC. (UMaine graduate students, from left, Casey Clark, Mojtaba Razfar and Lonnie Labonte test wireless sensors in UMaine's inflatable lunar habitat with Science PI Ali Abedi, an electrical and computer engineering professor who directs the Wireless Sensing Laboratory (WiSe-Net Lab).

Bridget Ziegelaar, ISS RM, Johnson Space Center



Wireless sensor

Future space travelers could someday be safer as they journey far from home, thanks to an EPSCoR-funded project at the University of Maine campus in Orono. There, inside the school's Wireless Sensing Laboratory (WiSe-Net Lab), researchers are designing and testing a wireless leak detection system for the International Space Station (ISS) that could lead to increased safety on ISS and other spacecraft, as well as on Earth in the event of gas and oil leaks at industrial plants. Leaks causing air and heat loss are a major safety concern in spacecraft. Finding and fixing a leak quickly could be the difference between life and death for astronauts living and traveling hundreds of miles above the Earth. The flight-ready, wireless sensor system under development uses ultrasonic sensor array signals to quickly detect and localize leaks. The proposed system is fast, accurate and capable of detecting multiple leaks and localizing them with a lightweight and low-cost system. Its prototype, developed by UMO researchers as part of a previous NASA EPSCoR project, has been tested on an inflatable lunar habitat at the school. The new EPSCoR funding is allowing researchers to make the system more rugged, robust and revise it for testing at the NASA's ISS Technology Demonstration Office at the Johnson Space Center in Houston, Texas. Two to three years later, it'll be sent up to the ISS for testing in microgravity.

This NASA–EPSCoR is one of five in the nation to receive funding for research and technology development onboard the ISS which consists of higher education institutions and nonprofit research organizations that are actively involved in aerospace-related research and education. ✺

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

Gulf of Maine Research Institute/NASA Jet Propulsion Laboratory, Science Mission Directorate

This winter was one of the coldest ever in New England. Using funding from NASA's EPSCoR program, we issued the first operational forecasts for how temperature will impact landing patterns in Maine's valuable lobster fishery.

During the winter and spring, lobsters are not as active and are in deeper water off shore. This makes them hard to catch, and catch rates are low. As waters warm up in the spring, lobsters become more active, migrate inshore, and shed their shell. This leads to a rapid increase in the catch rates, usually around July 4.

In 2012, warm water temperatures caused Maine lobsters to move inshore earlier than normal, kicking off the high-landings period in the fishery three weeks early. As the supply chain was not ready for this influx, product backed up and the price of lobster collapsed. Our project is intended to give the industry advanced warning of major changes in the timing of the high-catch period and the opportunity to avoid situations like what occurred in 2012.

We built the forecast model using historical lobster landings and temperature data from the Gulf of Maine to predict the start date for the season. Our forecasts began in March and were updated weekly through April 15 at www.gmri.org/lobster-forecast. Our final forecast predicts that the season has a 63% chance of being 1-3 weeks delayed, due to the cold water along the coast this spring. The year that is most analogous to the current forecast is 2005. The delayed start to the season that year caused total annual landings to be lower and prices to be higher than in normal years.

We will issue another round of forecasts next year. We are currently exploring how we can use NASA products, including satellite temperature and seasonal forecasts to issue accurate forecasts earlier in the year.

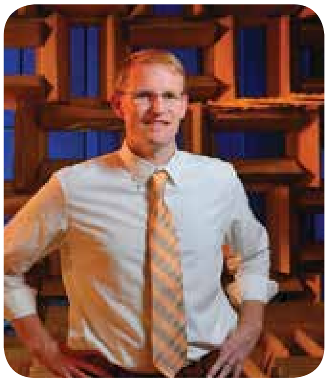
Dr. Andrew J. Pershing,
Science PI,
Gulf of Maine Research Institute

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

NASA Jet Propulsion Laboratory (JPL), located in Pasadena, California

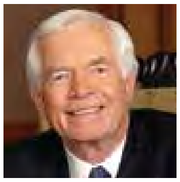
MISSISSIPPI

NASA EPSCoR in Mississippi fills a unique role within the state by infusing NASA investment into research asset development leading to the maturation of innovative research and technology ventures that are relevant to NASA and NASA related Mississippi industry. NASA EPSCoR programs have contributed significantly to innovation in high-performance computing, advanced composites and nano-materials, communications, and biological systems. These innovative research activities are responsible in part for Mississippi's growing list of global leaders in the aerospace industry, several of which are located at John C. Stennis Space Center. A focus on university/industry partnerships and workforce development is succeeding in long-term, self-sustaining, nationally competitive capabilities that will continue to attract aerospace industry to the state and provide a valuable contribution to NASA and the national space mission.



Dr. Nathan E. Murray, Director MS NASA EPSCoR, The University of Mississippi

The first stage booster of the Apollo/Saturn V space vehicle is static fired at the NASA Mississippi Test Facility (MTF), currently called Stennis Space Center.

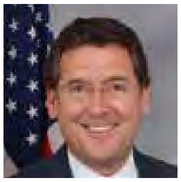


Senator Thad Cochran

Senator Roger Wicker

Representative Trent Kelly (1st District)

Representative Bennie Thompson (2nd District)



Representative Gregg Harper (3rd District)

Representative Steven Palazzo (4th District)

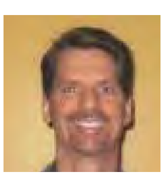
Mississippi TOC

Development of Advanced Turbulent Flow Prediction Methods for NextGen Air Transport

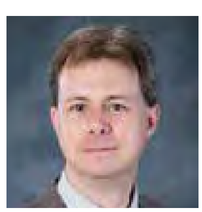
Mississippi State University/Jackson State University/NASA Glenn Research Center, Marshall Space Flight Center, Aeronautics Research Mission Directorate

Eric Robertson gets comfortable at CFD Research Corporation in Huntsville, AL, after pursuing B.S. and M.S. degrees at Mississippi State University with support from the NASA EPSCoR program.

The purpose of this project has been to enhance research competiveness in Mississippi while addressing critical technology needs for NASA in the area of computational fluid dynamics simulations for aeronautical and aerospace applications. We have sought to accomplish this by establishing a new collaborative research effort focused on turbulence modeling and advanced computational fluid dynamics (CFD) methods, and implementing them into commercial and inhouse CFD flow solvers. Our efforts have capitalized on existing strengths within the state, including expertise and infrastructure in computational science and engineering, while establishing new working relationships between two of the state's research universities (MSU and JSU) and NASA research assets. Successful completion of the three-year effort has resulted in new enabling technologies for analysis and design of complex aerospace flow systems, an established multiinstitutional research program in Mississippi that can successfully compete for extramural funding in this area, and significant enhancement of the education and training of graduate and undergraduate students, including members of under-represented groups at the state's largest research university (MSU) and largest minority-serving institution (JSU). ✺



Dr. James D. Heidmann, Sr.,
NASA Technical Monitor,
Manager, Transformational Tools
& Technologies Project,
Aeronautics Research Mission Directorate,
Glenn Research Center



Dr. D. Keith Walters,
Science PI,
Mississippi State University

MS MSI - Adverse Effects of High Energy Radiation on Astronauts' Vestibular Balance and Immune Function during Long Term Space Missions

Tougaloo College, University of Mississippi Medical Center and Johnson Space Center

The primary goal of the project is to engage Tougaloo College faculty and student in research and build research capabilities and/or research experience in Mississippi EPSCoR jurisdiction. This project addresses the adverse effects of high energy radiation on astronauts' vestibular/balance and immune functions during long term space missions. It involves collaboration between Tougaloo College (TC), a Historically Black college located in Tougaloo, Mississippi, the University of Mississippi Medical Center (UMMC) and NASA's Johnson Space Center (JSC).

The research activity has two specific aims. One is to investigate radiation effects on vestibular nerve fiber responses to angular and linear accelerations in rats. The other one is to investigate effects of synthetic Benzofuran-2-carboxylic acid derivatives as countermeasures for neuroprotection and immune modulation. NASA EPSCoR /MSI award made a great impact not only on faculty development and HBCU undergraduate student research training, but also helped us to develop a new course, *Advanced Immunology*, offered by Biology Department at Tougaloo College. This course is designed to challenge students and expose them to inquiry-based immunology research related to NASA within a research laboratory setting. The course emphasizes the fundamental concepts in immunology within the context of a discussion-based lecture which was also complemented by a novel lab section that would require students to utilize the techniques learned in the areas of Microbiology and Molecular Biology to develop their own NASA related research project, such as *Investigation of the effect of modulated microgravity on innate immunity*. Introducing this course increased the diversity of topics covered in the biology curriculum and exposed a larger number of students to NASA research.

Students not only plan and execute their projects with the course faculty, but also participate in such activities as developing presentation skills by presenting scientific journal articles in a journal club setting, writing a research 'paper' based on individual research. The course is organized around preparation for graduate school in the biological sciences using current techniques developed in the EPSCoR/MSI established research laboratory along with the equipment purchased from this award. There were 17 students enrolled in this class.

In 1998 the buildings of the old Tougaloo College campus were added to the National Register of Historic Places.

Dr. Jinghe Mao, Science PI, Professor of Biology, Tougaloo College

Theresa Martinez, PMP, NASA Technical Monitor, Kennedy Space Center

MS

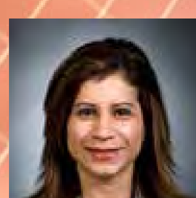
Hyper Velocity Impact - Environmental Resistant Nano Materials in Space Applications

University of Mississippi/NASA Marshall Space Flight Center, Human Exploration & Operations Mission Directorate, Space Technology Mission Directorate

Graduate Research Assistant Grace McMahen and Dr. Hunain Alkhateb conduct a molecular dynamics simulation on polymers.

Dr. Ahmed Al-Ostaz, Science PI, University of Mississippi

THE UNIVERSITY of MISSISSIPPI



Dr. Marisabel Lebron-Colon PhD, NASA Technical Monitor, Glenn Research Center

In the clutter of near-Earth space, the greatest threat to orbiting spacecraft is Man-made Orbital Debris (OD). OD can travel at velocities in excess of 6 km/sec. Spacecraft in Near-Earth Orbit (NEO) critical to national interests must be designed to survive OD. This research will develop and demonstrate the effectiveness of a new, unique state-of-the art material system, a composite with Nacre-like material properties that has exceptional hypervelocity impact resistance capabilities. Once developed and tested, this advanced material system could produce new, improved debris shields ready for retrofitting the International Space Station (ISS) and use on spacecraft destined for planetary missions.

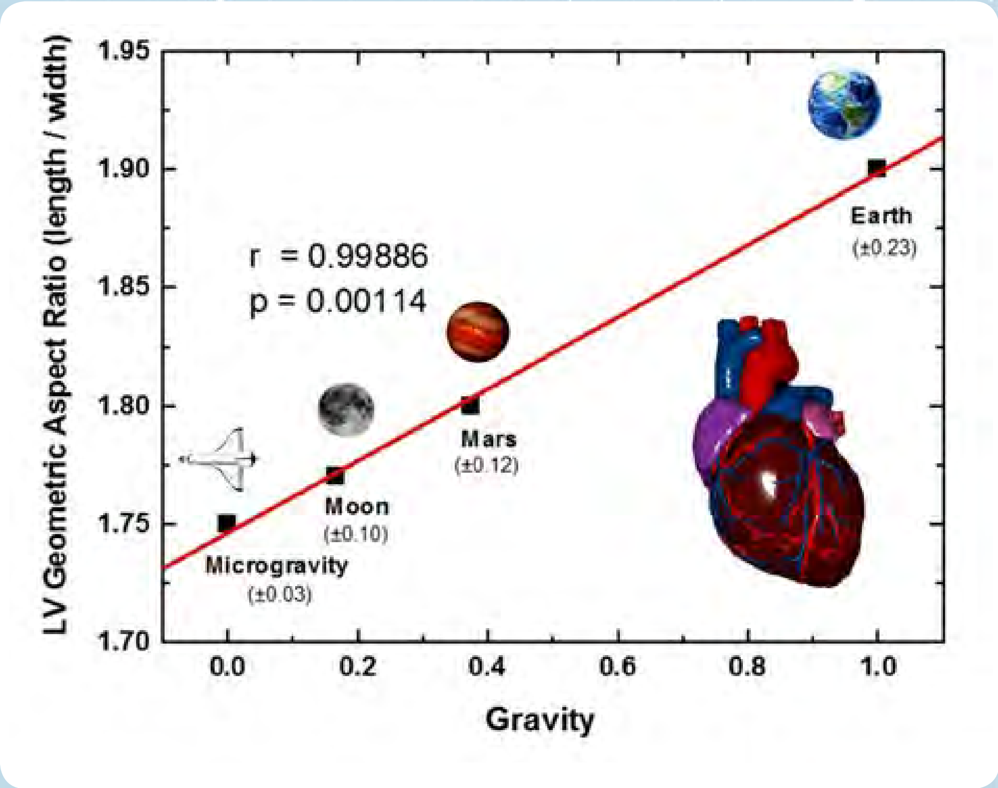
The University of Mississippi (UM) has started an industry/university collaborative research and test program to exploit the revolutionary properties of these new, "exotic", multifunctional nanocomposites for ultra-lightweight space structural applications under extreme environments and loading conditions. The research team is also interested in developing analysis methods to characterize the performance of these materials at the macro level to make these materials easier to analyze, design and, thus, expand their usage across different industries.

This research has gathered the cutting-edge research capabilities of UM and several Mississippi universities with a goal of stimulating the regional and national economy. The UM team has been working with Mississippi State University, Department of Aerospace Engineering, in exploring the use of developed materials for other applications, such as lightning protection and radar shielding.

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 at UM and partner universities are poised to contribute discoveries and innovations in the modeling, synthesis, characterization, and production of advanced materials. A number of academic courses and programs are preparing innovative professionals and scientists, knowledgeable leaders, and literate citizens for a "materials" world. ✺

Analysis of the Mechanisms of Cardiac Function and Rhythm Problems During Spaceflight

There have been evidences of myocardial atrophy and associated cardiac dysrhythmias during prolonged spaceflight that are identified by NASA as a significant risk for future human space exploration (Platts, Summers et al. NASA's HRP Evidence Books: NASA-TP:2010:1-17). The development of effective countermeasures requires a clear understanding of the biologic mechanisms driving the observed microgravity induced cardiac adaptations. Prior research had focused on pressure-driven stress changes as a driving mechanism. However, according to Laplace's law for hollow chambers (tension ∝ pressure · radius of curvature), the overall geometry of the ventricle and the resultant local wall radii of curvature are also important factors determining myocardial stress. A retrospective analysis of past spaceflight echocardiograms revealed that there are gravity dependent changes in the conformation of the ventricle that could alter the wall tension (Summers et al. Aviat Space Environ Med 2010;81:506-510). We then constructed a finite element model (FEM) of the heart in microgravity to further investigate the hypothesis regarding the causal mechanism of spaceflight induced changes in ventricular shape and stress based on a shape change alone (Summers et al. ICES513 Proceedings 2012;2012-3448). A simulation of the ventricular electrical propagation grounded in the predicted microgravity induced remodeling of the FEM myocardium is being derived for an analysis of the potential for arrhythmogenesis and determine the proficiency of the twisting motion of the ventricle cycle as it relates to systolic and diastolic function. This adaptive functioning will also be integrated into a broader model of human physiology as a part of the NASA Digital Astronaut Project. ✺



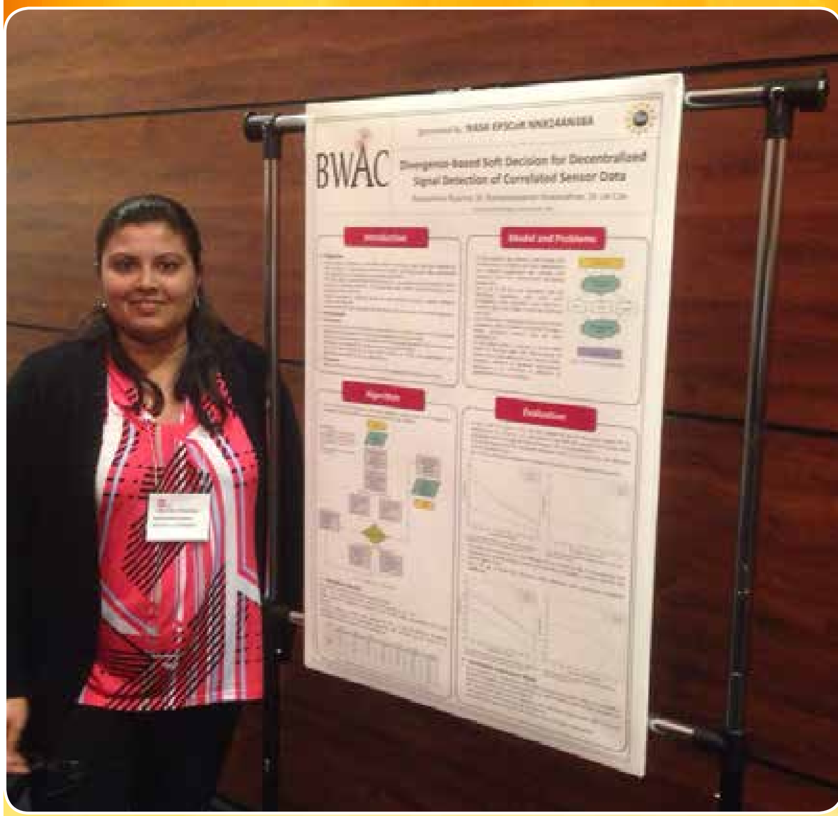
Dr. Richard Summers, Dept. of Emergency Medicine, University of Mississippi Medical Center

Dr. Richard Summers, Department of Emergency Medicine, University of Mississippi Medical Center

MEDICAL CENTER

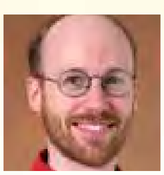
A New Paradigm for Efficient Space Communications: Rateless Coding with Unequal Error Control and Data Fusion

University of Mississippi/NASA Jet Propulsion Laboratory, Goddard Space Flight Center, Science Mission Directorate



Students present posters to disseminate the research outcome of this NASA project in a NSF BWAC workshop at Oxford, Mississippi on January 15, 2015. One of these posters has been awarded as the best poster in the workshop.

THE UNIVERSITY of MISSISSIPPI



Jon Hamkins, Ph.D.,
NASA Technical Monitor,
Supervisor, Information Processing Group Communications Architectures and Research Section
Jet Propulsion Laboratory

Dr. Lei Cao, Science PI,
Associate Professor,
University of Mississippi

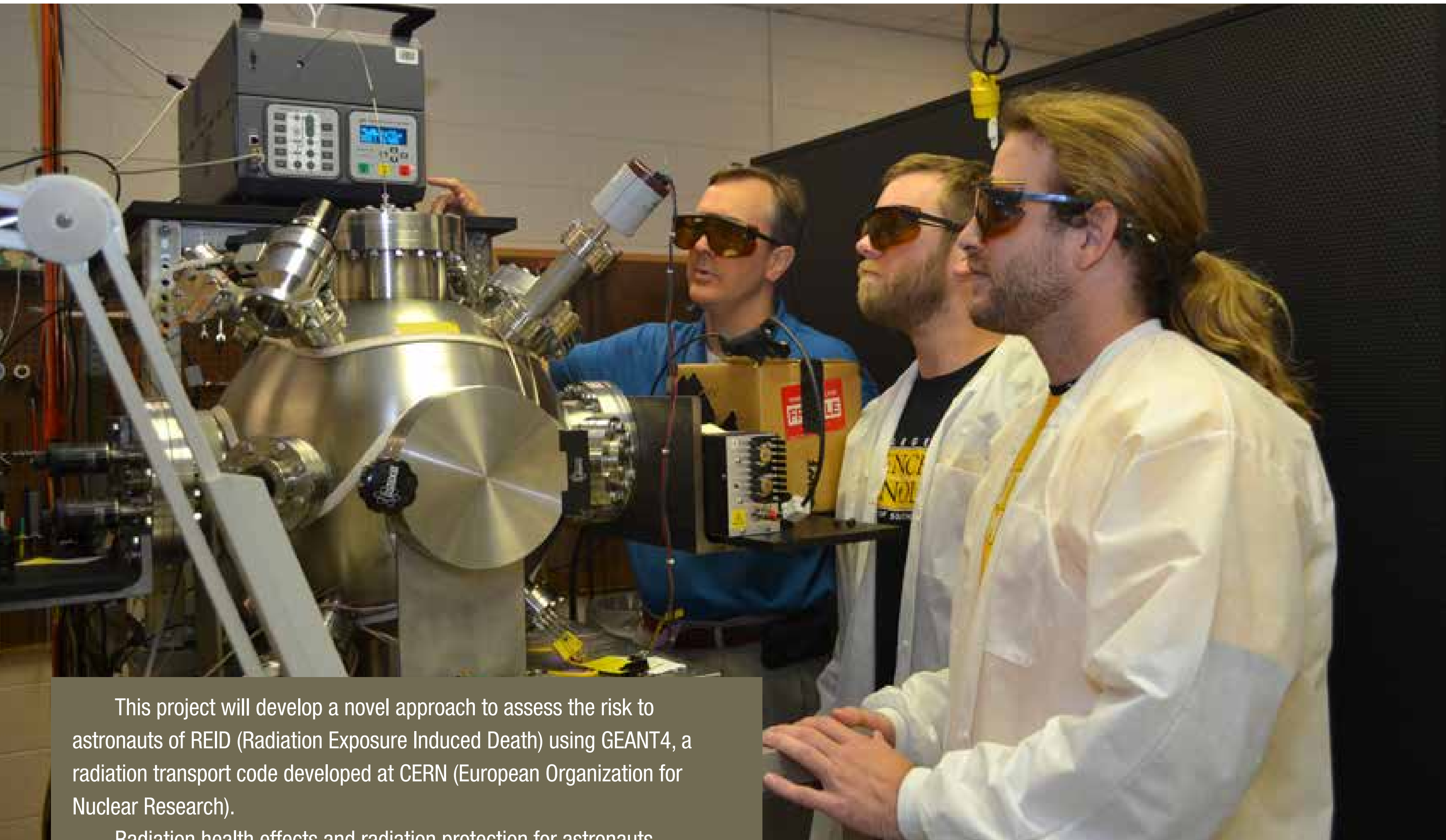
The funding of this grant has formed an energetic group at The University of Mississippi, including Drs. Peter Sukanek, Lei Cao, Ramanayaranan Viswanathan and John Daigle, focusing on some key wireless technologies for space communications. Through this grant, the research team has also built strong collaboration with Dr. Kenneth S. Andrews at Jet Propulsion Laboratory, and Dr. Natarajan Meghanathan at Jackson State University.

This grant has already generated some interesting outcomes, which have been disseminated through various ways. The research team had attended the BWAC (Broadband Wireless Access & Applications Center) workshop held at Oxford, Mississippi from January 15-16, 2015, which was sponsored by the NSF I/UCRC (Industry & University Cooperative Research Centers Program). The team had presented the scientific outcome of this NASA project in two regular lectures and four student posters in the workshop. These presentations have covered areas of file delivery with fountain codes, decoding of fountain codes in wireless channels, sensor localization, signal detection and decentralized data fusion. One of the posters, titled "Divergence-based Soft Decision for Decentralized Signal Detection of Correlated Sensor Data," was selected by the industry attendees from six different companies to receive the best poster award of the workshop.

In addition to research and technology development, this grant greatly enhances faculty development and higher education in Mississippi. One new course titled "Signal Detection" has been developed and offered to our graduate students due to this research. This grant also supports several graduate students and two undergraduate students including a woman student to gain hands-on research experience. ✺

GEANT4 Simulations for Astronaut Risk Calculations

University of Southern Mississippi/NASA Marshall Space Flight Center, Human Exploration and Operations Mission Directorate

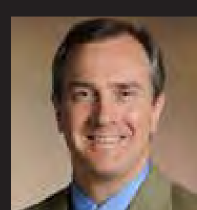


This project will develop a novel approach to assess the risk to astronauts of REID (Radiation Exposure Induced Death) using GEANT4, a radiation transport code developed at CERN (European Organization for Nuclear Research).

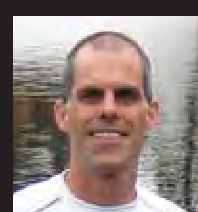
Radiation health effects and radiation protection for astronauts are among the most important concerns for deep space missions. The assessment of health risk can ultimately dictate the design and composition of the spacecraft.

The research involves two tasks enabled by the establishment of an expert GEANT4 user group in collaboration with NASAs Marshall Space Flight Center. First, the group will compare the results from GEANT4 with results from HZETRAN (a 1-D deterministic transport code currently used for REID calculations at NASAs Langley Research Center). We will study the effects of uncertainties in the Quality Factor, Low LET Risk model and uncertainty in nuclear cross sections for galactic cosmic rays and solar particles. This first task will evaluate GEANT4's promise in REID calculations and apply the considerable capabilities of GEANT4 directly to current NASA needs in statistical evaluations related to mortality data. The second task will extend the REID focus to include the health effects of the radiation flux on the DNA of the astronauts. The GEANT4 community is actively involved in the development of databases related to radiation-induced DNA effects. Although the physics related to the initial space radiation and the secondary particles it generates typically involves high-energy interactions, low energy interactions are critical in when considering effects on biomolecules. ✺

Ph.D. student Tyler Reese, master's student Patrick Ables, and Dr. Winstead with their laboratory atmospheric simulation chamber. This apparatus is used to study the effect of radiation on atmospheric chemistry.



Dr. Chris Winstead, Science PI, Professor and Chair, Department of Physics and Astronomy, University of Southern Mississippi



Dr. Kerry Lee, NASA Technical Monitor, Johnson Space Center

THE UNIVERSITY OF SOUTHERN MISSISSIPPI

The John C. Stennis Space Center (SSC) is a NASA rocket testing facility. It is located in Hancock County, Mississippi, on the banks of the Pearl River at the Mississippi-Louisiana boarder.

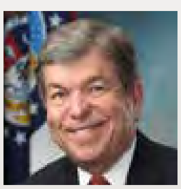
MISSOURI

NASA EPSCoR Missouri

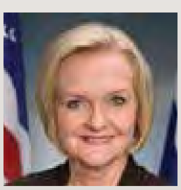
Dr. David Riggins,
MO EPSCoR Director,
University of Missouri - Rolla

NASA EPSCoR support in the state of Missouri for the past three years has helped enable the competitive development of significant research and technology at a wide range of academic institutions within the state. Specifically, cutting edge research and laboratory/facility development in scientific and technological areas focused on better understanding the universe, including our own planet, has been supported. Projects range from the analysis of exo-planets orbiting other star systems, to studies of extreme life forms and harsh environments here on earth to gain better understanding of possible life on other planets. Support for laboratory development of innovative plasmonic space propulsion systems has contributed to the development and testing of revolutionary new technology in the state of Missouri. Additionally, NASA EPSCoR is directly facilitating improvements in the ability to monitor and assess pollution effects on agricultural crops world-wide, using space-based sensing technology. Over eighteen projects with similar high impact for critical research infrastructure development within the state of Missouri have been funded through this program.

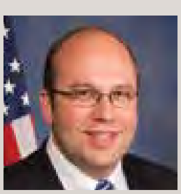
This NASA EPSCoR Jurisdiction is one of EPSCoR's success stories. In 2016 Missouri will have "graduated" from EPSCoR after only four years on its roles by exceeding the National Science Foundation's research funding percentage eligibility line as shown on their FY 2015 and subsequent eligibility tables.



Senator
Roy Blunt



Senator
Claire McCaskill



Representative
Jason T. Smith
(8th District)

Missouri TOC

Extremophiles from the Land Down Under

What are the limits to life on Earth? Answers to this question sought by Dr. Melanie Mormile and her team from the Missouri University of Science and Technology can help to guide people on the quest to determine if there is life elsewhere in our Solar System and beyond. For example, there is good evidence that Mars once had bodies of water that were acidic and salty. Thus far, there have been very few haloacidophilic bacteria described and no bacteria identified that can grow at high salinity and pH values below 4. If bacteria were isolated and characterized that could grow under these conditions, they can be of help to determine if there was previous life on Mars. The microbial communities in acidic saline lakes in Australia are being studied to provide this information. Water, sediment, and salt samples from four lakes, with pH values below 3.0, salt concentrations at saturation, and high metal content, were sampled. DNA is being extracted from these samples. The extracted DNA will be used for metagenomic analysis. The metagenomic data will provide information on the microbial communities present in the lakes. Attempts are also being made to isolate and characterize organisms that can grow with complex carbon sources from sediment samples taken from each of the lakes. This work is being supported by NASA Missouri EPSCoR in an ongoing Research Infrastructure Development grant in 2015. ✷

Researchers studying microbial communities in acidic saline lakes in Australia; understanding the possibilities of life in harsh environments on other planets.

MISSOURI S&T University of Science & Technology

Understanding the Atmospheres of Hot Earths and the Impact on Solar System Formation

Missouri University of Science & Technology/NASA Glenn Research Center, Science Mission Directorate

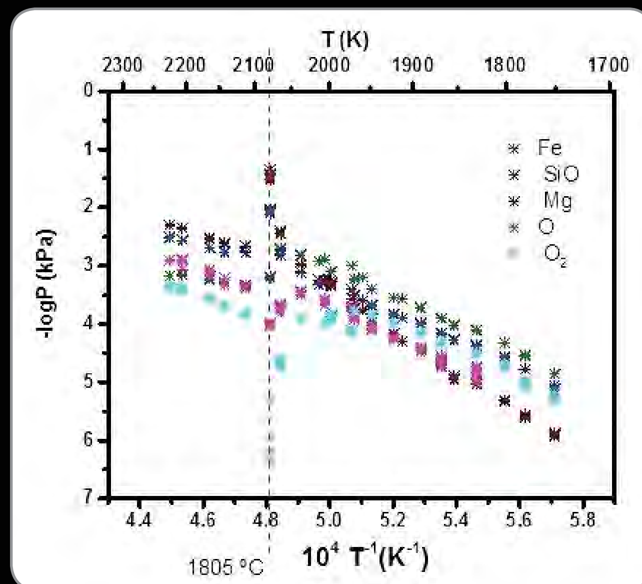
Are we alone in the universe? Where did we come from? Are there others like us?

Fundamental questions like these may someday be answered with data provided by NASA EPSCoR researcher, Dr. Michael Reed, Professor of Astronomy at Missouri State University.

Reed and his MoSU team are studying the atmospheres of some very hot, rocky exoplanets discovered by NASA s Kepler spacecraft to help determine whether our solar system formed uniquely to others. So hot are their surface temperatures (some can top 1,000 degrees Kelvin) that these exoplanets could not have formed close-in to their host stars; they had to have drifted into their extremely short orbits (less than a few days long!) only after their formation farther away. Theorizing that some of these exoplanets may have formed at distances similar to Earth's from our sun, Reed's team is studying gases released from these exoplanets' molten bedrock. Should they detect similarities to the chemical properties of our planet, or Mars, or Venus, their research could shed light on whether our genesis is one-of-a-kind – or mirrored elsewhere in the universe.

Reed's NASA EPSCoR grant also helped stimulate major improvements to MoSu's research infrastructure, including the construction of a new, high-temperature materials laboratory. Its upgraded infrared spectroscopy capabilities help Reed's team better detect and identify the exoplanets' different atmospheric gases.

This collaboration between MoSU, Washington University in Saint Louis, and Missouri University of Science and Technology helped nurture future members of our next generation STEM workforce. Stipends, equipment, travel money and release time were provided by the collaborative institutions to enable student participation in various capacities. MoSu's Baker Observatory was made available for student observations and analyses, and important mentoring opportunities, including an internship at NASA s Glenn Research Center, were established. These critical commitments would not have been made without this NASA EPSCoR project.



Results of experiments performed at NASA-Glenn by Drs. Jacobson and Costas showing vapor pressures versus inverse temperature (van't Hoff plot) for vapor species of Fe-rich olivine. To help identify the chemical properties/makeup of substances found on exoplanets discovered by NASA's Kepler spacecraft.

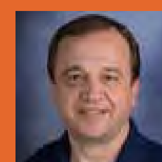
Dr. Mike Reed,
Science PI,
Missouri State University

Dr. Pamela Marcum, PhD,
NASA Technical Monitor,
Ames Research Center

Fabrication of Advanced Materials for Space Applications

Missouri University of Science & Technology/NASA Langley Research Center, Aeronautics Research & Space Technology Mission Directorates

Dr. Frank Liou,
Science PI,
University Of Missouri, Rolla



Dr. William J. Seufzer,
NASA Technical Monitor

Above: View of equipment in Laser Aided Manufacturing Process Laboratory at Missouri Science & Technology; NASA EPSCoR; fabrication of advanced materials for space applications.

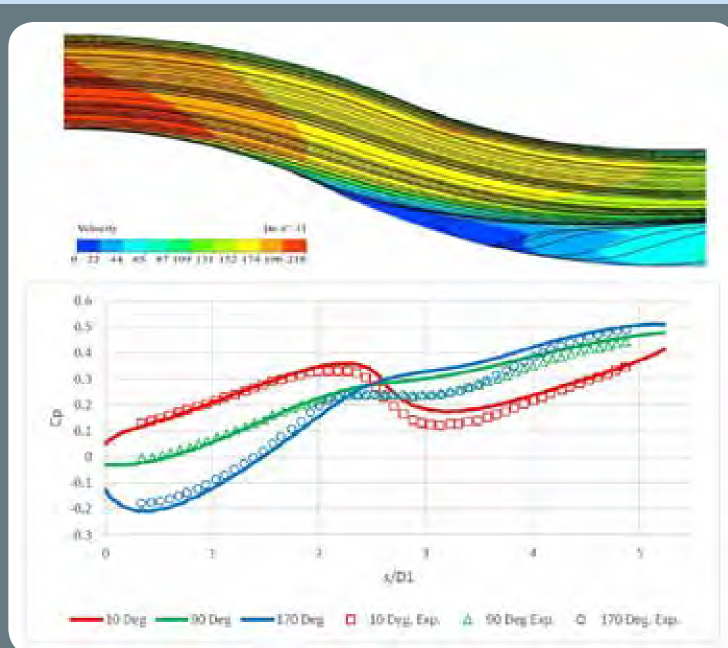
Left: Microstructures of deposits in materials of interest. The NASA EPSCoR-supported work has enabled the characterization of functionally gradient materials (of significant interest for space-based applications) and specifically has enabled improvements in fabrication utilizing these materials.

This NASA ESPCoR project focuses on the development of improvements in fabrication of advanced materials for space application, with specific focus on developing four types of Functionally Gradient Materials (FGM): Ti-6Al-4V/SS316, Cu/Ni, Ti-6Al-4V/TiB, and Ti-6Al-4V/TiC, all of great interest for space applications to NASA and the space industry. This project has brought together a direct laser deposition expert (Frank Liou), a material scientist (Joe Newkrik), manufacturing system integrator (Todd Sparks), electron beam deposition expert (Karen Taminger) from NASA Langley, and computation and modeling expert (William Seufzer) from NASA Langley in this collaboration. In terms of technology transfer and industrial collaborations, the Boeing Company has provided in conjunction with the NASA funds significant funds to conduct Boeing-related FGM research at Missouri S&T. This grant is allowing major improvements in research infrastructure at Missouri University of Science and Technology (S&T). At Missouri S&T, researchers have successfully enhanced metal deposition systems for functionally gradient materials (FGMs). Some of the successful FGM depositions are providing the basis for further advances in space material fabrication and applications. This project has developed techniques for and enabled the successful deposition and grading of advanced materials; including the integration of Ti64 and SS316. These two advanced materials are known to be impossible to integrate in a structure using conventional additive manufacturing processes. This work has demonstrated a general approach which should be useful to many distinct materials. ✺

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, Aeronautics Research Mission Directorate

One of the key goals of this research project has been to develop an improved turbulence model for RANS equations that can significantly increase the accuracy of flow simulations for separated flows, rough wall flows, flows with rotational and curvature effects, and flows with compressibility effects and temperature dependent eddy-viscosity. Development and implementation of rigorous and comprehensive uncertainty quantification (UQ) methodology was another main goal of this research project. The third objective of the project has been to conduct the aerodynamic shape optimization studies using both the deterministic adjoint approach and the stochastic surrogate approach. The research project directly addresses the critical areas listed under NASA's Aeronautics Research Mission Directorate – Fundamental Aeronautics Program's R&D priorities. In particular it addresses the NASA's "CFD Vision 2030" goals. A strong interaction has been established with the researchers in the Computational Aerosciences branch of NASA Langley Research Center and with CFD researchers at Boeing-St. Louis and UTRC. This project is serving as an important catalyst in improving the research and higher education infrastructure in the state of MO. It is allowing major improvements in research infrastructure at Washington University in St. Louis (WU), Missouri University of Science and Technology (MS&T) and Lincoln University. The CFD simulation capability has significantly enhanced addressing research in important areas of Turbulence Modeling, Uncertainty Quantification and Aerodynamic Optimization. At Lincoln University (HBCU), the students are being trained in CFD technology for the first time in its history. The computing infrastructure has also enhanced with the installation of GPU computers at WU. As a result of these major improvements in research infrastructure, it has been possible to develop a new more accurate and very efficient turbulence model for RANS equations of fluid dynamics used in CFD simulations and development of a new methodology for uncertainty quantification and sensitivity analysis. New advanced CFD courses are being developed including the results of this research and students are being trained. Such a trained work force in advanced CFD is very much needed by the aerospace industry. ✺



This figure shows an example of three-dimensional subsonic flow in an S-duct widely used in an aircraft propulsion system. The flow is separated at the lower surface of the duct creating a separation bubble. It is very difficult to predict this flow field using CFD; one of the primary reason being the inability of existing turbulence models to accurately compute the flow using the RANS equations. The top figure shows the velocity contours depicting the separation bubble. The bottom figure shows the comparison of the measured pressure distribution and the computed pressure distribution for flow in the NASA Glenn S-duct using th newly developed Wray-Agarwal model as a result of this grant. Other industry standard turbulence models, namely the Sparlart-Allmaras and Shear-Stress-Transport k-w fail to give such a good comaprision.

Dr. Ramesh K. Agarwal,
Science PI, Bayly Lab,
Washington University in St. Louis

Dr. Mujeeb Malik,
NASA Technical Monitor,
Langley Research Center

MO

Learning Algorithms for Preserving Safe Flight Envelope under Adverse Aircraft Conditions

Missouri University of Science & Technology/NASA Langley Research Center, Aeronautics Research Mission Directorate

Textron Aviation and WSU may partner on this project for flight testing on its specifically modified piston engine aircraft (CJ-144). Flight testing will be performed for the proposed learning algorithms for resilient flight control.

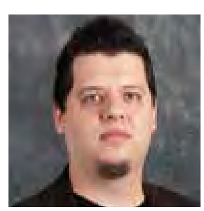
The CJ-144 fly-by-wire flight control system is designed around a Guide Star GS-411 system which interfaces with a 5-hole probe on the wing and a GPS antenna. A series of bezel keys on the glass cockpit give the left-seat pilot control over the flight test maneuvers, adaptive control design parameters, data-logging, and provides feedback on aircraft attitude and control.

Government and industry agree that learning algorithms have potential to provide flight safety in adverse conditions such as degraded modes of operation, loss of control, and imperfect aircraft modeling, and reduce aircraft development costs. However, widespread adoption is hampered by a lack in general and commercial aviation of a-priori, user-defined performance guarantees.

Current practice relies heavily on excessive flight testing as a means of performing verification. Besides the cost, the major drawback of excessive flight testing is that it only provides limited performance guarantees for what was tested; the fixed set of initial conditions, pilot commands, and failure profiles.

This EPSCoR-funded project will develop and flight test learning algorithms with a-priori performance guarantees under adverse aircraft conditions. The novel feature of this research is that the proposed algorithms will have the capability to preserve a given, user-defined safe flight envelope through formal analytical synthesis, and hence, they will not require excessive (costly) flight testing and tools to validate their performance characteristics during the post-design stage, unlike existing learning algorithms proposed for aerospace applications. In addition, methods will be developed to use these algorithms effectively in the pilot decision support display of NASA Ames that indicates the proximity of the aircraft to safe flight boundaries caused by adverse conditions.

The research will impact a broad range of applications utilizing learning algorithms for, among others, safe and effective aircraft control, crew decision-making in complex situations, and CEV/CLV vehicle control. Its outcomes, which include advancement of the theory on verifiable learning algorithms for flight control and pilot awareness systems, simulations at multiple levels of granularity, and flight experiments, will significantly contribute to the current and future NASA research and technology priorities.



Dr. Tansel Yucelen
Science PI
Missouri University of Science and Technology

Dr. Susan Frost,
NASA Technical Monitor,
Intelligent Systems Division,
NASA Ames Research Center

MONTANA

Dr. Angela Des Jardins, MT NASA EPSCoR Director

Great strides have been made in developing Montana research activities aimed at solving current technical and scientific problems facing NASA and the aerospace community. These accomplishments and their resulting infrastructure have allowed many Montana researchers to have opportunities to work with NASA that were not present prior to the implementation of NASA EPSCoR.

The membership of Montana NASA EPSCoR is broad and diverse. All 22 institutions of higher education in the state are affiliates, ranging from small undergraduate institutions, including seven tribal colleges, to Carnegie Research One Montana State University with more than 15,000 students enrolled. The differing nature of the various institutions requires that Montana NASA EPSCoR offer a wide variety of opportunities for faculty and students to match the missions and institutional expectations of the diverse affiliates.

Montana TOC

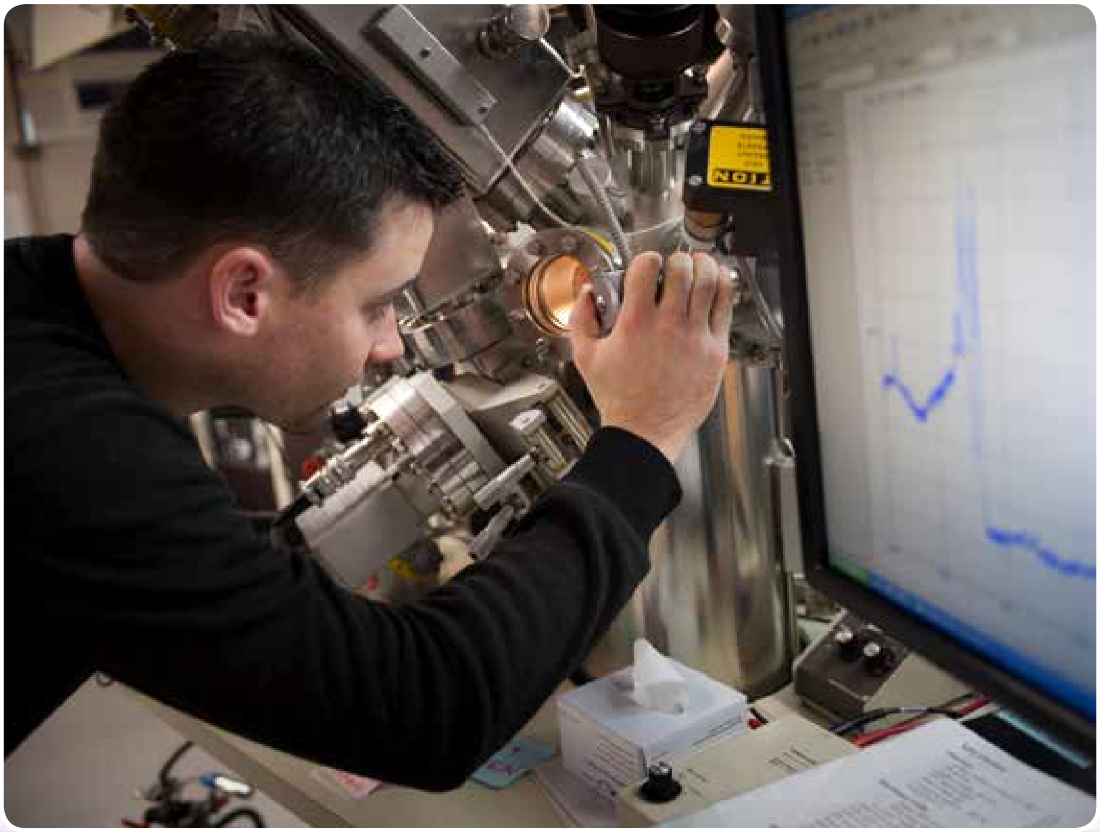
Senator John Tester

Senator Steve Daines

Representative Ryan Zinke (District At Large)

Regenerative SOFC Development for Aerospace Technology Platforms

Montana State University/Human Exploration & Operations Mission Directorate



Stephen W. Sofie,
Science PI,
Montana State University - Bozeman

MONTANA STATE UNIVERSITY

Dr. Serene Farmer,
NASA Technical Monitor,
Glenn Research Center

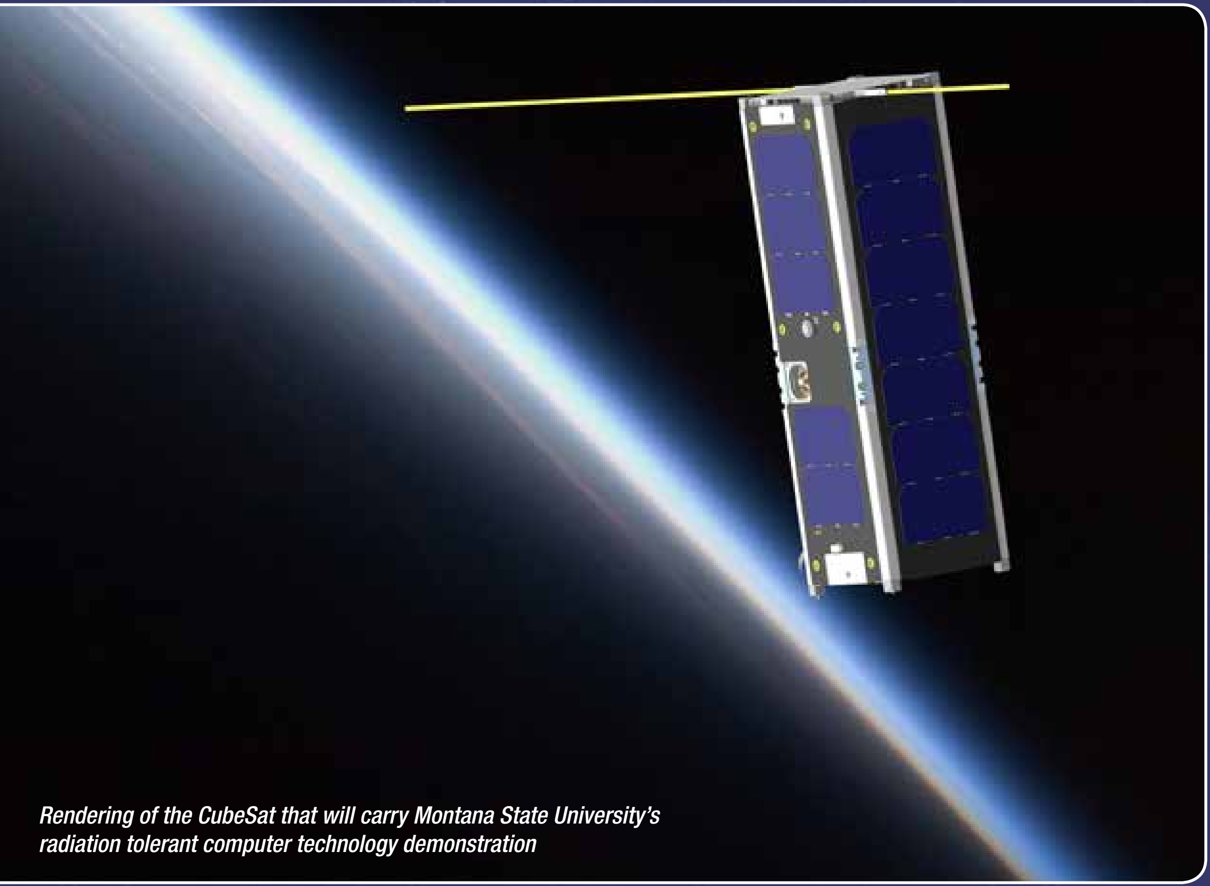
Here a graduate student, David Driscoll, works in the Solid Oxide Fuel Cell (SOFC) lab at Montana State University, where researchers are working to develop better high temperature SOFCs for use in space systems. The SOFC has many key advantages that make it stand out in the field of fuel cells. These capabilities make the SOFC highly versatile for: primary/secondary power systems, advanced life support, and in-situ resource utilization which may all be desired for a forthcoming Lunar return and Mars Exploration. This SOFC work was in collaboration with NASA's Glenn Research Center as well as Boeing. The team has won over $550,000 in follow-on funding for continued research.

The goal of this proposed project was to develop and test novel anode materials that can mitigate the deleterious effects of electrode catalyst coarsening under the high operational temperatures of aerospace based fuel cells. The objectives of this project focused on two parallel paths to enhanced temperature catalyst stability to meet both the project goals and to enhance NASA developed SOFC technology. In addition, project objectives also included enhancing the testing capabilities of high temperature electrochemical energy conversion systems at both the single cell and small stack scale with advanced in-situ diagnostic methods.

The achievements of this project are measured in not only the direct research outcomes, but also the growth of the MSU research capabilities that have enabled success in competitive grant support. These achievements include: a multitude of publications and presentations that were generated through the activities in this project, new testing capabilities that were established to test and evaluate larger scale fuel cell systems, many science and engineering outreach activities at local high and middle schools were facilitated by participating faculty to generate knowledge and interest in MSU/NASA technology development, numerous undergraduate researchers that have been integrated into NASA relevant materials and energy research, two PhD students graduated with dissertations that directly supported the project outcomes, collaborations with National Labs, Academic Institutions, and Industry that are continuing beyond the project duration, and finally $550,000 of competitive grant support was recently established through the results generated in this work. ✺

Development and Testing of a Radiation Tolerant Flight Computer with Real-Time Fault Detection, Recovery, and Repair

Montana State University, Bozeman/NASA Human Exploration & Operations Mission Directorate



Rendering of the CubeSat that will carry Montana State University's radiation tolerant computer technology demonstration

MONTANA STATE UNIVERSITY

Dr. Brock LaMeres,
Science PI,
Associate Professor,
Montana State University, Bozeman

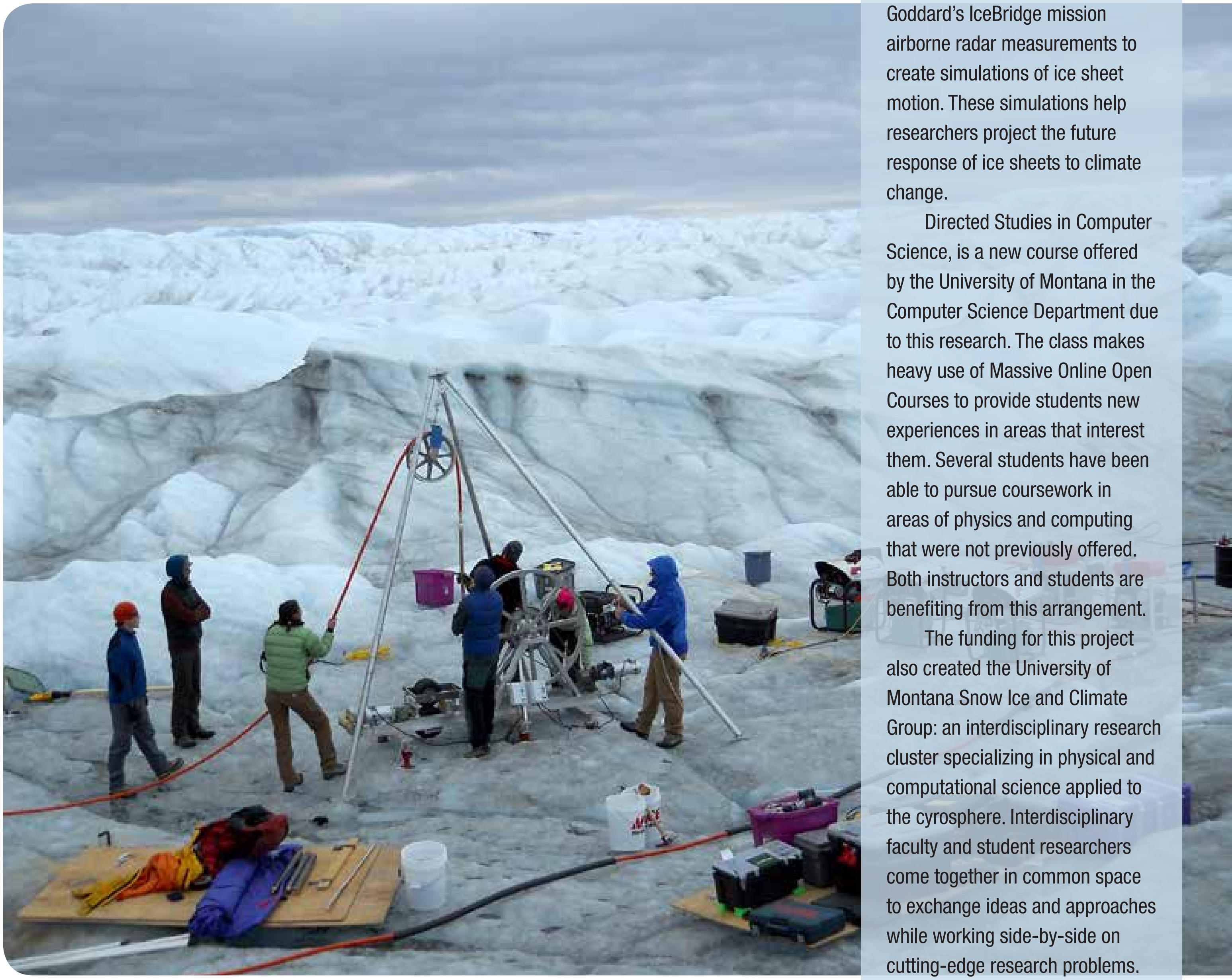
Eric Eberly,
NASA Technical Monitor,
Marshall Space Flight Center

The overall goal of the project was to design, manufacture, and test a novel reconfigurable flight computer that can deliver increased reliability in the presence of cosmic radiation. The research is in conjunction with NASA's Marshall Space Flight Center and Montana State University's Space Science and Engineering Laboratory. The primary systemic change created by the NASA EPSCoR funding is in the ability for Montana State University to conduct competitive research in the areas of: 1) space computer systems; 2) high energy radiation sensing; and 3) radiation tolerant space systems. Prior to EPSCoR funding, there was no research being conducted in these areas in the State of Montana. The lasting infrastructure built through EPSCoR funding includes faculty expertise, lab facilities to develop, test, and analyze these systems, design heritage of incrementally maturing computer technology that motivates future research, and a comprehensive publication set that is used to train future faculty and students. The resulting computer technology has been licensed for commercial use in small-satellite systems. ✺

Enhancement of NASA's Polar Research Missions: Adjoint Data Assimilation into Numerical Models to Reveal Physical Properties of the Greenland Ice Sheet

MT

The University of Montana/NASA Goddard Flight Research Center



Researchers from University of Montana gather data in the field that is paired with the NASA Goddard's IceBridge mission airborne radar measurements to create simulations of ice sheet motion. These simulations help researchers project the future response of ice sheets to climate change.

Directed Studies in Computer Science, is a new course offered by the University of Montana in the Computer Science Department due to this research. The class makes heavy use of Massive Online Open Courses to provide students new experiences in areas that interest them. Several students have been able to pursue coursework in areas of physics and computing that were not previously offered. Both instructors and students are benefiting from this arrangement.

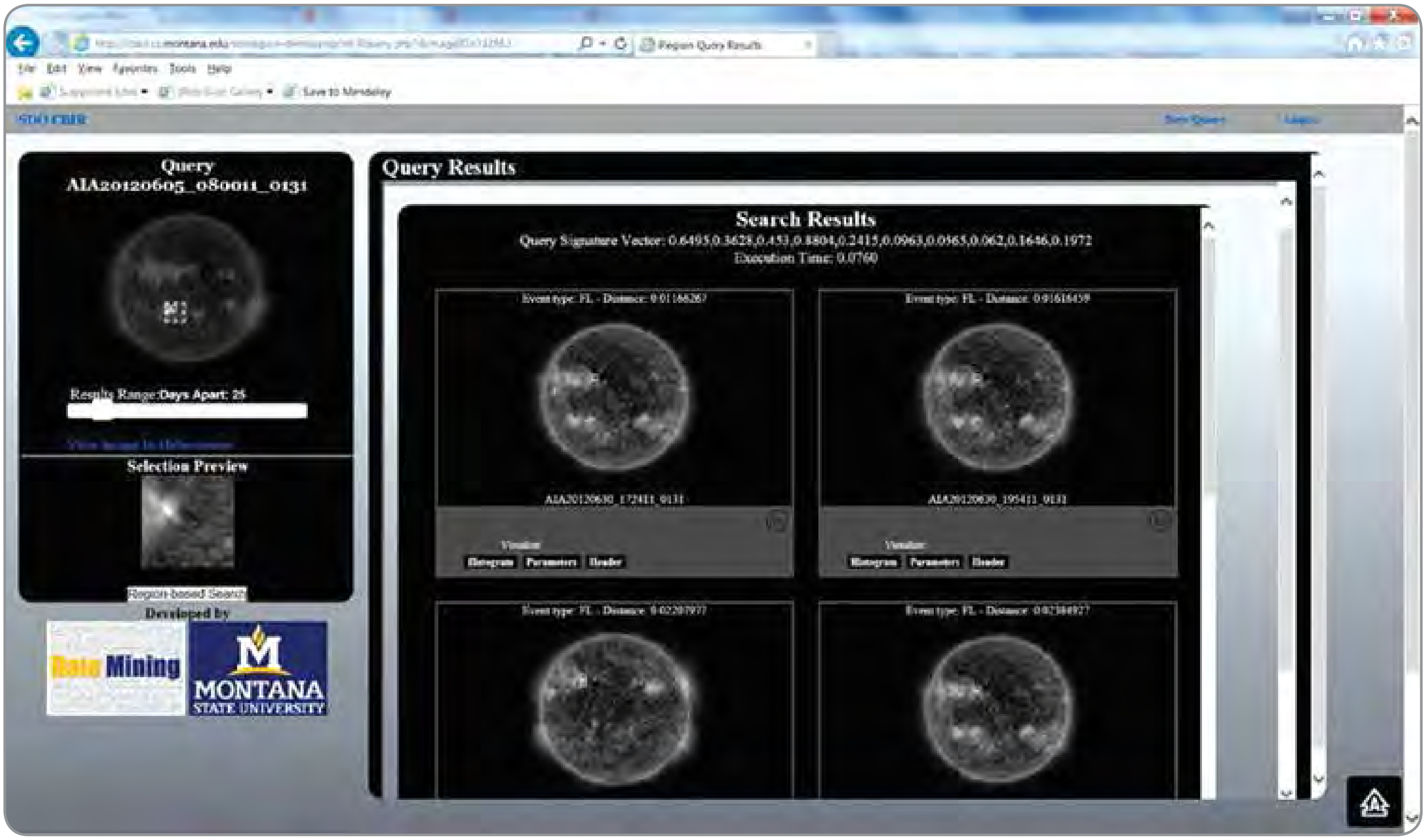
The funding for this project also created the University of Montana Snow Ice and Climate Group: an interdisciplinary research cluster specializing in physical and computational science applied to the cyrosphere. Interdisciplinary faculty and student researchers come together in common space to exchange ideas and approaches while working side-by-side on cutting-edge research problems. The experience and momentum gained from this project has establish the group in the top five in the world, greatly increasing their competitive for follow-up funding and perform cutting-edge and transformative research. ✺

Joel T Harper and Jesse Johnson, Co-Science PIs, Montana State University

Thomas Wagner, NASA Technical Monitor, NASA Headquarters

Large-scale Content-based Image Retrieval System (CBIR) for Interactive Search through the Virtual Solar Observatory (VSO)

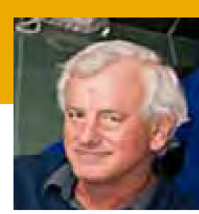
Montana State University/NASA Goddard Space Flight Center, Science Mission Directorate



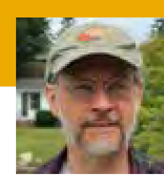
We started our work on this grant at the end of 2011, and made the first public release of the system's prototype about a year later. The first release enabled image search using entire disk images. Since 2013 we kept working on enabling a far more challenging (but also more desired) region-based Content-based Image Retrieval (CBIR) system for SDO data. Currently, we are happy to report that the first version of our region-based CBIR system has been released (new URL: http://cbsir.cs.montana.edu/sdoregion-demo/php/rrt-sdoRegion-demo.php). The region-based CBIR will enable the solar physicists to look for visually similar solar phenomena (marked as region(s) on the Sun). Now, the main (and non-trivial challenge) is to transfer Ph.D. work of our graduate assistant on multi-dimensional data index to the actual backbone of our CBIR system, that will enable such search in the real-time through the repository as massive as Solar Dynamic Observatory.

Despite significant reduction in the number of graduate assistants employed by this grant (last year we had three, and now we have one), we have been making study progress on the development of data sets benchmarks and high dimensional indexing technique for our database. The first is necessary to accurately assess the results returned by our region-based CBIR system; the second is of crucial importance for our solutions to scale-up to the image data repository of the size as big as the SDO mission. ✺

Our $1.5M NSF grant (Title of Award: CIF21 DIBBs: Systematic Data-Driven Analysis and Tools for Spatiotemporal Solar Astronomy Data) had press release at GSU. You can read about it at: http://news.gsu.edu/2014/09/03/researchers-get-1-5-million-develop-solar-astronomy-data-larger-scale/



Petrus C. Martens, Science PI, Montana State University



Dr. Aaron Roberts, NASA Technical Monitor, Goddard Space Flight Center

MONTANA STATE UNIVERSITY

Minority Serving Institution Faculty Development Program

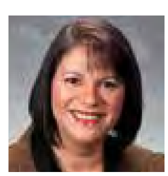
Montana State University/College of Menominee Nation/JPL and Johnson Space Center

A former president of the College of Menominee Nation rocketry club and a mentor to students at Wisconsin tribal colleges interested in space flight hardware development was in residence at SKC (Salish Kootenai College) learning about the BisonSat design and the development approaches used by the BisonSat team. He also made substantial contributions to the modeling of the thermal behavior of BisonSat, and helped BisonSat student team members with the design and construction of a torsion pendulum for measuring BisonSat moment of inertia tensor components and played a key role in helping develop the solar panel fabrication process we used for BisonSat and mentoring SKC students who performed the panel fabrication. Other tribal faculty members and students from the College of Menominee Nation participated in the summer workshop. The SKC CubeSat (BisonSat) team was notified in February 2013 that it was selected for manifesting on the National Reconnaissance Office L-55 GRACE mission scheduled for launch as early as December 2014, with CubeSat delivery to the launch provider required in June 2014 to support the December 2014 launch date, later delayed to September 2015. BisonSat has been completed and delivered to the launch provider. The outcome has been achieved.

Many of the space flight hardware development that were performed by the BisonSat team were the first time these tasks have been performed at SKC, and so these experiences have significantly increased the capability of SKC to participate in or lead future space hardware development projects.

Assembly of the BisonSat flight unit in preparation for bakeout and thermal vacuum testing. This work was performed in December 2014 at the Montana State University Space Science and Engineering Laboratory. Bakeout is one of the required procedures and tests needed to certify the satellite as safe for flight. BisonSat has been certified as flight ready and is awaiting launch on the NRO GRACE/ELaNa-12 mission in September 2015.

Angela C. Des Jardins, PhD, Science PI, Montana State University, Bozeman



Theresa Martinez, PMP, NASA Technical Monitor, Kennedy Space Center

Research Infrastructure Development (RID)

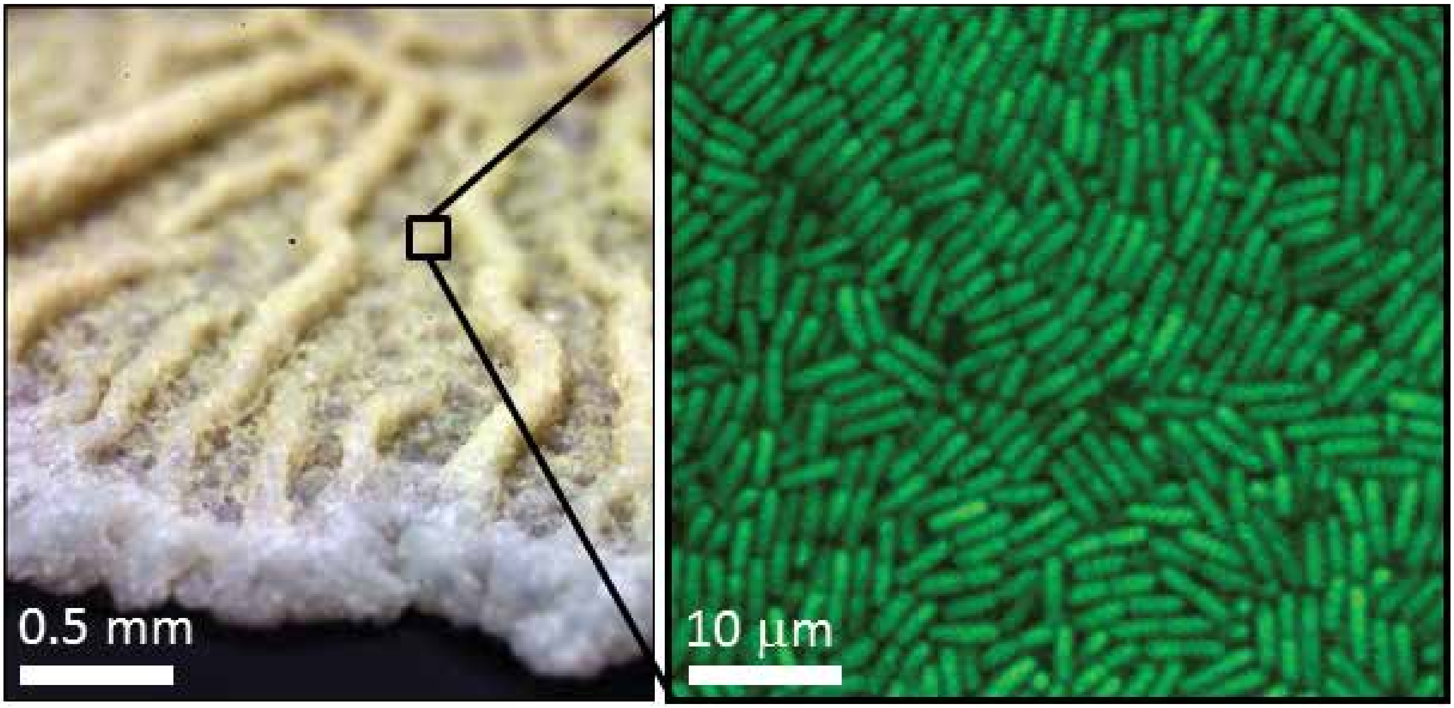


Photo by 2015 Research Initiation Grant PI Dr. James Wilking. Dr. Wilking's work, in conjunction with NASA Johnson Space Center researchers, is to better characterize biofilms in human space water recovery systems. Left: Bacterial biofilm grown on a petri dish. Right: Microscopy image of biofilm structure. Bacteria (green) densely packed in a polymer gel (not visible).

The Montana RID award's goal is to boost the research programs of Montana college and university faculty research in areas that match scientific and technical problems of importance to NASA to a new level of national prominence, enabling them to compete successfully for regular NASA research funding.

RID Opportunities

An initial step on the ladder of NASA-related research opportunities available to Montana faculty since 2011 is our NASA EPSCoR Faculty Connections Program. The purpose of the Faculty Connections Program is to lay a foundation for long-term NASA relationships by creating opportunities for deeply meaningful visits to NASA centers by Montana faculty who are interested in fostering NASA-related research on their home campus. General travel for faculty, postdocs, and students to explore and develop collaborations with NASA researchers at Centers and at NASA-related conferences is also available and is a cornerstone of the RID program.

Farther up the ladder are Research Initiation Grants, intended to help new or transitioning faculty at Montana colleges and universities develop nationally competitive research programs in fields related to space sciences and engineering. Grants are for a period of one year and all grantees are expected to submit a follow-on proposal to NASA, other agencies, or industry. Proposals are reviewed by an internal panel comprised of faculty representatives from several campuses with expertise in a variety of technical fields and strong previous involvement with NASA programs. The review panel ranks the proposals according to: 1) scientific/Engineering impact, 2) NASA connection, 3) technical feasibility, 4) broader impacts such as state research infrastructure and economic development, 5) suitability of the proposed research team and 6) probability of the work resulting in further NASA funding

While past participation in the higher rung Research Initiation Grants has primarily been at the larger research institutions, a current and ongoing priority is to increase the involvement of Montana's smaller schools, particularly the Tribal Colleges.

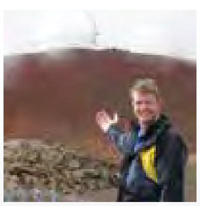
MT

Minerva: A Dedicated Observatory for Exoplanet Science

University of Montana, Missoula/NASA Goddard Space Flight Center, Glenn Research Center, Jet Propulsion Laboratory, Ames Research Center, Science Mission Directorate

UNIVERSITY OF MONTANA

The four telescopes of Project MINERVA are located at Fred Lawrence Whipple Observatory in Arizona. The University of Montana telescope, funded by a NASA EPSCoR grant, is at the far right of the image. These four telescopes observe targets together or separately to search for rocky, Earth-analogue exoplanets around nearby Sun-like stars.The fifth telescope, in the foreground, is the related project MINERVA-Red, which will search nearby low-mass stars for exoplanets.



Dr. Nate McCrady,
Science PI,
University of Montana, Missoula

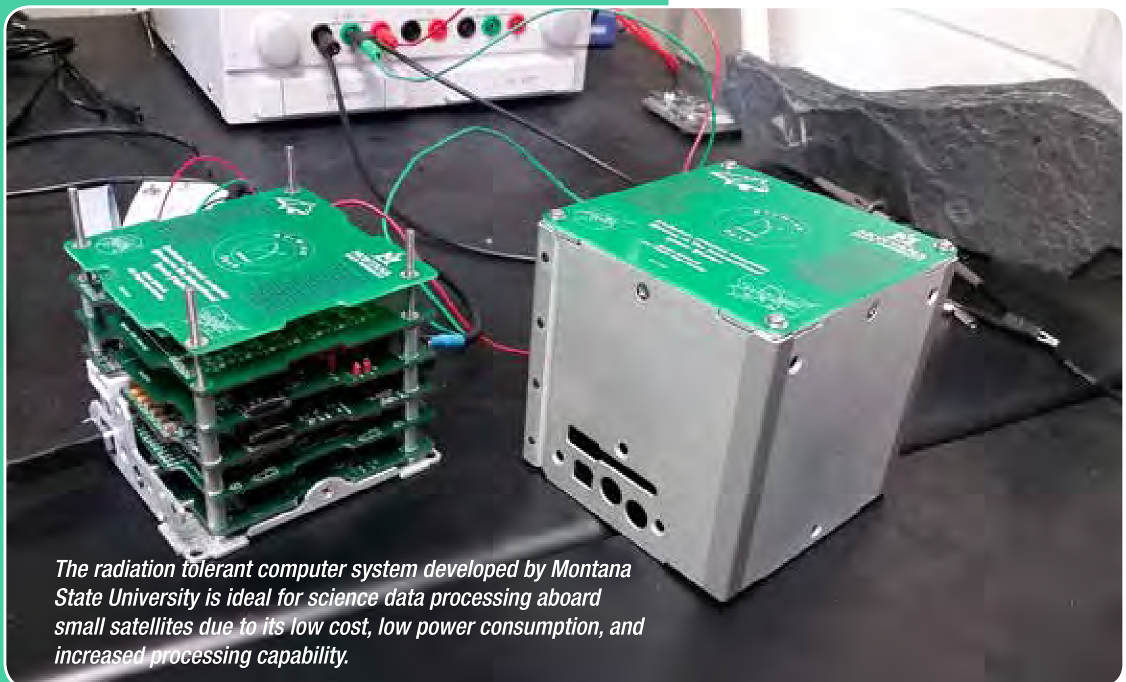
Dr. Charles Beichman,
NASA Technical Monitor

MINERVA science aligns with the NASA Exoplanet Exploration Program (ExEP) in the Astrophysics Division of the NASA Science Mission Directorate (SMD). The goal of detecting nearby habitable planets was established by the 2004 report The Vision for Space Exploration, which directed NASA to "Conduct advanced telescope searches for Earth-like planets and habitable environments around other stars." The 2010 Science Plan for SMD reaffirms the ultimate goal of extending exoplanet "exploration to the detection of habitable, Earth-like planets around other stars... and to search for indicators that they may harbor life."

MINERVA research at the University of Montana has significantly enhanced research infrastructure in Montana. UM faculty and undergraduate students are now using world-class telescope and imaging equipment, both in person (at the MINERVA observatory site at Whipple Observatory in Arizona) and remotely via the Internet. EPSCoR funding has established an exoplanet research group at UM, led by Scl McCrady, currently number two faculty and seven current or just-graduated undergraduates. ✷

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

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



The radiation tolerant computer system developed by Montana State University is ideal for science data processing aboard small satellites due to its low cost, low power consumption, and increased processing capability.

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

Steve Huning, NASA ISS RIM, Johnson Space Center

MONTANA STATE UNIVERSITY

A demonstration on the International Space Station is the next step in the technology maturation of a radiation tolerant computer system that was invented at Montana State University. The new computer system promises to deliver increased reliability and performance at a fraction of the cost of existing rad-hard space computers. The computer was developed through NASA EPSCoR funding and uses off-the-shelf Field Programmable Gate Arrays (FPGAs) to dynamically detect and repair faults caused by ionizing radiation. The FPGA contains a many-tile architecture that allows redundant versions of the computer system to run in parallel in addition to spare processors that can be brought online in the event of a failure. The system also contains a spatial radiation sensor to provide information about radiation strikes that may have occurred but have not yet caused a computer failure. This technology has been demonstrated under radiation bombardment in a cyclotron, numerous high altitude balloon flights, and on a sounding rocket mission. Through funding from the NASA EPSCoR ISS Flight Opportunity program, the MSU computer will be demonstrated on a six month mission in Low Earth Orbit to stress the system in its harshest environment yet. ✷

Montana State University students work in the nano fabrication lab.

Nanostructured Polarization Optics for Atmospheric Remote Sensing

MT

Montana State University – Bozeman/NASA Jet Propulsion Laboratory, Goddard Space Flight Center, Ames Research Center, Science and Space Technology Mission Directorates

The overall goal of this project is to develop new tools for polarimetry and polarimetric imaging using nanotechnology. An enhanced ability to "see" polarized light and at wavelengths outside the visible range (e.g. in the infrared) can provide a wealth of new information, and has potential applications in remote sensing, environmental monitoring, and medical applications. In this project, we intend to develop a new family of infrared wavelength and polarization filters based on nanostructures in silicon and compatible materials. A key advantage of this technology is that it can be readily adapted to different wavelengths and polarization configurations, making it a flexible platform for the development of filters optimized for a range of applications. The first application goal for this project is a study of polarimetric imaging for the discrimination of cloud phase (ice/water), addressing one of the most significant open questions in current climate models. Once this technology platform is developed, it can be used to extend to a broad range of further applications involving polarization-based sensing and imaging. ✺

Students working in the clean room on the fabrication of novel polarization and wavelength filters based on optical nanostructures in silicon and compatible materials.

Dr. Wataru Nakagawa, Science PI, Montana State Untiversity

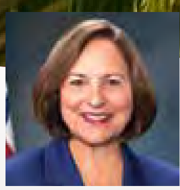
Dr. David J. Diner, NASA Technical Monitor, Jet Propulsion Laboratory

MONTANA STATE UNIVERSITY

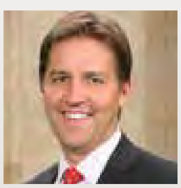
NEBRASKA

Dr. Scott Tarry,
NASA Nebraska EPSCoR

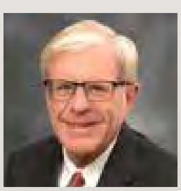
The NASA EPSCoR Research Infrastructure Development (RID) program has been especially influential in the enhancement of research capacity in the State of Nebraska. We have leveraged RID funds to seed research that is not only aligned with and supportive of NASA's mission, but also focused on topics and disciplines that are important to Nebraska and its research universities. Eight of the projects seeded with RID funds since 2008 have gone on to win NASA EPSCoR Research funding at the national level. These projects have, in turn, then successfully competed for non-EPSCoR funds from NASA and other federal programs. For example, RID funds helped seed the University of Nebraska at Omaha's Biomechanics Research program which recently received the largest grant in university history, a $10 million award from NIH to support research and education, as well as $6 million in private funds to build a new research facility.



Senator
Deb Fischer



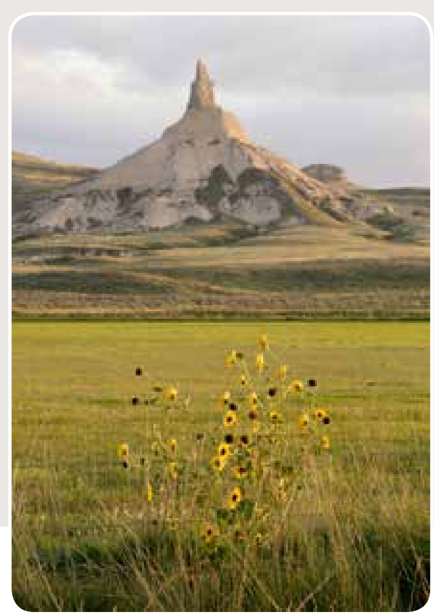
Senator
Ben Sasse



Representative
Brad Ashford
(2nd District)

Representative
Jeff Fortenberry
(1st District)

Nebraska TOC

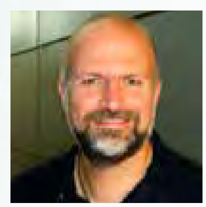


The Role of Tactile Sensation on Locomotor Adaptation in Astronauts Returning from Long Duration Spaceflights

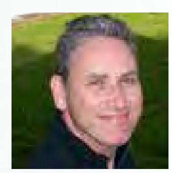
University of Nebraska at Omaha/NASA Kennedy Space Center, Human Exploration & Operations Mission Directorate

Experimental setup in the virtual reality laboratory (top). The visual stimulus provides accurate optic flow to enhance the illusion of self motion during treadmill locomotion. In specific aim 3, data collection is performed at Johnson Space Center (bottom).

The research is to determine the effect of stimulation to different sensory systems, specifically through Virtual Reality and vibrotactile stimulation, on locomotor adaptation, in hopes of developing interventions to attenuate the effects of sensory disturbances resulting from space flight. The project is based upon the investigator's previous work on the effects of VR on human locomotion. Six faculty including three post-docs, and two graduate students were part of the research team in the past year. ✺



Dr. Nick Stergiou,
Science PI,
University of Nebraska at Omaha

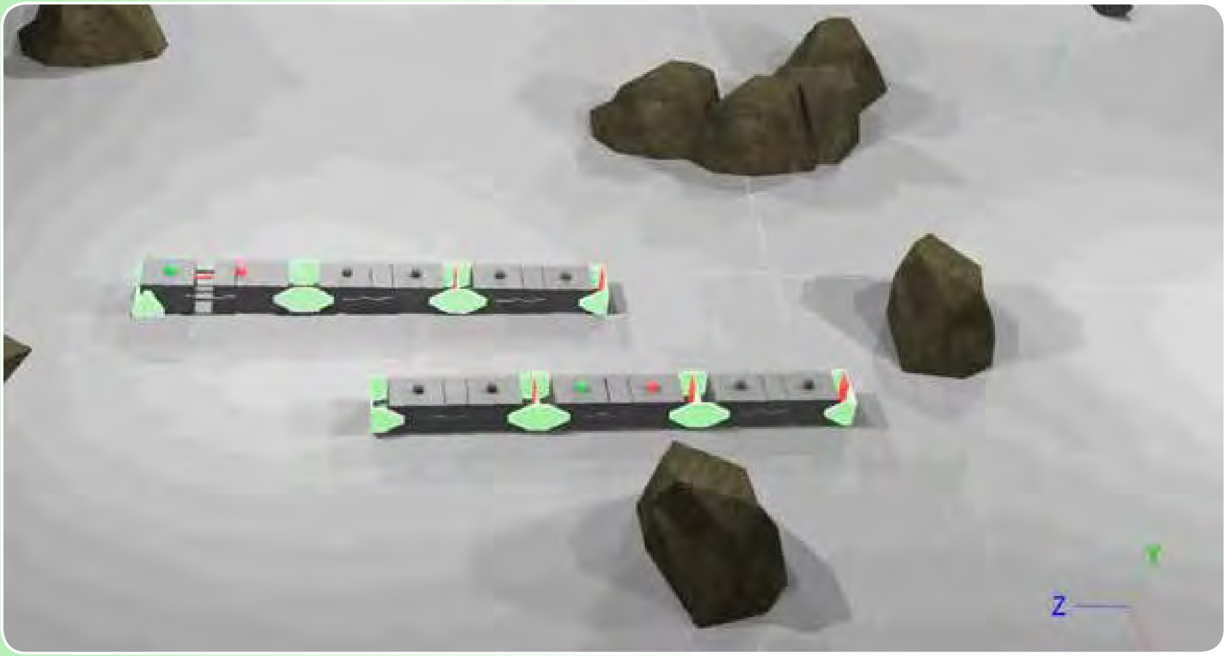


Dr. Jacob Bloomberg,
NASA Technical Monitor,
Johnson Space Center

UNIVERSITY of NEBRASKA OMAHA

A Highly Dexterous Modular Robot with Autonomous Dynamic Reconfigurations for Extra-Terrestrial Exploration

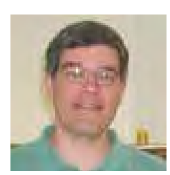
University of Nebraska at Omaha/NASA Johnson Space Center, Human Exploration & Operations Mission Directorate



The research goals related to hardware development in the original proposal were: develop more advanced 4-DOF MSR prototypes; optimize robot for minimum weight and high dexterity; demonstrate/quantify task-based performance gains compared to past MSRs; and demonstrate flexible self-reconfiguration abilities. We have made significant progress in all these areas during the current reporting period. The new version of the ModRED modular robot system has now been designed, and includes upgraded computational hardware, sensors, motors and motor control, and docking mechanisms. It is much more weight-efficient compared to earlier prototypes and will therefore be more task-capable. In a PhD thesis directly resulting from this work, just completed recently, comparisons are made between the current ModRED design and other existing modular robots. Performance gains are noted in docking time and holding force, dexterity and gaits, and variety of possible configurations. Prototype fabrication is currently being finalized, and upcoming testing is expected to bear out these improvements. Collectively and with the doubling of docking ports on the new robot design, this is expected to lead to demonstration of flexible self-reconfiguration abilities. ✺

UNIVERSITY of NEBRASKA OMAHA

Raj Dasgupta,
Science PI,
University of Nebraska at Omaha



Dr. James G. Mantovani,
NASA Technical Monitor,
Johnson Space Center

Nebraska Research Infrastructure Development

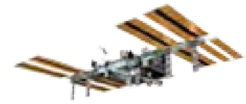
NE

A Novel and Simple Tool to Measure Health

A team of scientists at the University of Nebraska at Omaha (UNO) has developed a novel device aimed at measuring health and the presence of pathology. Dr. Jenna Yentes and graduate student, William Denton, have been working for the past year on the development of a noninvasive, simple, and effective tool that could potentially determine irregularities in biological systems and/or the effectiveness of rehabilitation. The device monitors human movement variability, which are the natural fluctuations, or variations, present in any given movement. These fluctuations represent healthy movement patterns as they are adaptable and can vary to the ever-changing needs of the body. The device monitors these fluctuations, alerting the end-user (e.g., health care provider) of changes in the health of the individual. The NASA EPSCoR mini-grant award has allowed them to determine the validity and reliability of the prototype. This research has successfully allowed them to enter a licensing agreement with a corporation to develop their device commercially and the commercial development is currently underway. Dr. Yentes' future work will focus on the clinical utility of the device, determining the validity of predicting pathological events by monitoring biological rhythms through the device. This device is the first of its kind. Significant findings from this research project could lead to challenging current rehabilitation dogmas, setting UNO in an elite league of institutions. ✺

Dr. Jenna Yentes, University of Nebraska at Omaha

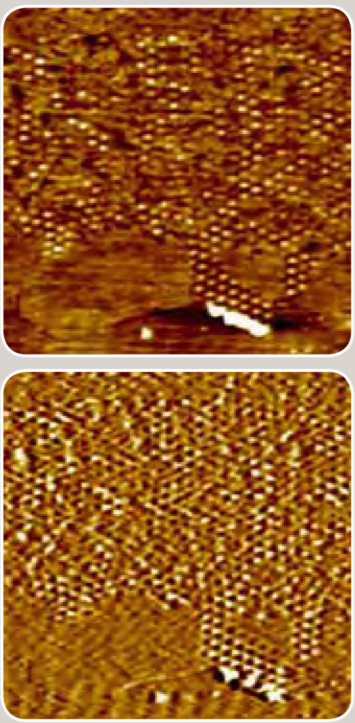
Dr. Yentes and subject during a data collection to test the validity of the device that was developed to monitor human movement variability.



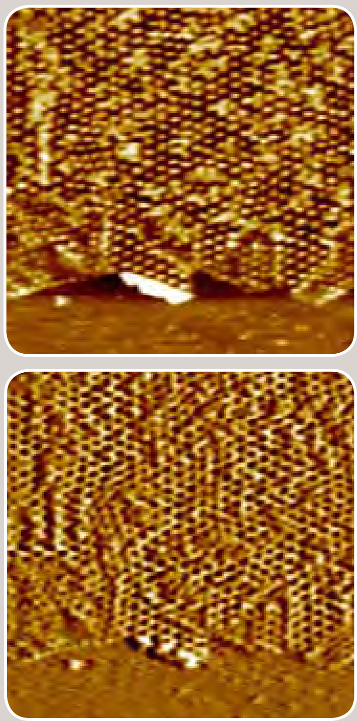
ISS Flight Op - Investigation of fatigue due to solar neutron and other radiation absorption in new materials for neutron voltaic devices

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

The goal of this project is to develop a boron-carbide-based semiconducting neutron/alpha particle voltaic device that can be ultimately employed to power NASA deep space probes. Since solar power is not available in deep space, deep space probes are currently powered by sub-critical thermo-nuclear reactors fueled by plutonium 238. This power generation approach is inefficient, hot and requires a relatively large amount of plutonium and extensive shielding to protect satellite systems from the generated radiation. An alternate approach would be to employ neutron based photovoltaic devices, which have the potential to supply the energy needed to power deep space satellites and probes. The key component in this scheme is the neutron voltaic device, which will be developed through this project. This research aligns with the NASA Strategic Vision and Strategic Plan which both outline NASA's goal to "Create the innovative new space technologies for our exploration, science, and economic future." To achieve the research goal the PIs collaborate with NASA scientists at Glenn Research Center and have formed a partnership with NASA's ISS space flight program to install a materials science experiment at the International Space Station.

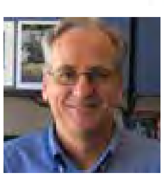


Top: STM image at +2V bias voltage. Bottom: corresponding map of the electronic density of states from tunnel spectroscopy.



Top: STM image at +4V bias voltage. Note the contrast inversion with respect to the image above left. Bottom: corresponding map of the electronic density of states from tunnel spectroscopy.

Nebraska Lincoln



Steve Huning,
NASA Technical Monitor,
Research Integration Manager,
NASA Johnson Space center

Prof. Axel Enders,
Science PI,
University of Nebraska, Lincoln

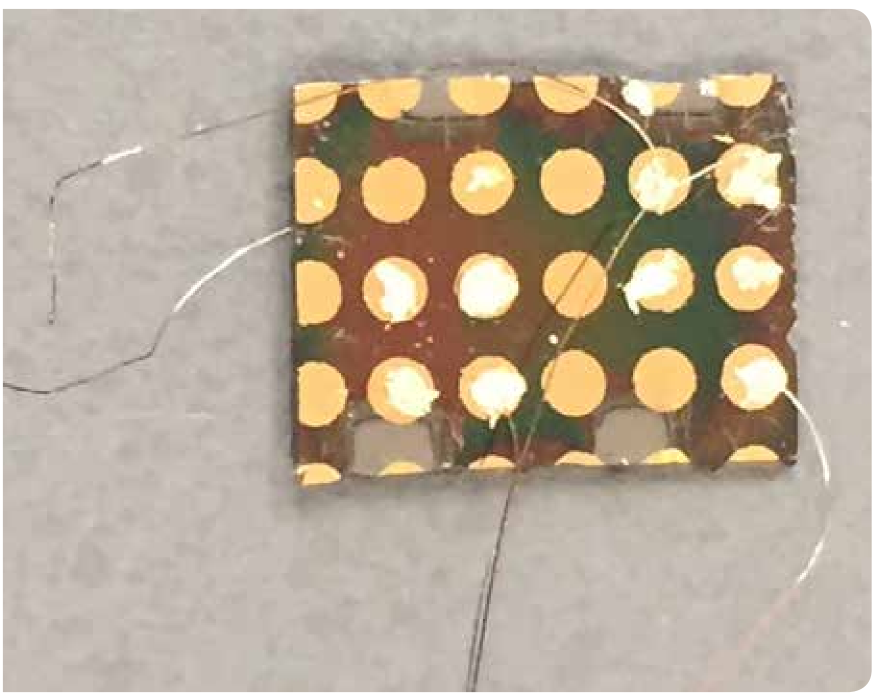
Through this NASA-EPSCoR-funded project the PIs were able to establish fruitful collaborations with other federal agencies such as the Air Force, with researchers from 4 other academic institutions, and have formed a partnership with private sector industry, specifically here with Rhombus LLC. Through these collaborations this research project is expected to impact not only the development of new boron-carbide based semiconductors for neutron voltaics, it will more broadly accelerate the developments of new materials for power generation and radiation detection and shielding.

Systemic changes enabled through this grant include the installation of a new research facility at UNL's Department of Electrical Engineering, to perform Plasma Enhanced Chemical Vapor Deposition (PECVD) System for thick film growth. This facility and the research that emerges from its availability does not only enable additional partnerships with scientists from the academic and the private sector, it has also helped the team attract additional funding for related research projects and to make the Nebraska University a recognized center for the development of boron carbide based materials. Leveraged with other funding, this project thus far has provided research opportunities to 4 faculty at the University of Nebraska, 4 postdoctoral researchers, 7 graduate students and 12 undergraduate researchers. Three of our graduate students were able to receive competitive, prestigious research awards. The University of Nebraska as well as the Nebraska Research Initiative have recently committed significant additional funds to support the collaborative research of the PIs beyond its current level. ✺

Neutron Voltaics for Deep Space Missions

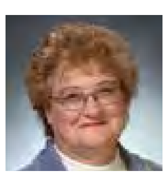
University Of Nebraska at Omaha/NASA Marshall Space Flight Center, Goddard Space Flight Center, Glenn Research Center, Ames Research Center, Jet Propulsion Laboratory, Human Exploration & Operations Mission Directorate, Science Mission Directorate, Space Technology Mission Directorate

Complete PECVD system showing plasma chamber on the left and instrument control track on the right.



The goal of this project is to develop a boron carbide based p-i-n neutron/alpha particle voltaic device that can be ultimately employed to power NASA deep space probes. This goal will be achieved by pursuing 4 clearly stated objectives during this 3-year project. In agreement with our research plan, we performed research addressing our objective #1 "Develop boron carbide based semiconductor materials with enhanced charge separation to allow for efficient charge collection in neutron voltaic devices", and partially addressing our objective #2 "Explore a matrix of dopant materials to control the electronic properties of boron carbide in order to yield the most effective devices." In addition, we prepared the infrastructure to grow thicker boron carbide films, which enables us to perform research addressing objective #3 "Develop approaches to grow thick materials for the I layer without sacrificing material properties" and objective #4 "Design, fabricate and test p-i-n device structures for neutron voltaic applications" in years 2 and 3. Key to success is our close collaboration between nanomaterials scientists, device engineers, and theorists.

Prof. Axel Enders, Science PI, University of Nebraska, Lincoln



Dr. Sheila G. Bailey, NASA Technical Monitor, Glenn Research Center

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

University of Nebraska at Lincoln/NASA Glenn Research Center, Space Technology and Aeronautics Research Mission Directorates

Nebraska Professors George Gogos, Dennis Alexander and Sidy Ndao are leading an interdisciplinary effort to create functionalized metallic surfaces for thermal management systems in space applications. They treat a surface with a laser to create microstructures and nanostructures, thus giving the metal entirely different and desirable properties.

This method is preferred over coatings and polymers as they are not very permanent, especially at high temperatures. The team says many of these other polymers are wonderful, but we all know Teflon comes off our cooking pans. "When we functionalize a metallic surface, the altered surface material is exactly the same as what you start out with. Because of that, the functionalized surfaces are much more permanent," says Alexander

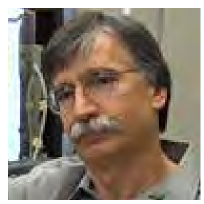
When the researchers functionalized stainless steel pans, they noticed that water boiled more quickly than in an untreated pan. That is when research began on the heat-transfer properties associated with these new surfaces.

The NASA EPSCoR grant will allow for better thermal management of NASA applications by using titanium and silicon carbide in the functionalization process to improve thermal heat management during space travel.

The team has strong NASA collaborations at NASA's Glenn Research Center, including work with Dr. Janet Hurst, Dr. Mohammad Hasan, and Dr. Vehda Nayagam. A doctoral student on the team is the recipient of the prestigious NASA Space Technology Research Fellowship, the first awarded to a Nebraska student.

This research is making an impact on the research capacity in Nebraska. An invention disclosure has been submitted and is currently being considered for patent application. The research is of interest to Nebraska industry where the team is collaborating with companies such as Hexagon Lincoln, Li-Cor, ConAgra, and Global Functionalized Surface Technologies (GFS) to solve specific problems and advance manufacturing technology. ✺

Video Link:
https://youtu.be/4EzcX5oDxhY?list=UUZ624sI5RmsyzOyOB89xGTg



Prof. George Gogos,
Science PI,
University of Nebraska Lincoln

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

University of Nebraska Lincoln

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

University of Nebraska/NASA Johnson Space Center, Human Exploration & Operations Mission Directorate, International Space Station

NE

Superoxide dismutases (SODs) are important antioxidant enzymes that protect all living cells against toxic oxygen metabolites, also known as Reactive Oxygen Species (ROS). SODs are the first line of defense to protect organisms against metabolic- and ionizing radiation-induced ROS. Mutations in SOD lead to degenerative diseases such as amyotrophic lateral sclerosis (ALS), diabetes, and cancer.

Despite the biological and medical importance of SOD, the enzymatic mechanism is still unknown; precise structural data are needed to understand it. This proposal will study SODs from the model system Escherichia coli as they are easy to produce, stable, and the active sites are identical with human homologs. Bacteria have both Fe and MnSOD. The binding sites of the diatomic substrate and product as well as the source of the protons in the reaction have been studied but their exact identification has not been possible.

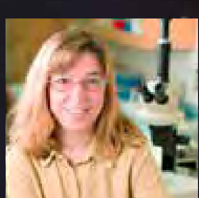
This detailed information can only be determined by neutron diffraction. Complexes of the Fe and MnSOD including structural intermediates and mutants will be the targets for large volume crystal (1 mm cubed) growth for structure determination by Neutron Macromolecular Crystallography (NMC). SOD crystals large enough for neutron studies were successfully grown by the Borgstahl laboratory on the International Space Station (ISS) in 2001.

With NASAs renewed interest in protein crystal growth aboard the ISS we would like to move forward with these exciting early microgravity crystallization results for SOD. Existing crystallization facilities, such as the Granada Box Facility (GBF) that employs capillary counterdiffusion protocols, or the Protein Crystallization Facility (PCF) that uses vapor diffusion methods, will be used to achieve these goals. NMC will be performed with collaborators at Oak Ridge National Laboratory. ✺

▲ Innovation and imagination are all that are required to use the Light Microscopy Module (LMM) as a laboratory microscope to perform research aboard the International Space Station (ISS). The LMM, used here by Italian astronaut Paolo Nespoli, a remotely controllable, time—the effects of the space environment on physics and biology. Specimens can be studied without the need to return the samples to Earth.

◄ The LMM flight unit features a modified commercial laboratory Leica RXA microscope configured to operate in an automated mode with interaction from the ground support staff. Its core capabilities include a level of containment, white light imaging, fluorescence, confocal microscopy (available in 2016 to 2017), and an imaging capability from a Q-Imaging Retiga 1300 camera.

UNIVERSITY of NEBRASKA OMAHA



Gloria Borgstahl, Ph.D., Science PI, Professor, Eppley Institute, University of Nebraska Medical Center

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

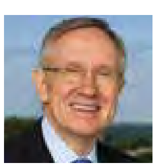
NEVADA

Dr. Lynn Fenstermaker,
Director NV NASA EPSCoR,
University of Nevada, Reno

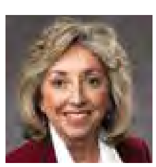
Nevada research, infrastructure development and student training have and are continually being enhanced by NASA EPSCoR programs. During the past year, four research projects and several proposal development efforts were performed by NV System of Higher Education faculty. Research capabilities have been enhanced in a number of science and engineering areas including materials engineering, computer science and hydrology. Specific research topics have included: a better understanding of snow pack and its relationship to climate; physics-based modeling that simulates mechanoelectrical transduction of 3D polymer metal composites; polymer-metal composite behavior under prolonged exposure to space; and development of novel rover localization techniques using horizon line, object recognition techniques for crater and sand dune detection and terrain characterization for rover traversability.

Nevada TOC

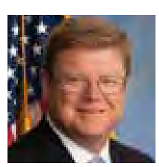
Senator Dean Heller



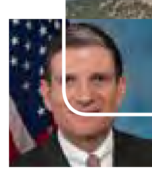
Senator Harry Reid



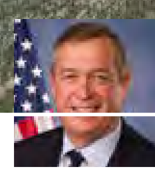
Representative Dina Titus (1st District)



Representative Mark Amodei (2nd District)



Representative Joseph Heck (3rd District)



Representative Cresent Hardy (4th District)

Building Research and Educational Capacity for Satellite Remote Sensing of Aerosols and their Radiative and Climate Change Impacts

Desert Research Institute/NASA Science Mission Directorate

DRI Desert Research Institute

University of Nevada, Reno

TMCC Truckee Meadows Community College

The goal of this project was to build research and educational capacity in the state of Nevada for satellite remote sensing of aerosols and for assessing their radiative and climate change impacts. A significant result of the project has been the receipt of United States Patent No. 8,396,700, Aggregate Simulation by R.K. Chakrabarty, H. Moosmüller, M.A. Garro and C. Herald (2013).

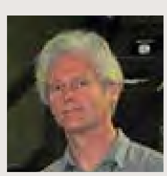
Three of our undergraduate students (Sumlin, Rainwater, and Karr) together with a fourth student (Zunino) founded a startup company "Mining Environmental Technology and Services" (METS) with the goal of commercializing some of our optical aerosol sensing technology for the mine safety marketplace. This spinoff was initially funded by the $50,000 prize they won in the 2012 Sontag Entrepreneurship Competition.

Ben Sumlin speaks for team METS after it won the Sontag Entrepreneurship Competition. He is joined by teammates Heather Zunino, David Karr, and Bryan Rainwater.

The Mining Environmental Technology and Services (METS) team plans to develop, produce and market optical instruments to detect potentially harmful airborne particulates in mining workplaces, improving safety in the mining industry. In accepting the award, team leader Ben Sumlin explained that they were doing atmospheric research, using weather balloons to quantify distribution of pollution in the atmosphere, when they realized the same technology could also be put to use in the mines, to measure diesel exhaust and improve safety in the mines.

Three (Sumlin, Rainwater, and Karr) of the four students in team METS were working on the NASA EPSCoR project "Building Research and Educational Capacity for Satellite Remote Sensing of Aerosols and their Radiative and Climate Change Impacts." The technology proposed by METS is based on an instrument they developed for balloon platform sampling of aerosol light scattering coefficients in the atmosphere, from the surface to the stratosphere, in support of the NASA EPSCoR project. Drs. Arnott and Chakrabarty served as faculty adviser of team METS. ✺

Hans Moosmuller,
Science PI
Desert Research Institute



Dr. Brian Cairns,
NASA Technical Monitor,
Ames Research Center

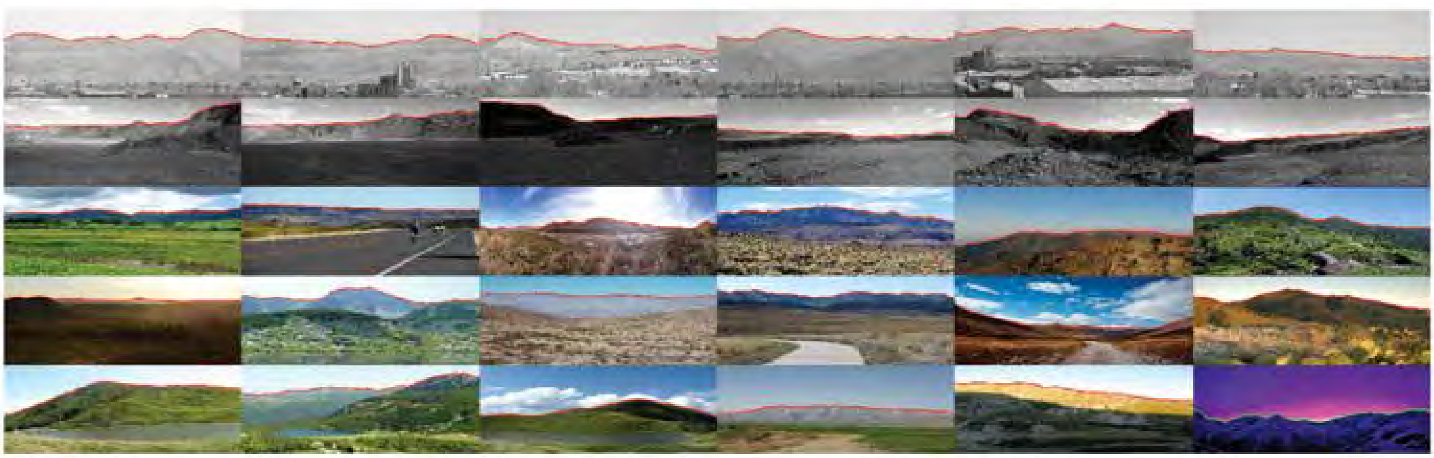
Advanced Computer Vision, Robotics, and Visualization Algorithms for Improving Planetary Exploration and Understanding

University of Nevada at Las Vegas/NASA Ames Research Center, Space Technology Mission Directorate

Researchers from the University of Nevada at Reno (UNR), University of Nevada at Las Vegas (UNLV), and Desert Research Institute (DRI) have been working together on advancing NASA's technologies for planetary exploration and understanding.

The UNR team has developed a new technique for horizon line detection using machine learning to aid in determining rover location and orientation. They have also been working on detecting craters from orbital images by developing a novel methodology that employs convex grouping for extracting candidate crater regions and machine learning for verifying them. The UNLV team has developed new techniques using GPU boards as well as an interactive rock segmentation and quantification (RSQ) tool to reduce image noise. The RSQ tool allows users to select an area of interest, segment rocks of interest, and calculate various rock properties based on color, texture, and shape. The DRI team has employed image and elevation data analysis techniques for mapping rover mobility over a landscape that exhibits variable surface lithology and geometries.

We have strengthened our collaboration with NASA as a result of this NASA EPSCoR project and are now working with the Intelligent Robotics Group (IRG) at NASA Ames. We have been holding annual meetings with IRG to review our progress. One result has been joint publications in peer-review journals and conference presentations. A special session on "3D Mapping, Modeling and Surface Reconstruction" was organized at ISVC'14. Research results have been incorporated in student classes and seminars have been provided by invited NASA researchers. Highly qualified students have been involved in this project as research assistants or summer interns. We have leveraged project results to obtain new funding; to deploy UAVs for improving situational awareness of first responders. ✺



Sample results illustrating our horizon line detection approach: City data set (row1), Basalt Hills data set (row2) and Web data set (row 3 through 5). Detected horizon lines are highlighted in red/green.

University of Nevada, Reno

UNLV

DRI Desert Research Institute

Dr. George Bebis, Science PI, Nevada System of Higher Education

Terry Fong, NASA Technical Monitor, Kennedy Space Center

Nevada NASA EPSCoR Research Infrastructure Development

At the recent NV NASA ESPCoR caucus a proposal development workshop and series of breakout discussions occurred. This was the first time in Nevada that a statewide workshop enabled participants to identify faculty with common research interests and then work with these collaborators to develop initial proposal concepts. The concepts identified are at the nexus of the NASA Strategic Plan (2014) and Nevada's science and technology, and economic development plans. The specific topic areas include terrestrial climate change, use of NASA satellite assets, unmanned aircraft systems (UAS) development and STEM education. The primary seed grant topics that Nevada will pursue in the following year include the following (in no particular order):

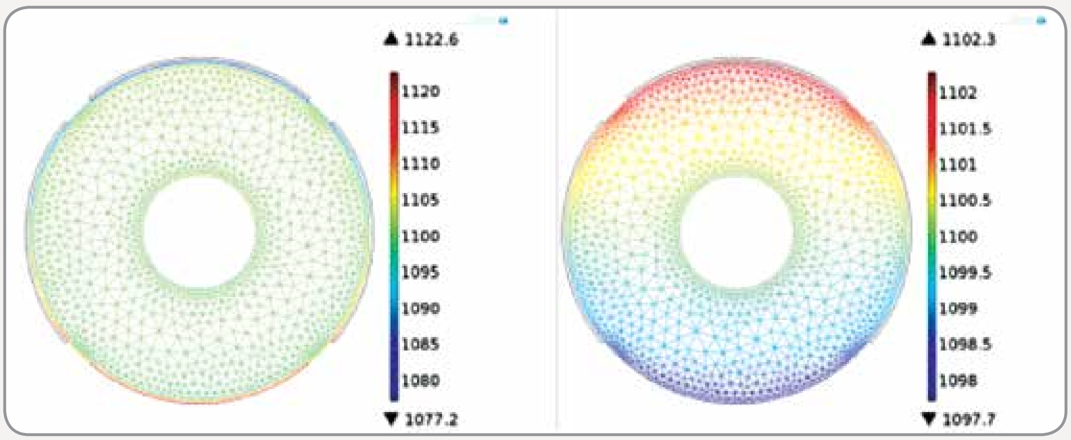
- *Quality of Clouds and Precipitation in a Changing Climate:* A warming climate will likely lead to increases in the frequency of extreme rain events and a shift in precipitation from snow to rain. However, the detailed processes driving these changes are devilishly complicated. Neither will result from a simple extrapolation from the trend in temperature. This project will explore the multi-scale aspects of these changes from the scale of snowflakes and rain drops to the multi-decadal shifts and planetary-scale circulations driving these changes.
- *Collaborative Communication among UAS:* this project will explore the utility of UAS for instant communication and real-time data analysis.
- *Geospatial Data for Nevada Resources – Database and Groundtruth for Satellite Systems:* This project will design and develop a database incorporating historical and modern data such as temperature, precipitation, aerosols, dust, vegetation and land cover. The goal is to provide statewide and regional context for research into the evolution and change of these properties and their implications for water and energy resource use and development in the current changing climate. The data would be widely available in an accessible format to the public and Nevada stakeholders.
- *Great Basin Biodiversity and Ecosystem Services:* Nevada contains most of the Great Basin. Mountain "islands" created by the basin and range physiognomy are ideal for studying the species/genotypic refugia and the role these isolated plant/animal/microbial communities, species, populations and their trophic interactions play in determining ecosystem services. They are also ideal for studying biodiversity conservation, especially in the context of quantifying the effects of climate and global change across small (10 m) to large scales (10^2 to 106 m).
- *Hogwart's School of Science and Engineering:* This project would adapt three previously developed hands-on engineering activities to a transportable kit that can be shipped statewide. This builds on the success of the Nevada Society of Professional Engineers (NSPE) program and DRI's Green Box program to deliver hands-on science to K-6 students in Nevada.
- *NV Sat (or Shadow Sat or Twilight Sat):* This is a CubeSat project to examine aerosols and possibly ocean wave height. The NV Sat imaging would use a visible camera and would occur at dawn and dusk. The concept would be verified by looking at GOES dawn and dusk images. A sun synchronous dawn/dusk orbit would be established to follow the line of dawn/dusk around the globe. Some initial testing of cameras could be performed using NV's high altitude ballooning program and the International Space Station.
- *Planetarium Presentations:* The results of many NASA funded research projects are often difficult to convey to the general public. By taking the research results and turning them into a visualized planetarium show, we can bring scientific results to the general public in a way that no journal article can. The planetarium show can be made available to audiences all over the world. In addition, extremophiles research in the Nevada deserts may hold the key to understanding the possibility of life on other planets. ✺

Nevada System of Higher Education faculty lined up to "pitch" collaboration and seed grant proposal ideas at a recent NV NASA EPSCoR meeting.

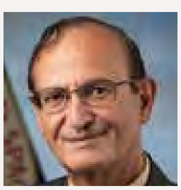
Advanced Electroactive Polymer Actuators and Sensors for Aerospace Robotic Applications

University of Nevada, Las Vegas/NASA Jet Propulsion Laboratory, Johnson Space Center, Langley Research Center, Human Exploration & Operations, Science, and Space Technology Mission Directorates

A journal paper entitled "Physics-based Modeling of Mechano-electric Transduction of Tube-shaped Ionic Polymer Metal Composite," was recently published in Journal of Applied Physics (Vol. 117, 114903, 2015; http://dx.doi.org/10.1063/1.4914034). This paper reports our research results in a physics-based model that is proposed to simulate mechanoelectrical transduction of 3D shaped ionic polymer metal composites. The lead author Tyler Stalbaum is a PhD student in the Mechanical Engineering Department of UNLV. ✺



Left: Cation concentration near fixed end at max bending input. Right: Anion concentration near fixed end at max bending input. Input is tip displacement at 1.5 mm amplitude, 1 Hz. Concentration in units [mol/m3].



Dr. Kumar Krishen, NASA Technical Monitor, Johnson Space Center

Prof. Kwang Kim, Science PI, University of Nevada, Las Vegas

The performance of an IPMC actuator (defined as β - angular spread of the tangent of the actuators tip).

A journal paper entitled "Ionic Electroactive Polymer Artificial Muscles in Space Applications," was recently published in Scientific Reports (Vol. 4, 6913, 2014; http://www.nature.com/srep/2014/141105/srep06913/fig_tab/srep06913_T1.html). This paper includes our research results regarding the material behaviour of ionic polymer-metal composite actuator under prolonged exposure to space environment. This paper was based upon a multi-national collaborative effort including European Space Agency and NASA EPSCoR.

Building Capacity in Interdisciplinary Snow Sciences for a Changing World

Desert Research Institute/NASA Goddard Space Flight Center, Ames Research Center, Science Mission Directorate

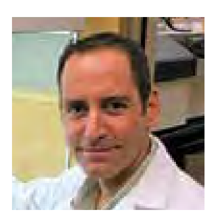
Field sampling and measurement campaigns at a site near Sagehen Creek Experimental Forest, the Sierra Nevada mountains and Pacific Crest were performed to study the importance of dust for snow surface properties, snow nutrients, and snow algae growth and spatial heterogeneity and canopy effects for snow physical, chemical, and biological properties by students and faculty of this NASA EPSCoR project.

This project aims to develop new research, technology, and education capacity in Nevada for the interdisciplinary study of snowpack, and will contribute to NASA strategic research and technology development priorities in the Science Mission Directorate and NASA's Astrobiology program. Due to profound regional and global impacts of global change on snowpack, this project addresses key questions of NASA's Earth Science Division such as "How is the global Earth system changing?" and "How will the Earth system change in the future?".

The educational highlights of the first months of this project include a new graduate level "Snow Science Seminar" class that has been taught in the spring semester 2015 (University of Nevada Reno, GEOL 701 Z). The class combined lectures by experts in snow hydrology, optics and energy balance, biology, and biogeochemistry, and provided a multidisciplinary education of students and faculty in these fields. A new "hands-on" Environmental Science class is in development by our local Community College faculty, and the class will open for student enrollment in the fall 2015 semester. This new class will prepare students for careers as environmental scientists, snow specialists, and technicians.

Research highlights so far included first field visits and sample collections. Two field sites were selected this winter, including a site near the Sierra Nevada Pacific Crest to analyze deposition and vertical distribution of dust, impurities, nutrients, and impacts on supporting growth of snow algae. A second field site in a forested catchment in the Sierra Nevada for quantifying spatial distribution of snowpack properties, including depth, density, snow water equivalent, snow chemistry, and biological properties. Several transects from canopy-free locations to forested areas were sampled, and will serve to quantify spatial heterogeneity as well as impacts of plant and canopy covers on snow physical, chemical, and biological processes. Laboratory analytical procedures, new instruments for spectral characterization of snow surfaces, and remote-sensing capabilities are now being developed by Nevada faculty to enhance our capacity to study snow locally and across the world. ✺

Dr. Brian Cairns,
NASA Technical Monitor,
Ames Research Center



Dr. Daniel Obrist,
Science PI,
Desert Research Institute

Advanced Transport Technologies for NASA Thermal Management/Control Sytems

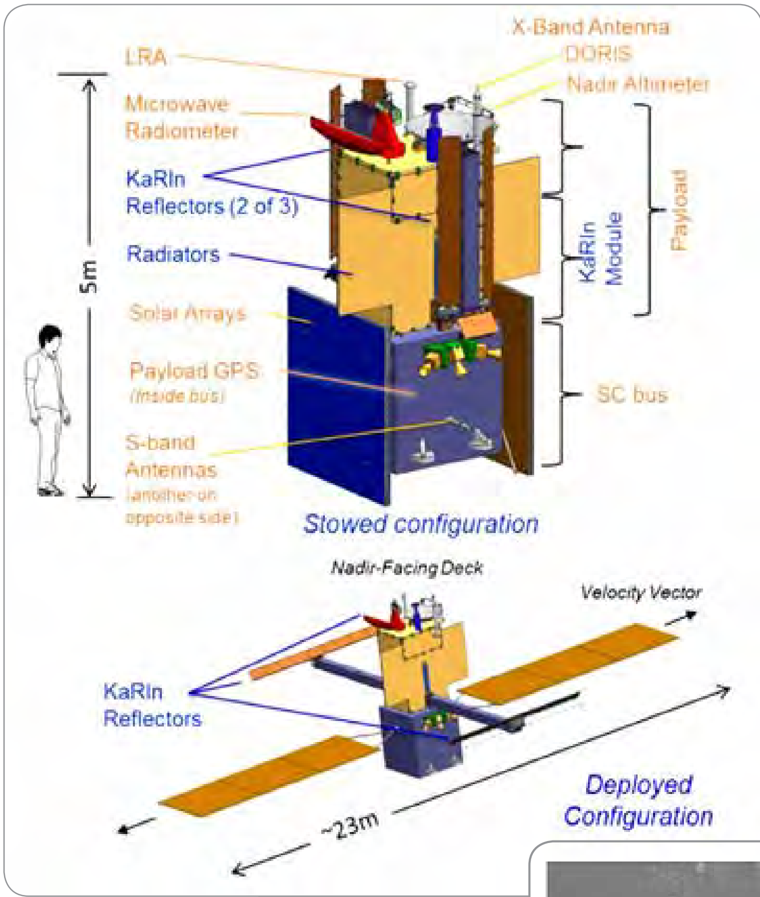
University of Nevada, Reno, NASA Glenn Research Center, Space Technology Mission Directorate

Thermal management of NASA life-support, high-power electronics, and measurement systems enables a wide variety of crucial space, air-flight, and monitoring technologies. These systems employ fluids to cool heat-generating modules and efficiently transport that energy to components for utilization or rejection to space.

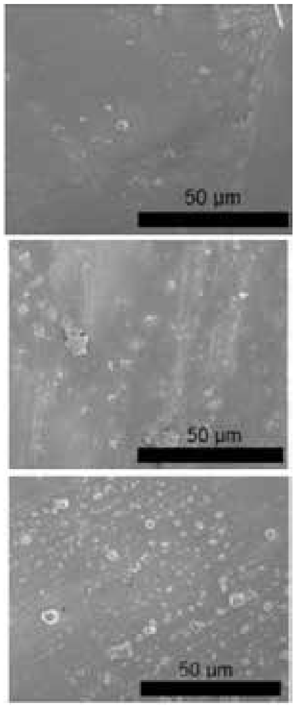
Current heat exchangers at the interfaces between the thermal management system and these components rely on single-phase convection. As a result, these heat exchangers are relatively large and heavy. Augmented single-phase and phase-change (in which the fluid boils and/or condenses) heat exchangers hold promise to reduce the size and enhance the performance of these systems, if reliability issues can be resolved.

A highly-integrated, statewide research and educational advancement program will be conducted among four Nevada System of Higher Education (NSHE) institutions: the University of Nevada, Reno (UNR), the University of Nevada, Las Vegas (UNLV), Truckee Meadows Community College (TMCC), and the Desert Research Institute (DRI). The program objective is to develop advanced single-phase and phase-change loop heat transfer technologies that will enhance the performance and reliability of the NASA thermal management/control system.

In addition, this work will be the basis for the development of innovative and interactive educational modules as well as technology transfer. The proposed work will fund four faculty members and four Ph.D. students who will gain experience in areas of interest to NASA. ✺



⮝ *Ilustration of a proposed flight system for the Surface Water Ocean Topography (SWOT) mission*



➤ *Scanning Electron Microscope (SEM) images of self-assembled nano particles (SANPs) in various concentrations of silver nitrate solution: (top) 1 mM, (middle) 10 mM, and (bottom) 100 mM (unpublished data by K. Kim)*

Miles Greiner, Ph.D., Science PI, ASME Fellow, University Of Nevada, Reno

Dr. Eric Sunada, NASA Technical Monitor, NASA Jet Propulsion Lab

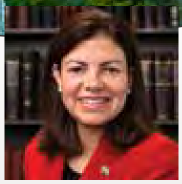
NASA John H. Glenn Research Center (GRC) at Lewis Field is located within the cities of Brook Park, Cleveland, and Fairview Park, Ohio

NEW HAMPSHIRE

Dr. Antoinette B. Galvin,
NH EPSCoR Director,
University of New Hampshire,
Durham

With a strong university-based research heritage in the space sciences, earth sciences, and related engineering activities, including the development of advanced space flight instrumentation for more than 60 years, New Hampshire has developed a vested economical interest in these endeavors. Since the time our NASA EPSCoR eligibility began in 2004, our state's research universities (the University of New Hampshire, Dartmouth College, and increasingly Plymouth State University) have directly benefited from NASA EPSCoR awards. NASA EPSCoR has supported the creation of mutually advantageous university research partnerships and interactions with at least seven NASA Centers and Facilities, government laboratories such as the U.S. Army's Cold Regions Research and Engineering Laboratory (CRREL), various state and local government agencies, and local industries. NASA EPSCoR awards also directly fund STEM-discipline college students in New Hampshire, providing undergraduate hands-on experiential internships and graduate-level research fellowships, thereby contributing to our state's future STEM workforce. As a cost share program, NASA EPSCoR represents a true federal and state-level partnership with many success stories.

The Old Man of the Mountain



Senator
Kelly Ayotte

Senator
Jeanne Shaheen

Representative
Frank Guinta
(1st District)

Representative
Ann McLane Kuster
(2nd District)

New Hampshire TOC

NH

Responsive Autonomous Rovers to Enable Polar Science

Dartmouth College/NASA Goddard Space Flight Center, Science Mission Directorate

This research builds on Dartmouth's success in developing autonomous robots to expand ground-based remote sensing in Polar regions. We will develop protocols and conduct autonomous studies using ground-penetrating radar (GPR) and albedo sensors mounted on Dartmouth's polar robots to provide data that link to firn compaction and surface mass balance of the Greenland ice sheet and associated climate models. Robotic surveys can provide high-resolution spatiotemporal data to improve ice sheet mass-balance models, provide ground truth for data from aerial and satellite assets such as NASA's IceBridge and MODIS crafts, and more broadly provide paradigms for extra-planetary ground-based science.

We have demonstrated the value of autonomous robots through Antarctic and Greenland field deployments totaling over 1000 km of autonomous operation. Through these deployments, we have gathered data via GPS-guided grid surveys conducted with Dartmouth's two polar robots Yeti and Cool Robot towing instruments. Dartmouth has collaborated with scientists at the Universities of Maine and New Hampshire, and the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) on these projects. This collaborative NASA EPSCoR project between Dartmouth College, Univ. of New Hampshire, CRREL, and NASA Goddard scientists now extends the science impact of autonomous robots as roving science platforms and develops new capabilities within New Hampshire to compete for non-EPSCoR funding.

The proposed research builds infrastructure and capacity for Dartmouth College and University of New Hampshire students in Polar science and engineering that is linked to NASA's remote sensing products and for extending collaborations to include scientists in other states. This EPSCoR project will leverage this outreach grant and provide opportunities for many students to work with faculty on robotic-based remote sensing. ✺

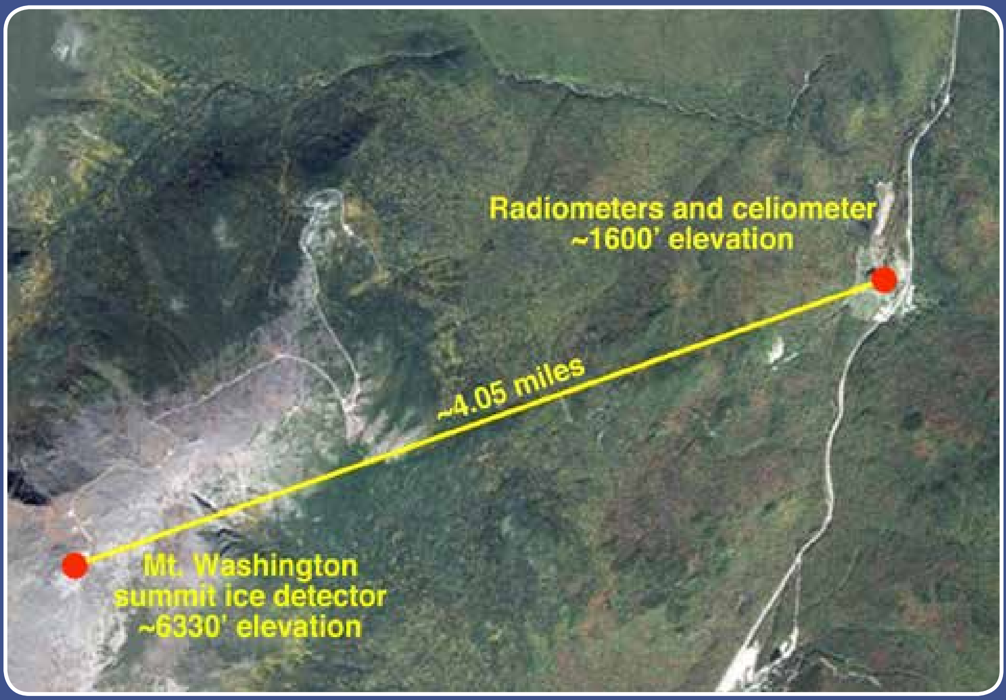
Dr. Brooke Medley,
NASA Technical Monitor,
Physical Scientist,
Cryospheric Sciences Laboratory,
Goddard Space Flight Center

Dr. Laura Ray,
Science PI,
Professor, Dartmouth College

Site Assessments in Cold and Alpine Environments for Wind Power Generation

Plymouth State University/NASA Aeronautics Research Mission Directorate

Plymouth State UNIVERSITY



For this study, icing detectors and radiometers were located on Mt. Washington and the nearby Mt. Washington Auto Road; the icing detectors provide an estimate of supercooled liquid water content within a cloud volume, the radiometer indicates the volume of both frozen and liquid water, and the celiometer determines the height of the cloud base.

James Koermer,
Science PI,
Plymouth State University

NASA Technical Monitor:
Dr. Mario Vargas,
Glenn Research Center

Icing Assessments in Cold and Alpine Environments was designed to develop data, tools and techniques to model ice accretion in cold alpine environments. This study focused on the Presidential Range of New Hampshire, known for its complex terrain and meteorology. Ice detectors located throughout New England provided validation for icing forecast models.

The primary collaborators, Plymouth State University (PSU), the U.S. Cold Regions Research and Engineering Laboratory (CRREL) and Mount Washington Observatory (MWO) extended their research capabilities with support from NASA Glenn Research Center, who provided a radiometer and accompanying technical support, NASA Langley Research Center, who provided satellite data useful in identifying probable icing events, and the National Center for Atmospheric Research, who contributed to modeling efforts. CRREL researchers had support from the National Weather Service in Burlington, VT.

Researchers improved their knowledge of microwave radiometry and refined their modeling of cloud microphysics. MWO, with a decades-long history of weather data collection, expanded their capabilities and increased skills in installation and operation of this suite of instruments.

Students were included in this project from beginning to end, resulting in six student Master's theses using research from this project: five from PSU and one University of Nebraska at Lincoln. Numerous student conference presentations were based on this research, and three different CRREL scientists served on M.S. committees of PSU students working on this project. At last report, each of these students has continued work in a STEM field, with employers including: Univ. of Wisconsin Cooperative Inst. for Meteorological Satellite Studies, University of Utah Atmospheric Science Dept., National Weather Service, SUNY Oswego, Iowa State University, and CRREL. ✺

Passive Microwave Detection of Snowmelt and Runoff

University `of New Hampshire/NASA Science Mission Directorate

NH

The UNH and CRREL project team was recently award the NASA Earth Sciences Applications grant “Satellite Enhanced Snowmelt Flood Predictions in the Red River of the North Basin” to advance the capability of snowmelt flood prediction in the Red River Basin via a partnership among the University of New Hampshire (UNH), North Dakota State University (NDSU), National Oceanic and Atmospheric Administration (NOAA) National Weather Service’s (NWS)’s North Central River Forecast Center’s (NCRFC), the USACE Cold Regions Research and Engineering Laboratory (CRREL), and the USDA Hydrology and Remote Sensing Laboratory. The goal is to improve the NCRFC flood prediction models using satellite observations that capture the magnitude, timing, and spatial distribution of watershed scale snow and snowmelt parameters as well as antecedent soil conditions. The Red River Basin has historical record of floods and weak flood prediction capability and high associated costs for flood-induced losses as well as preparation costs. As an example, during the 2013 flood, the city of Fargo and the US Army Corps of Engineers St. Paul District each spent in excess of $3M for temporary protection measures in response to an initial forecast of record flood levels at Fargo, which turned out to be unnecessary. With the information and models that were available at the time, the NCRFC had forecasted a peak flow that exceeded the observed by 70%. This project has the potential to improve forecasting to avoid expenditures of that magnitude in the future. ✺

Doug Osborne, UNH graduate student, measures the snow temperature profiles at Hubbard Brook Experimental Forest during winter 2013-2014. Photo by Carrie Vuyovich.

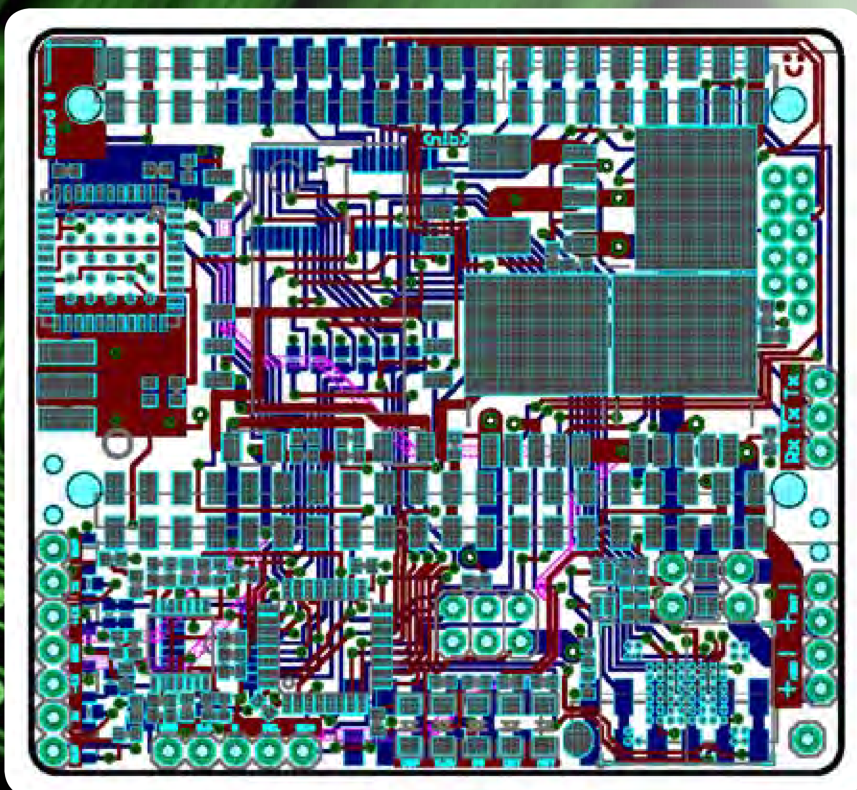
University of New Hampshire

Jennifer M. Jacobs,
Science PI,
University of New Hampshire

Robert Freeman,
NASA Technical Monitor,
Kennedy Space Center

Research Infrastructure Development

Dartmouth



The *HIGHLY MANUFACTURABLE IONOSPHERIC SCIENTIFIC SPACECRAFT* focused on developing low-resource multiple-point sensorcraft for studies of structure and dynamics in the auroral ionosphere.

The primary collaborators, the Dartmouth Lynch Rocket Lab and GreenCube student research group, extended their research capabilities with support from NASA JPL (for undergraduate research and mission planning for cubesat design), from NASA WFF (for technical and design support for science-competed NASA sounding rockets), and from Dartmouth College (for undergraduate and graduate research in the sciences). Our science-competed Isinglass mission (NASA LCAS 36.303 and 36.304) would not have been possible without the technology development enabled by EPSCOR funding.

One aspect of this work required our finding an optimum balance between specifically-designed hardware, and commercially available technologies including Arduinos. Student designs led to a board we call the “BobShield4.2”, which will enable us to fly 10 small subpayloads on NASA sounding rockets this coming fall and winter.

Students of all levels have been included in this project from beginning to end. Two Dartmouth senior honors theses were supported by this work; one on analysis of spacecraft attitude sensors, and one on the orbital dynamics of swarms of low-resource CubeSats. Both theses were influenced by a parallel project with JPL involving a mission design study of our group’s candidate Ionospheric CubeSwarm mission, which has grown out of our EPSCoR studies of low-resource CubeSat possibilities.

The BobShield (figure to the left) illustrates the spacecraft bus board designed by Jacob Weiss, an undergraduate in the Dartmouth GreenCube lab. This control board will enable our small spacecraft development, including balloon-borne experiments, and our upcoming multipoint sounding rocket NASA flights, as we refine our plans for an eventual CubeSwarm mission. The control board works in parallel with an Arduino board to form the basis of our spacecraft bus. It supports an Xmega coprocessor, power regulation and relays, ADCs and DACs, a DNT900MHz radio, and interfaces to science sensors; for our balloon payloads, it supports a 2Gb NANDflash and a GPS. ✺

Integrated Modeling of Microgravity-Induced Visual Changes

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

Astronauts are returning from space mission with changes to their vision. Understanding these changes has been challenging, since microgravity produces changes within the body that are impossible to replicate on Earth. One approach to understanding these changes is to use numerical modeling.

In April 2014, our research team conducted research on the short-term effect of microgravity on the eye and surrounding structures. Subjects flew aboard a specially designed aircraft that was able to generate multiple periods of ~15-25 seconds of microgravity by flying a parabolic flight pattern. During the periods of microgravity, the research team acquired eye data from the subjects. Our results show that even short periods of microgravity produce measurable changes in the eye, and these data are being used to build and validate the numerical model of the eye. This work was a coordinated effort between the research team from the Geisel School of Medicine at Dartmouth College, the engineering firm Creare Inc., and the crew at the Reduced Gravity Office at Johnson Space Center. Students from the NH-IMBRE program participated in the flight program. ✺

Making eye measurements on the microgravity flight

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

NASA Technical Monitor: Dr. William J. Tarver, MD MPH, Johnson Space Center

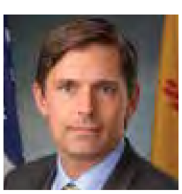
NEW MEXICO

New Mexico EPSCoR

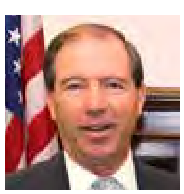
New Mexico was admitted into the congressionally mandated NASA EPSCoR program in 2007. NASA EPSCoR supports aerospace research throughout New Mexico. Technical areas include but are not limited to low-earth orbit vehicle and testing programs, micro-gravity research, deep space exploration and sensor networks. Other technical areas are radio astronomical observation, solar observation, and space communications. EPSCoR is focused on enabling the growth of competitive research programs that stimulate economic growth in New Mexico. EPSCoR focuses on supporting our institutions at the highest level of education by strengthening their research capabilities as well as providing opportunities that attract and prepare increasing numbers of students for high technology careers within the state. Through our EPSCoR programs we are striving to significantly increase the research experiences for students, to improve our research labs and facilities, and to support interdisciplinary research collaborations across colleges, research units and with NASA Centers. The following reports are examples of the outstanding research being conducted at our universities and its impact.

Dr. Patricia Hynes,
NM EPSCoR Director,
New Mexico State University

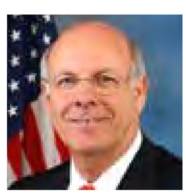
New Mexico TOC



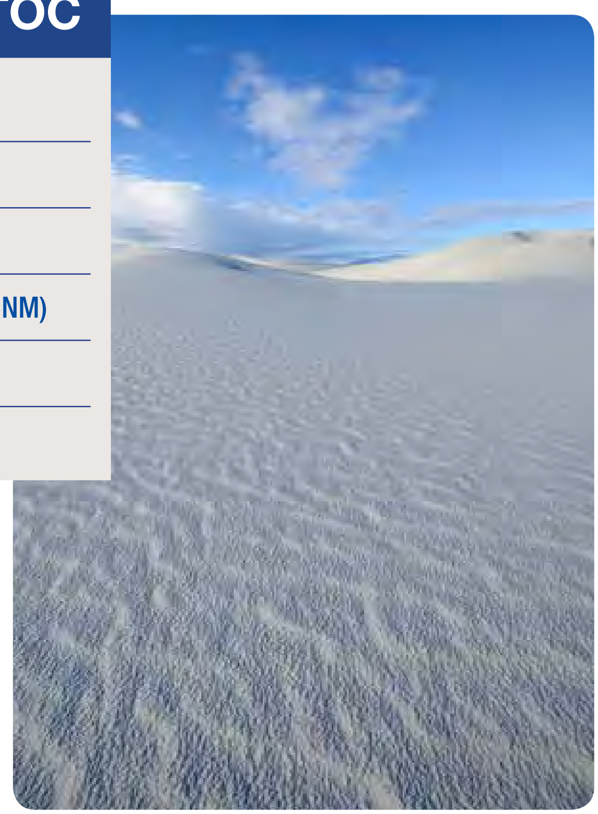
Senator
Martin Heinrich



Senator
Tom Udall



Representative
Steve Pearce
(2nd District)



NESSI: New Mexico Exoplanet Spectroscopic Survey Instrument

New Mexico Institute of Mining and Technology/Space Technology Mission Directorate

The New Mexico Institute of Mining and Technology's 2.4-meter (7.9-foot) Magdalena Ridge Observatory in Socorro County, N.M., home to NESSI. Image credit: New Mexico Tech

NESSI on the MRO 2.4m 'scope during commissioning.

So many new worlds to explore, yet so little we know about them.

That's the primary rationale for the building of the New Mexico Exoplanet Spectroscopic Survey Instrument (NESSI). Designed partly using NASA EPSCoR funds, NESSI will help astronomers decipher the chemical composition of exoplanets at a time when more and more of these bodies are discovered orbiting stars beyond our sun.

Deployed at the New Mexico Institute of Mining and Technology's Magdalena Ridge Observatory in Socorro County, NESSI got its first peek at the sky on April 3, 2014.

"Planet hunters have found thousands of exoplanets, but what do we know about them?" said Michele Creech-Eakman, the project's principal science investigator. "NESSI will help us find out more about their atmospheres and compositions."

A collaborative effort between NMT, New Mexico State University and NASA's Jet Propulsion Laboratory, NESSI will focus on about 100 exoplanets, ranging from massive versions of Earth, called super-Earths, to scorching gas giants known as "hot Jupiters." All of the instrument's targets orbit closely to their stars. Future space telescopes will use similar technology to probe planets more akin to Earth, searching for signs of habitable environments and even life itself.

Ten undergraduate students – and numerous local and regional industry suppliers - helped make NESSI happen. Despite concerns over a current lack of funding to regularly operate NESSI, the project's backers believe its sky-gazing future should eventually brighten.

"We're watching the next generation of scientists and engineers get excited about exoplanets," said Creech-Eakman. "Who knows what they will be able to see when they're older -- perhaps the atmospheres of potentially habitable worlds." ✺

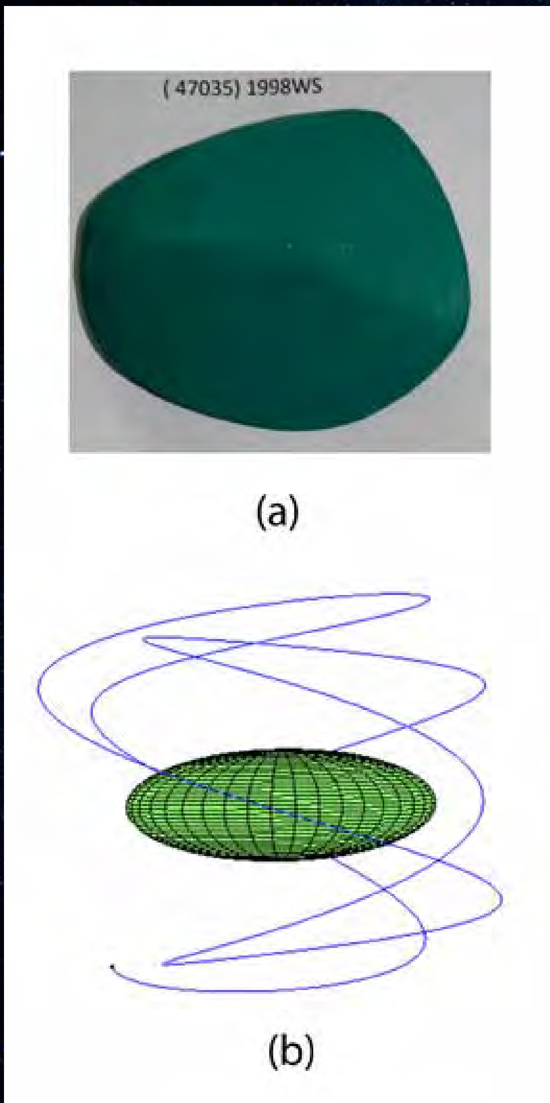
http://krqe.com/2014/04/04/nm-tech-exoplanet-search-is-earthalone

Michelle Creech-Eakman,
Science PI,
New Mexico Institute
of Mining and Technology

NASA Technical Monitor:
Dr. Mario Perez

Proximity Operations for Near Earth Asteroid Exploration

NM State University, NASA Kennedy Space Center, Science Mission Directorate

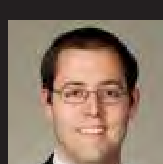


(a) Shape model for asteroid 1998WS created using observations by co-PI Klingesmith;

(b) Orbital simulation created using triaxial ellipsoid model developed by co-PI Sheeres.

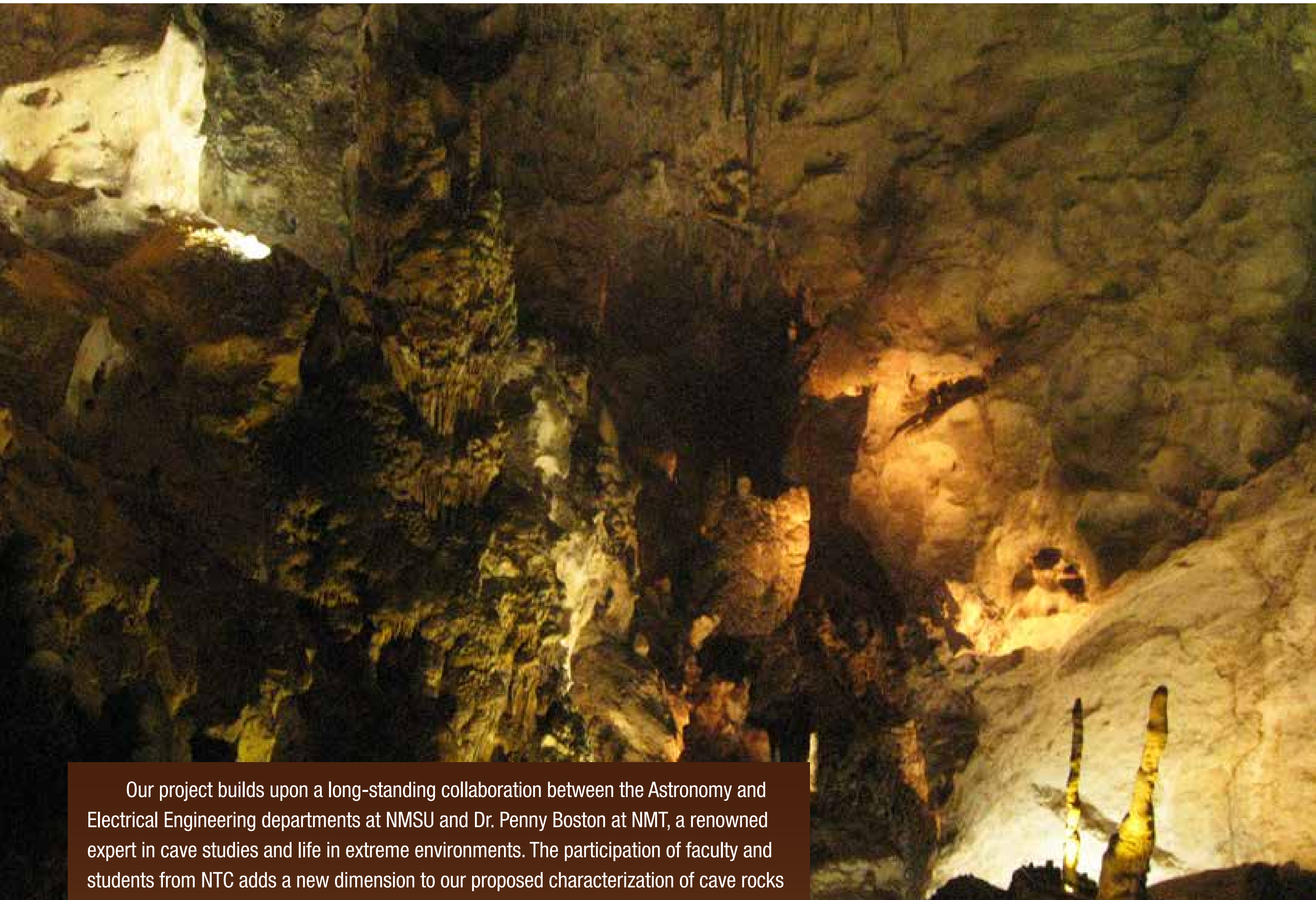
The goal of this project was to study some of the problems associated with spacecraft operations in the vicinity of near-earth asteroids (NEAs). An interdisciplinary team composed of engineers, space scientists, and astronomers from four academic institutions in three states worked together to better understand the issues associated with NEA operations, including asteroid modeling, dynamics modeling in the small body proximity environment, spacecraft control, and communications modeling. Over the course of this research project, the research team has had a number of successes. First, we have developed more accurate asteroid models (Figure (a)). Second, we have implemented sophisticated orbit-attitude coupled dynamics models (Figure (b)) which we have used both to analyze communications issues in the vicinity of NEAs to infer information about a specific NEA's composition (e.g., mass distribution) with the help of sophisticated Kalman filters. Finally, we have also developed efficient spacecraft control algorithms which use an advanced mathematical framework to reduce propulsion requirements. In total, this research has resulted in 56 conference papers and 12 journal papers. In addition to its research contributions, this project has also helped train a new generation of engineers and scientists, including 8 students from three institutions with 6 of these being New Mexicans. ✺

Dr. Eric A Butcher,
Science PI,
NM State University



David J. Miranda,
NASA Technical Monitor,
Kennedy Space Center

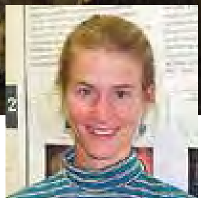
MSI - Exploring Surface Texture, and Reflectivity of Cave and Related Surface Environments as Harbingers for Life



Our project builds upon a long-standing collaboration between the Astronomy and Electrical Engineering departments at NMSU and Dr. Penny Boston at NMT, a renowned expert in cave studies and life in extreme environments. The participation of faculty and students from NTC adds a new dimension to our proposed characterization of cave rocks and surface materials through the inclusion of 3-D and textural mapping and enriches the existing research collaboration network between NMSU, NMT and NTC. Our NTC colleague identified a biology and a chemistry instructor at NTC to participate in this project, thereby extending the impact of this work to a broader range of students and faculty. This dynamic interaction enhances the research capabilities of faculty at NTC, a designated MSI, and will foster a meaningful, longterm collaboration between NTC faculty and research institutions within the New Mexico EPSCoR jurisdiction. We will continue this partnership after the award period ends through future grant proposals and research projects.

The team has also developed a partnership with the National Park Service to facilitate access and permitting requirements for our field expeditions to caves of interest.

An important outgrowth of this project is a new collaboration with Dr. Aaron Parness at the Jet Propulsion Laboratory, who is building a rock-climbing robot for the robotic exploration of solar system caves. He plans to use his robot in Four Windows cave, and we will attach the NMSU-built spectrometer to the robot for field demonstrations.



Dr. Nancy Chanover, Science PI, New Mexico State University

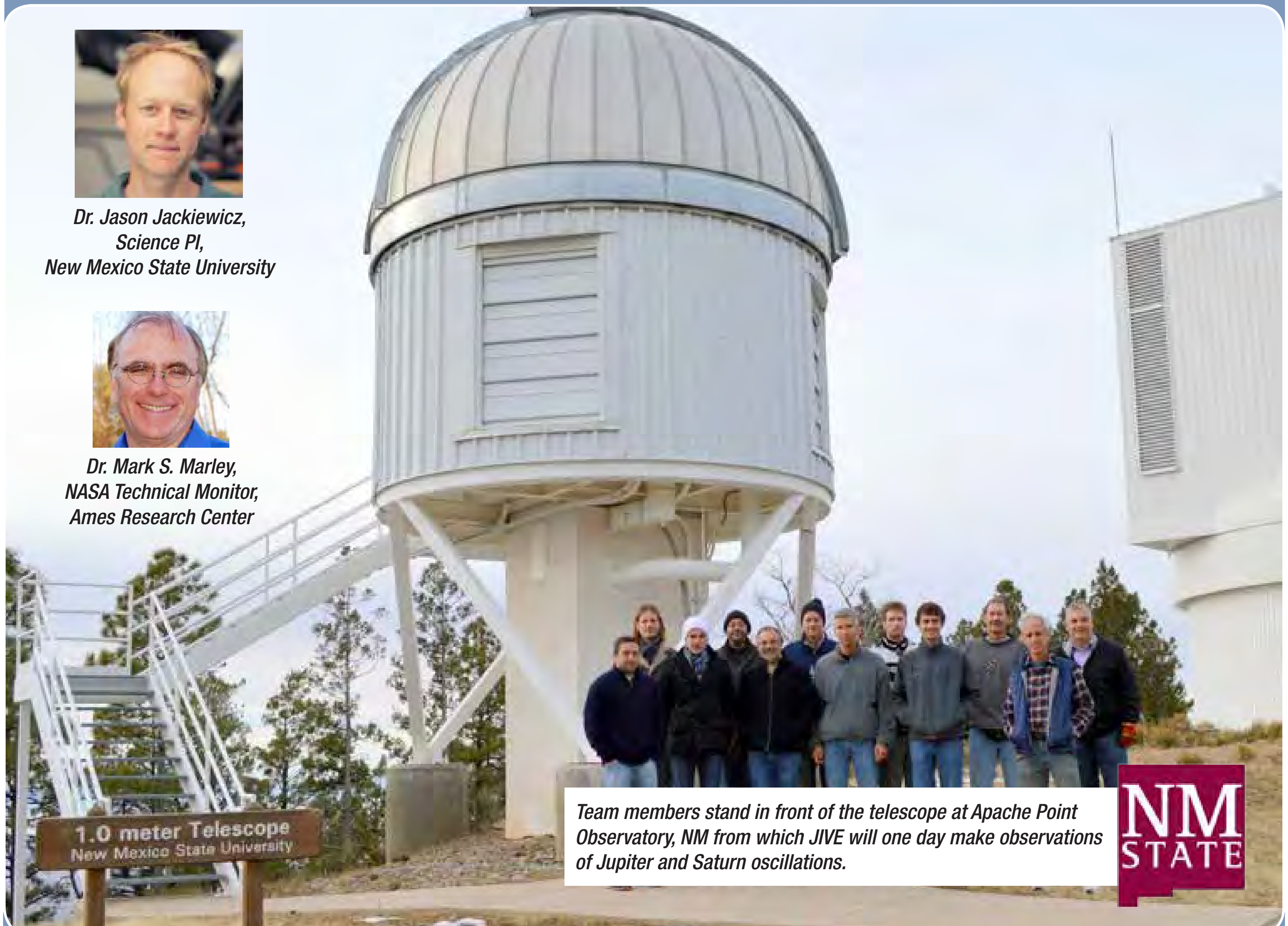
Theresa Martinez, PMP, NASA Technical Monitor, Kennedy Space Center

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

New Mexico State University/NASA Ames Research Center, Jet Propulsion Laboratory, Goddard Space Flight Center, Science Mission Directorate

Dr. Jason Jackiewicz, Science PI, New Mexico State University

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



Team members stand in front of the telescope at Apache Point Observatory, NM from which JIVE will one day make observations of Jupiter and Saturn oscillations.

NM STATE

One of the main questions in planetary astronomy is how did the solar system form, and how did the planets come together and then evolve? Jupiter is the most massive planet, representing 70 percent of the mass in the solar system apart from the Sun. An international team of researchers working on the Jovian Interiors from Velocimetry Experiment (JIVE) in New Mexico, is developing a ground-based instrument that will measure oscillations on Jupiter. Its results could help understand the interior structure and composition of the planet and the solar systems development for the first time.

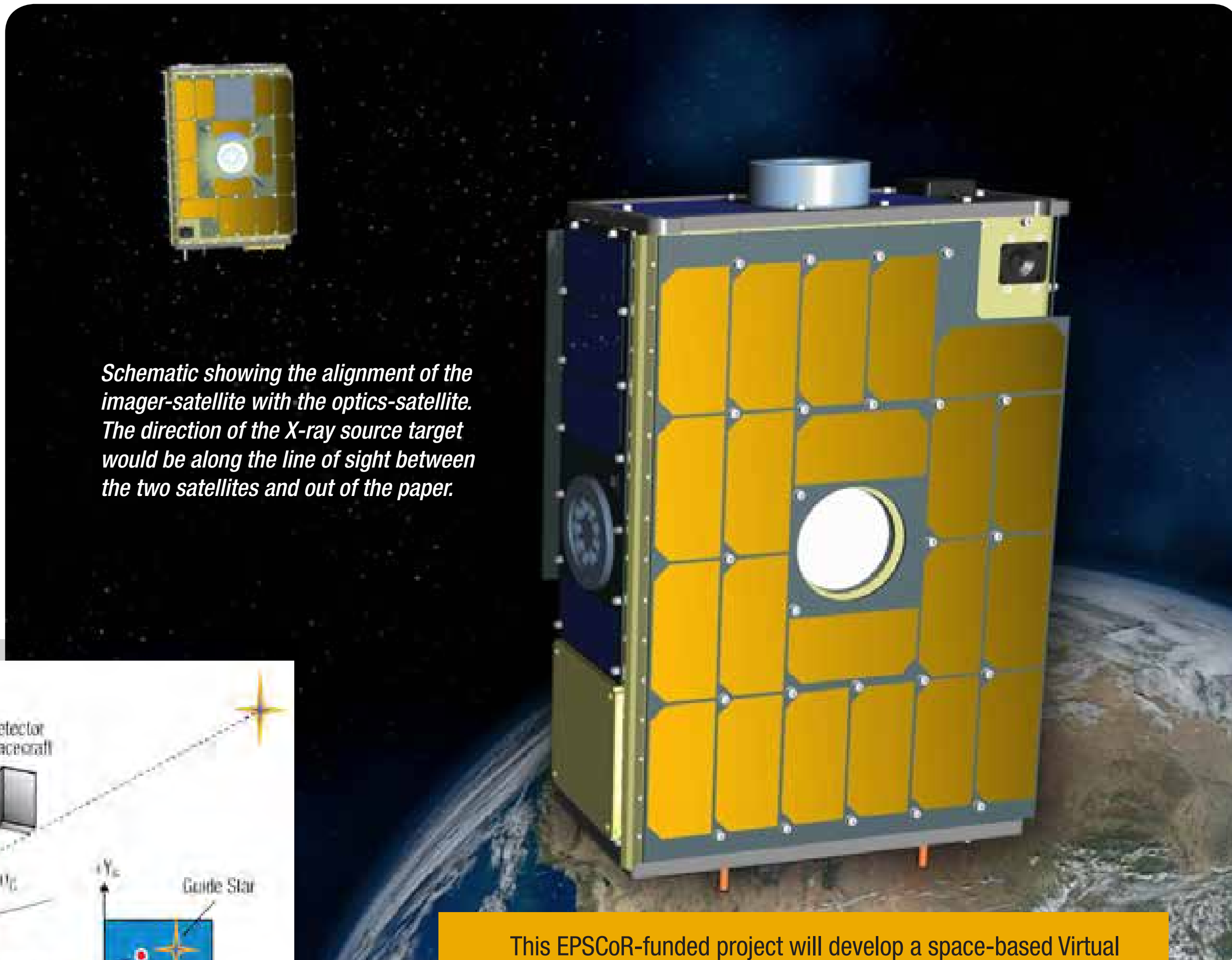
Giant planets like Jupiter or Saturn are mostly fluid (they contain no solid surface), which makes their seismology much closer to that of stars than that of rocky planets like Earth. Furthermore, observations of the circulation speeds of planet atmospheres is usually not very accurate. With JIVE, we'll be able to measure the instantaneous speed of the clouds directly, helping to understand large storm systems.

The project has strong alignment with NASA's plans for planetary exploration and the importance of the proposed low-cost approach by NMSU to use ground-based support will enable verification of NASAs Juno mission space observation data. The installation of the instrument could make NMSU a hub for planetary seismology, and the project is well underway. ✺

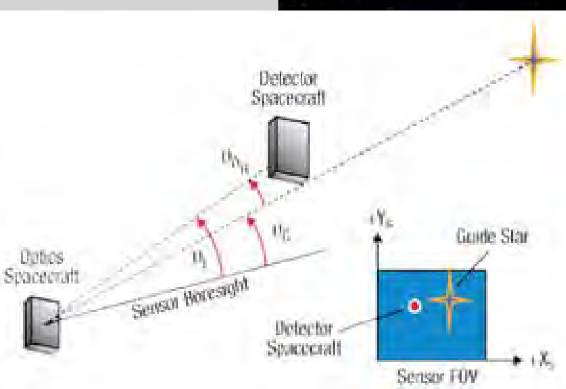
Virtual Telescope for X-ray Observations

New Mexico State University/NASA Goddard Space Flight Center, Science Mission Directorate, International Space Station

NM

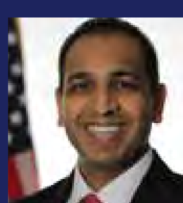


Schematic showing the alignment of the imager-satellite with the optics-satellite. The direction of the X-ray source target would be along the line of sight between the two satellites and out of the paper.



Dual Spacecraft Precision Astrometric Alignment Architecture (Shah et al., 2014). The control objective is to close the transverse relative position through actuation of a micro-propulsion system.

Dr. Steve Stochaj,
Science PI,
New Mexico State University



Mr. Neerav Shah,
NASA Technical Monitor
NASA Goddard Space Flight Center

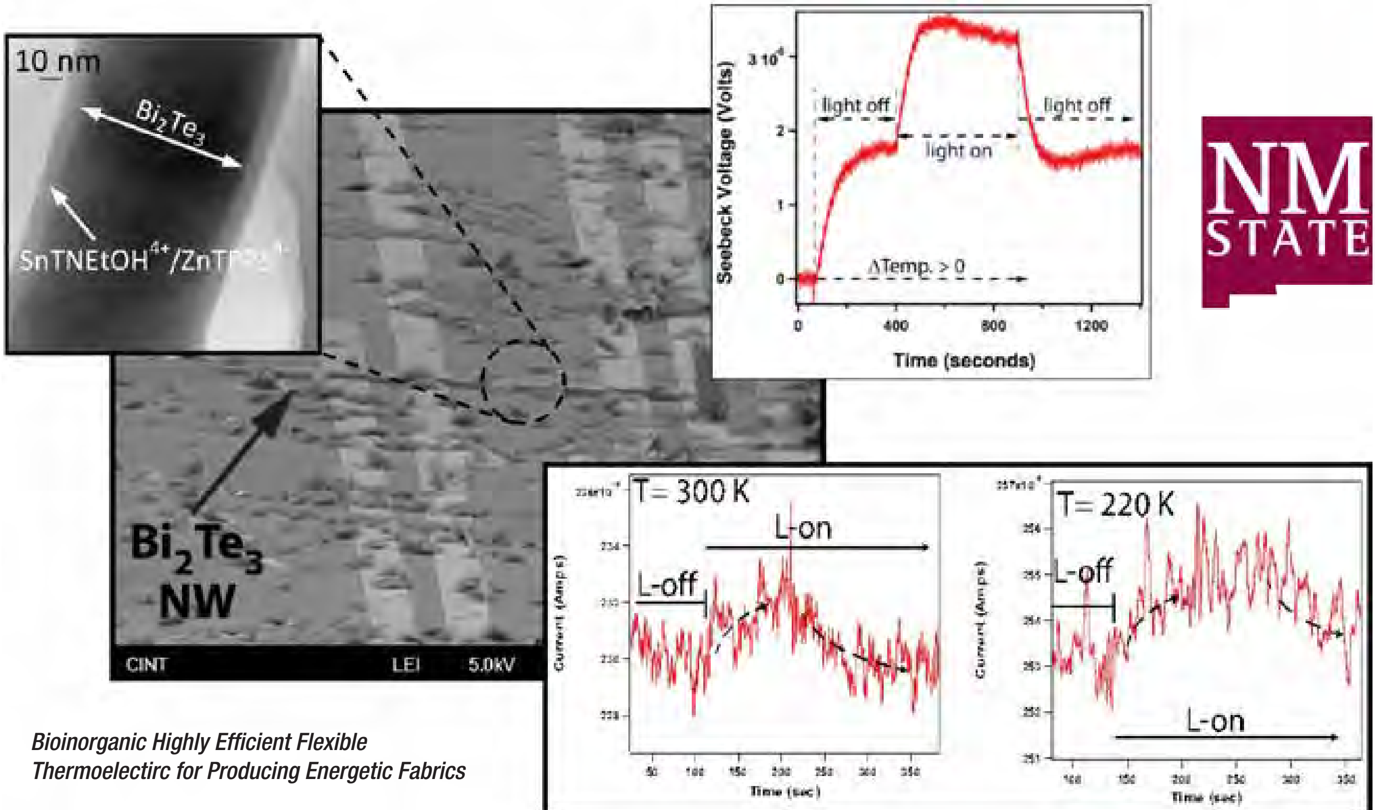
This EPSCoR-funded project will develop a space-based Virtual Telescope for X-ray observations. This system will consist of two 6U-CubeSats; one carrying a Phased Fresnel Lens and the second an X-ray sensitive camera. The two CubeSats will fly in precision formation to form a very long focal length (> 100 m) telescope: a Virtual Telescope. This is intended as a demonstration flight that will showcase the feasibility of the Virtual Telescope approach and raise the Technology Readiness Level to the point where the technique can be proposed for a much larger NASA mission.

This multidisciplinary project involves researchers from New Mexico State University and the University of New Mexico working in collaboration with researchers at NASA's Goddard Space Flight Center. The project addresses two Technology Areas from the NASA Space Technology Mission Directorate's Technology Roadmap: X-ray optics and multi-spacecraft formation flying, navigation, and control. The science enabled by this technology is closely tied to the Strategic Goals of NASA's Science Mission Directorate in the Heliophysics and Astrophysics Divisions.

This project aligns with the state of New Mexico's stated need to produce more technologists to satisfy projected workforce needs, and supporting the workforce needs of the state's aerospace industry.

Research Infrastructure Development

New Mexico State University/NASA Kennedy Space Center, Armstrong Research Center/ Jet Propulsion Lab/Goddard Space Flight Center



Bioinorganic Highly Efficient Flexible Thermoelectirc for Producing Energetic Fabrics

The purpose of the New Mexico NASA EPSCoR Research Infrastructure Development (RID) Program is to build the core competitive research strength in New Mexico, and to grow research and technology development core capabilities. We enable faculty to compete for funds from NASA and non-NASA sources outside of the EPSCoR program in order to find solutions for scientific and technical problems of importance to NASA Centers, Mission Directorates, and the Office of the Chief Technologist. New Mexico NASA EPSCoR RID focuses on collaborative activities and relationships to develop long-term, self-sustaining, nationally-competitive capabilities in space and aerospace-related research. These capabilities will, in turn, contribute to New Mexico's economic viability and expand the Nation's base for science and technology innovation agendas.

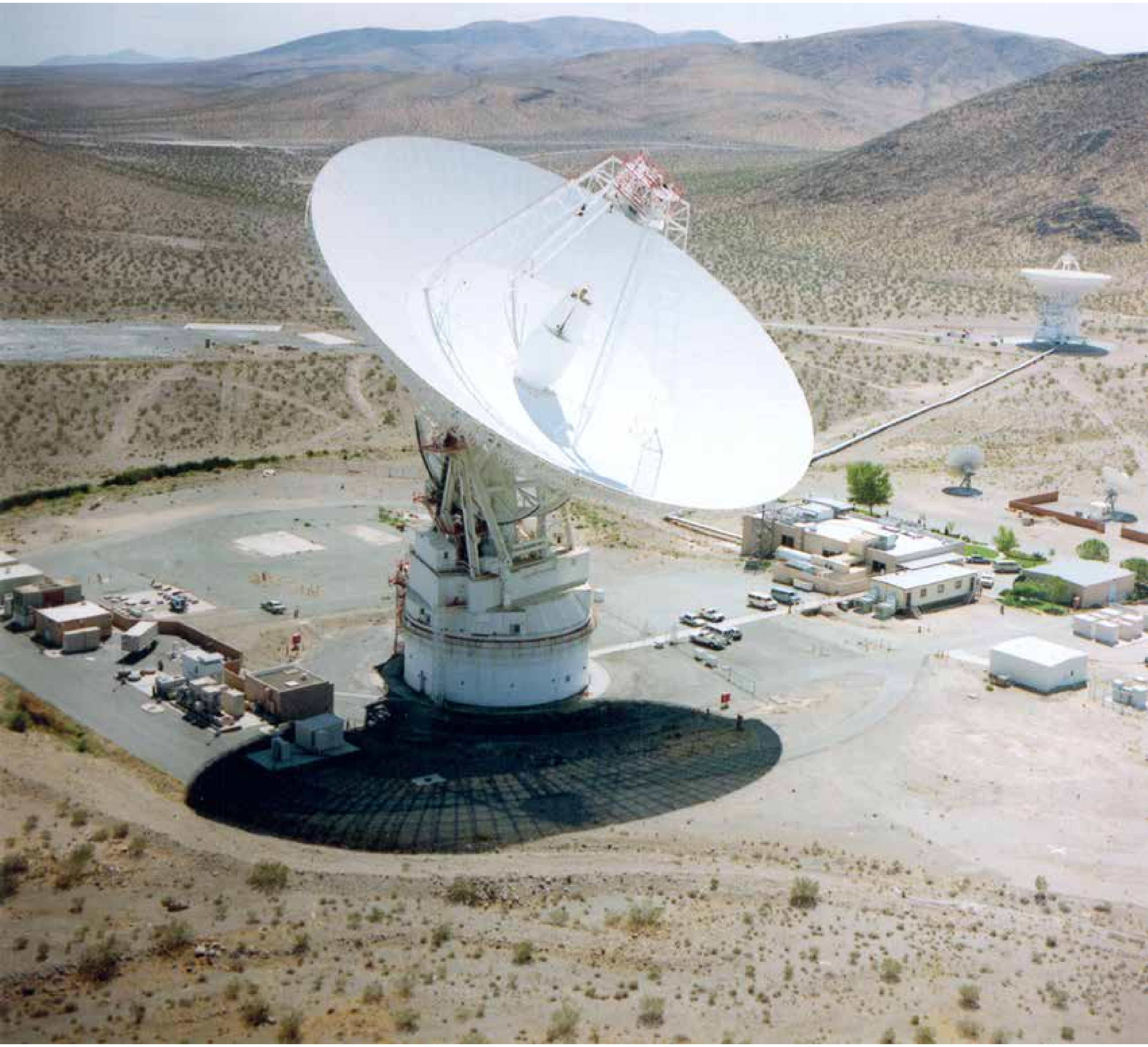
Research Initiation Grants (RIG) are offered statewide to all NMSGC, and NM NASA EPSCoR partners. It is designed to help new or transitioning faculty at New Mexico colleges and universities develop nationally competitive research programs. Faculty can apply for up to $25,000 in RIG funding.

11 research projects are currently supported from New Mexico State University, University of New Mexico and New Mexico Institute of Mining and Technology.

Faculty are required to:

- Secure non-federal matching funds
- Create a research program that supports at least one of NASA's strategic goals
- Secure a NASA collaborator
- Indicate where follow-on funding will come from
- Track students

All grants are competitively awarded. ✺

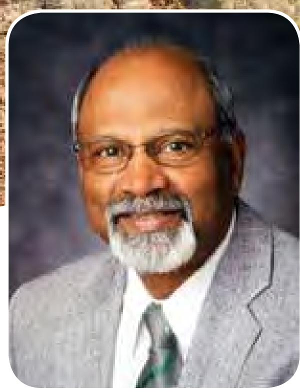


NASA's Deep Space Network is the largest and most sensitive scientific telecommunications system in the world. The DSN consists of three facilities spaced equidistant from each other around the world. These sites are at Goldstone, near Barstow, California (pictured); near Madrid, Spain; and near Canberra, Australia. The strategic placement of these sites permits constant communication with spacecraft as our planet rotates.

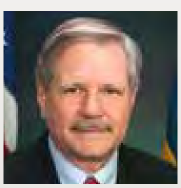
NORTH DAKOTA

Through ND NASA EPSCoR funding, faculty and students from both research universities in the state, North Dakota State University and the University of North Dakota, have been able to make connections across the country with industry partners and NASA centers that would not have been possible without the support of the NASA EPSCoR program.

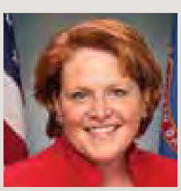
North Dakota is not the first state that comes to mind when one mentions research in space exploration, but we are well on our way through various EPSCoR projects on subjects like human space exploration, spacecraft structures, and climate change. Through the EPSCoR program, students and faculty receive hands-on experience in NASA-relevant research right here in our own backyard. This has opened employment opportunities for students at multiple NASA centers, as well as helped to advance researchers' careers in STEM.



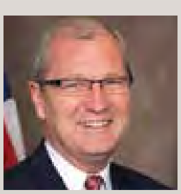
Prof. Santhosh Seelan,
ND NASA EPSCoR Director,
University of North Dakota



Senator
John Hoeven



Senator
Heidi Heitkamp



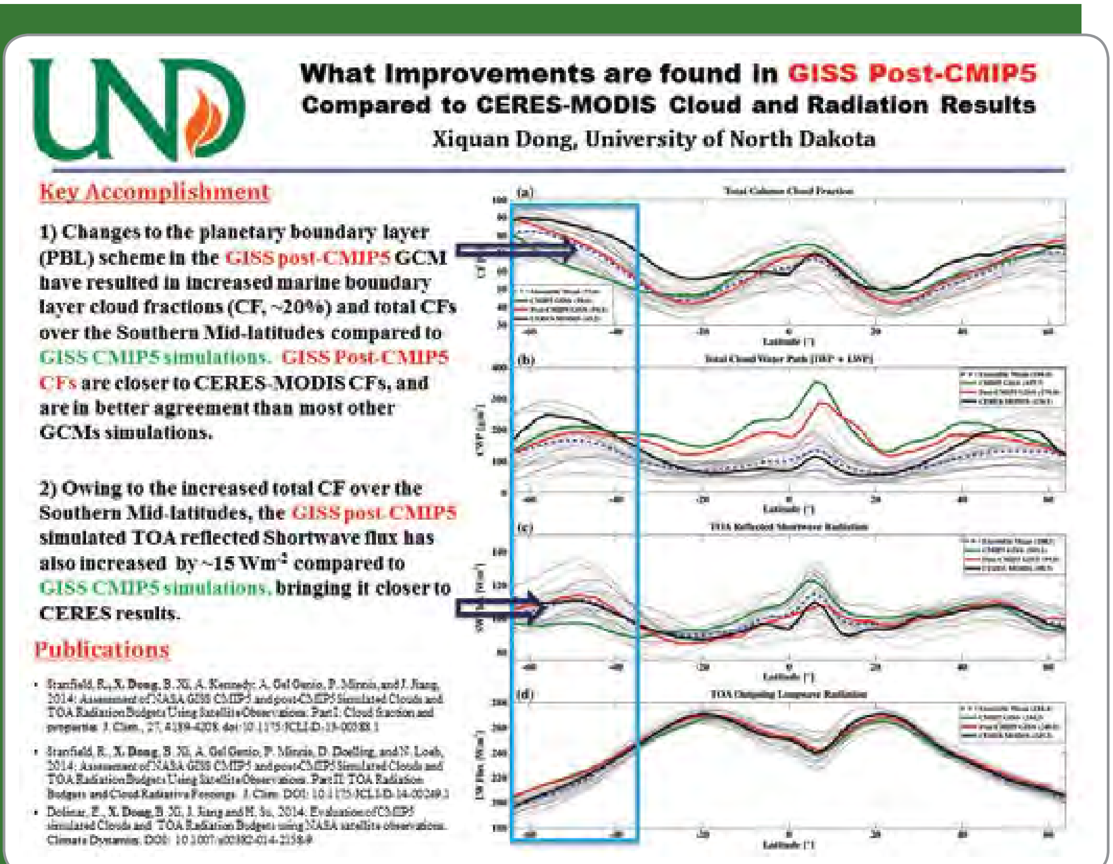
Representative
Kevin Cramer
(District At Large)

North Dakota TOC

Evaluation of NASA GISS ModelE AR5 Simulated Global Cloud Fraction and Radiation Budgets Using the MODIS-CERES Observations and MERRA Reanalysis

University of North Dakota/NASA Langley Research Center, Science Mission Directorate

The goal of this study is to investigate NASA GISS GCM biases and determine whether they are due to errors in the parameterizations of cloud and radiation or the model dynamics. In the meantime, other GCMs simulations in CMIP5 were also evaluated; including a total of 27 GCMs simulated cloud properties and radiation budgets. Cloud processes and properties, as well as their interactions with aerosols, are extremely important parts of the climate system. Their treatment in climate models is one of the largest sources of uncertainty in predicting any potential future climate change (IPCC Chapter 8, 2008). Dr. Dong's research results have drawn NASA program manager's attention. For example, four research highlights from Professor Dong's group have been selected by NASA MAP program manager, Dr. David Considine, and recommended for the Monthly Status Report at NASA Headquarters. One highlight reported the key improvements in GISS post-CMIP5 GCM simulated clouds and radiation compared with CERES-MODIS clouds and radiation results and other GCMs (Stanfield et al. 2014a, b; Dolinar et al. 2014). In the second highlight, an algorithm was developed to identify the width of the Intertropical Convergence Zone (ITCZ), and compared modeled ITCZ zones with TRMM and GPCP observations. ITCZ is a major feature of the global circulation, and its position is a good metric for testing GCMs (Stanfield et al. 2014c). A submittal is in work for the second term proposal to continuously investigate the GISS GCM simulated clouds, precipitation, radiation, related processes, and their relationships with large-scale atmospheric variables, which will help the NASA GISS modelers to improve their simulations and leverage the NASA GISS GCM results in the IPCC AR6. ✺

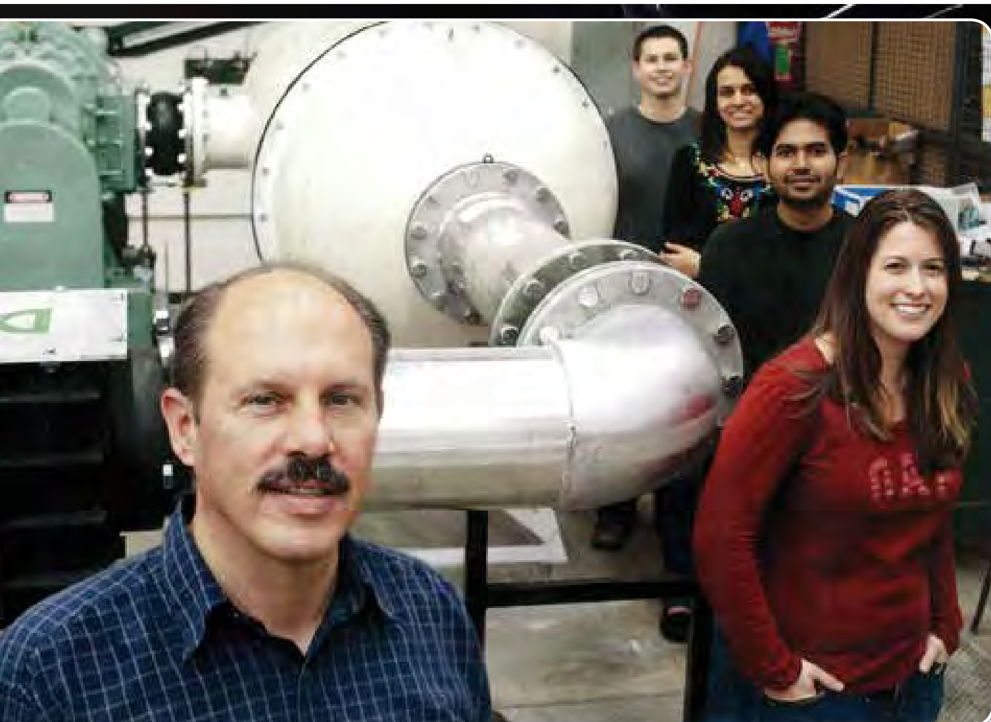


Dr. Xiquan Dong,
Science PI,
University of North Dakota

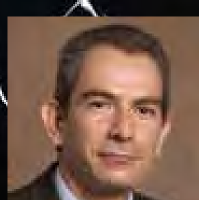
Dr. Patrick Minnis,
NASA Technical Monitor,
Langley Research Center

Experimental and Computational Investigation of Low Pressure Variable-Speed Turbine Aerodynamics: Benchmark Data Set and Predictive Tool Development

University of North Dakota/NASA Glenn Research Center, Aeronautics Research Mission Directorate



Pictured is the University of North Dakota's compressible flow facility. Counterclockwise starting with the bottom left is Dr. Forrest Ames, and students: Juli Pearson, Nifiz Chowdhury, Preethi Gandavarapu, and Matthew Mihelish.



Suzen Yildirim Bora, Science PI, University of North Dakota

Dr. Gerard E. Welch, NASA Technical Monitor, Glenn Research Center

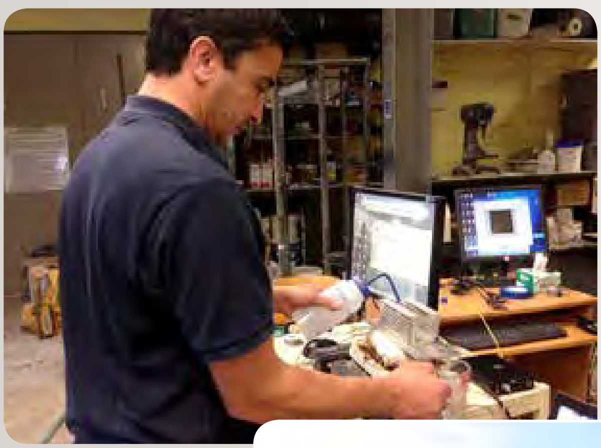
The design of variable speed power turbines (VSPT) is particularly challenging due to their highly loaded blades, and often widely varying incidence angles combined with low Reynolds number during normal operation. Moreover, the thermodynamic efficiency of gas turbines is strongly dependent on power turbine efficiency. This research aims to establish a combined experimental and computational investigation on VSPT flows. This work supports NASA's Aeronautics Research Mission Directorate (ARMD) Fundamental Aeronautics Program in the area of Subsonic Fixed Wind and Subsonic Rotary Wing Projects. This is a collaborative project, pairing the experimental capabilities of the University of North Dakota (UND) with the computational capabilities of North Dakota State University (NDSU) to pursue VSPT research of direct interest to the Turbomachinery and Heat Transfer Branch of NASA Glenn Research Center as well as to Rolls Royce of North America. The UND experimental research has acquired aerodynamic loss data in their new high-speed low Reynolds number facility. The NDSU study has addressed transition, separation, and unsteadiness using both conventional and more advanced methods in CFD. This effort has been used to further build experimental and computational methods, defined as crucial needs by NASA and the gas turbine industry for advancing understanding of complex VSPT flows to improve VSPT efficiencies. This research has also built collaborations with the US aviation gas turbine industry (Rolls Royce, Pratt and Whitney, GE, Honeywell, and Williams International) and the Air Force Research Laboratory. Further, the project has developed outreach activities to local Tribal Colleges and high schools to improve the demographics of underrepresented groups in engineering in order to help supply the workforce needs of the gas turbine and aerospace industries. ✺

North Dakota Research Infrastructure Development

University of North Dakota

➤ *UND students Lindsay Anderson and Tiffany Swarmer work with faculty member Pablo de León on research project titled, "Preliminary Research on Space Suited, Instrumented, full-scale anthropomorphic test devices (ATD) at the NASA-Ames 20-G Centrifuge."*

⮟ *UND student Tyler Hill completes routine examination of integrated system of inflatable habitat, docking tunnel, and electric rover during 30-day stay in a Lunar/Martian analog mission.*



⮝ *Multilayer composite insulations for extreme temperature environments are calibrated and validated through laboratory testing at North Dakota State University.*

⮜ *UND student Tyler Hill sets up geological survey site during extravehicular activity as crewmember of 30-day stay in a Lunar/Martian analog mission.*

➤ *Students within the Muscle, Metabolism, and Ergogenics Laboratory at North Dakota State University work to understand more about the fitness requirements for future an astronaut missions to deep space.*

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

University of North Dakota/NASA Kennedy Space Center, Human Exploration & Operations Mission Directorate

The University of North Dakota (UND) Human Spaceflight Laboratory will develop a Multi-Purpose Research Station in North Dakota designed to expand NASA-relevant research opportunities for students and faculty within the state, as well as project collaborators.

The research will be a collaborative effort between numerous departments across the UND campus, colleges and universities from across the state, and multiple NASA centers. This research station will include geological studies, extra-vehicular activity (EVA) research and operations, plant production studies, and human factors research (both physiological and psychological studies).

The location of a research station is key to the success and effectiveness of NASA-relevant analog studies. North Dakota offers a unique environment for this type of research. The climate's extremes are ideal for testing performance of equipment designed for similar conditions on other planetary surfaces; there is no NASA center or related industry in the area; and isolated, yet accessible locations are plentiful.

These factors make North Dakota an optimal location for these simulation studies so integral to NASA's preparation for deep space missions. This permanent experimental station will help our next generation of explorers reach new worlds beyond Earth. ✺

Dr. Pablo de León, Science PI, Associate Professor, University of North Dakota and student fit test the lunar rover and suit.

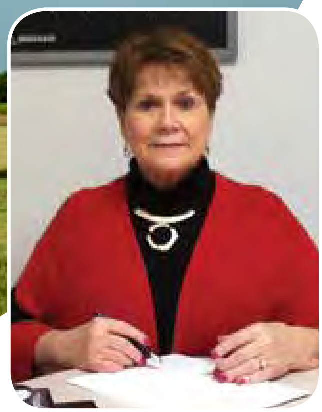
Mr. Douglas Gruendel, NASA Technical Monitor, Kennedy Space Center

Checkout of the upper torso of the space suit.

Team member testing flexibility of new suit design.

The John F. Kennedy Space Center (KSC) is the National Aeronautics and Space Administration's Launch Operations Center which supports Launch Complex 39 (LC-39), originally built for the Saturn V, the largest and most powerful operational launch vehicle in history, for the Apollo manned Moon landing program.

OK OKLAHOMA



Dr. Victoria Duca-Snowden,
OK EPSCoR Director

NASA EPSCoR aligns with OneOklahoma, the state's Strategic Plan for Science and Technology in Oklahoma and supported university research in core S&T industry sectors - agriculture, energy, weather, aviation, biotech, sensors, and unmanned vehicle systems. It provided significant opportunity to foster research clusters among institutions and develop partnerships with science and technology companies: 17 new collaborations among researchers, private industry, and government resulted in external funding of $3,400,200.

STEM education was advanced through 37 new or revised courses developed by EPSCoR funded faculty. Internships led to full-time employment for seven students with two science and technology companies and supported 181 students working on advanced degrees in STEM.

NASA funding benefitted Oklahoma's economic development, such as the project in which researchers developed instruments for radiation detection in space. Technology was transferred to instrumentation monitoring proton and heavy ion beams used in cancer radiation treatments, now utilized by an Oklahoma company.

Senator
Jim Inhofe

Senator
James Lankford

Representative
Jim Brindenstine
(1st District)

Representative
Tom Cole
(4th District)

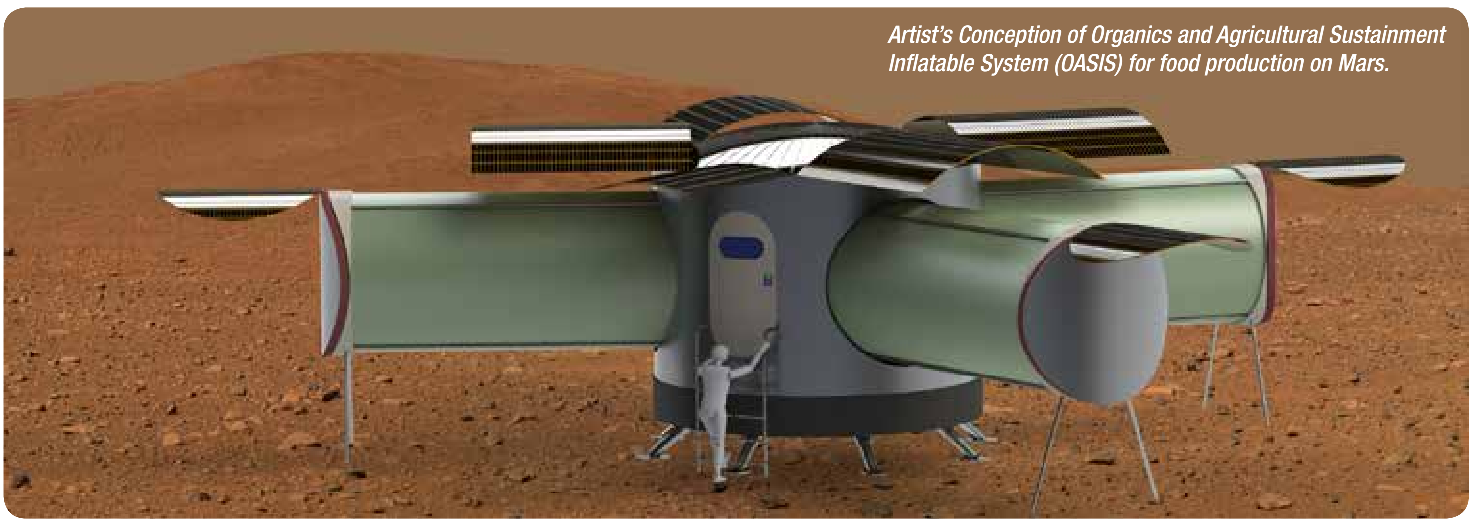
Oklahoma Research Infrastructure Development

eXploration Habitat (X-Hab) Academic Innovation Challenge seeks to provide university students with the opportunity to be on the forefront of technological innovation. Each university team accepted into the X-Hab program works to design a system that fulfills the requests for a mission proposed by NASA. That team then constructs an analog prototype to demonstrate and test its design. The X-Hab Program benefits NASA by producing, demonstrating, and testing multiple design concepts and approaches to a single problem, which can then be modified, combined, or thrown-out, ultimately increasing the efficiency of NASA's design process. Since its inception in 2011, the X-Hab program has become an integral part of NASA's Demonstration Unit-Deep Space Habitat research. Up to five proposals are selected each year representing student teams from across the nation.

Oklahoma State University (Space Cowboys) remains the only team that has been selected every year to become part of the X-Hab Program.

This year's design competition both develops a method and creates a facility for growing food on Mars, which will be a supplemental food source for four astronauts on a five-hundred-day surface mission. OSU's Organics and Agricultural Sustainment Inflatable System (OASIS) was designed by a team of aerospace, agricultural and architectural engineering students to meet these requirements and provides a realistic solution to the issues surrounding food production on the Martian surface while providing a real world design problem for engineering students.

The present design incorporates a solid central structure that is integrated with inflatable growing modules to maximize the plant growth footprint while reducing total mass and packed volume. In the current approach, deployment and structural design are driven by plant growth requirements and minimal crew interaction. ✺



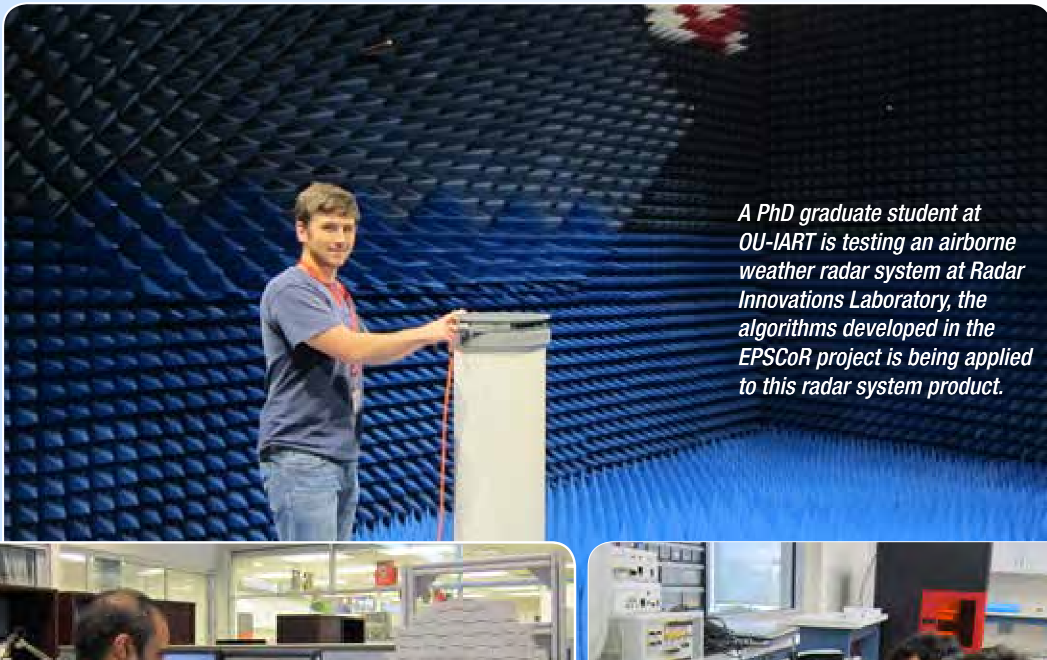
Artist's Conception of Organics and Agricultural Sustainment Inflatable System (OASIS) for food production on Mars.

The window goes in and the end-cap is done!

Danni North (Architectural Engineering student), Jessica Barber (Aerospace Engineering student), Ariel Barnes (Aerospace Engineering) and Hannah Moore (Architectural Engineering student) work on components of the full scale Martian greenhouse analog.

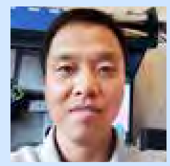
Solid-state Radar Transceiver Optimization through Adaptive Pulse Compression for Spaceborne and Airborne Radars

ARRC, The University of Oklahoma/NASA Goddard Space Flight Center, Science Mission Directorate

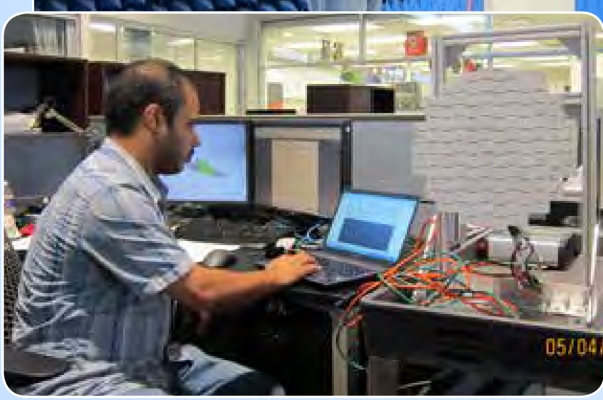


A PhD graduate student at OU-IART is testing an airborne weather radar system at Radar Innovations Laboratory, the algorithms developed in the EPSCoR project is being applied to this radar system product.

Dr. Yan (Rockee) Zhang, Science PI, Associate Professor, The University of Oklahoma



Dr. Lihua Li, NASA Technical Monitor, NASA GSFC



◄ Graduate students working together on the Ku-band solid-state radar transceiver optimization testbed.

▲ Mr. Mansur Tyler, an American Indian student, is working on solid-state radar scattering experiment and usage of the information for better transceiver design in a brand new facility at OU.

This project completes the first comprehensive studies and applications of Adaptive Pulse Compression (APC) and joint transceiver optimization implementations with airborne weather radar, which is an emerging and unique research area in the state of Oklahoma. It solves the range sidelobe contamination problem by innovative algorithms and software and proves the feasibility of applying the algorithms to actual NASA radar data. The OU team is currently working with NASA-GSFC team to deploy the technologies to current NASA-operating radar and data products. The technology is also successfully applied to OU's ground based solid-state radar in 2013-2014, and obtained significantly improved sensing result for the May 2013 Moore, OK tornado observation campaign.

The technologies developed in this project are used in other ongoing projects developments beyond weather remote sensing applications. An important application developed during the period is the improvements in general air-surveillance, especially for the detection, tracking and identification of small aerial objects including small unmanned aerial vehicles (UAVs), which is a new research area emphasized by state of Oklahoma. Technology was successfully applied to GBSAA and ABSAA experiments and achieved significant impacts on the DoD organized UAS-EXCOM in 2014.

The EPSCoR project supported the design and build of the first large scale fixed wing unmanned aerial vehicle – OUAV-One in OU campus, in 2013, which laid a potential infrastructure for future flight test of our new radars for atmospheric remote sensing research.

Collaboration with Garmin International from 2013 is a milestone of the program which not only allowed the research and development team in state of Oklahoma to transfer the technology to commercial products, but also allowed them to learn from an industrial leader in airborne radar area. ✺

Advanced Digital Radar Techniques for the Next Generation of Synthetic Aperture Radar (SAR) and Student Training

The University of Oklahoma/NASA Goddard Space Flight Center, Space Technology and Science Mission Directorates

Lockheed WP-3D Orion at MacDill Air Force Base where

Dr. Mark Yeary,
Science PI,
University of Oklahoma

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

Dr. Mark Yeary and his EPSCoR-funded team at the University of Oklahoma is helping NASA better understand how and why our climate is changing. Yeary and his student researchers have partnered with engineers and scientists at NASA's Goddard Space Flight Center (GSFC) to design "EcoSAR", a new synthetic aperture radar (SAR) for taking ecological measurements. This new radar will map forest cover, above ground biomass, disturbance due to deforestation and logging, forest recovery, and wetland inundation, all contributing factors to Earth's carbon cycle. These measurements directly support science requirements for the study of the carbon cycle and its relationship to climate change, recommended by the National Science Foundation's Decadal Survey (2007) and highlighted in NASA's Plan for a Climate-Centric Architecture (2010).

This EPSCoR grant laid the foundation for the April 2014 opening of Oklahoma University's new Radar Innovations Lab (RIL). The 35,000 square-foot facility is dedicated to the design and construction of radar systems. The RIL supports the efforts of the university's Advanced Radar Research Center, one of the largest academic centers in the world, focused on innovations in radar science and engineering,

Yeary's EPSCoR-funded students gained hands-on experience in designing and conducting research-related experiments, thereby improving their transitioning from undergraduate to graduate research experiences.

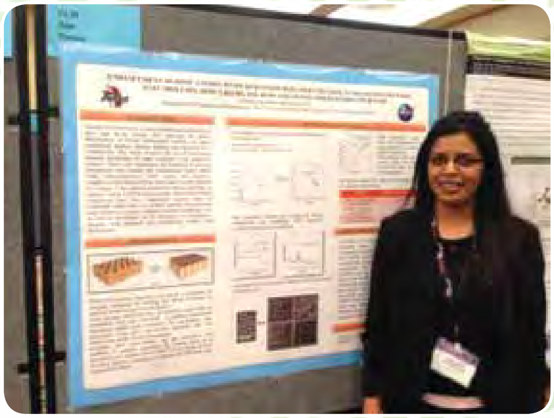
Dr. Yeary is collaborating with the Oklahoma Climatological Survey (OCS) to devise an airborne synthetic aperture radar experiment that can measure soil moisture levels in Sooner crop lands. The Survey maintains an extensive array of climatological information, operates Oklahoma's world-class ecological measuring system, Mesonet, and hosts a wide variety of educational outreach and scientific research projects. ✺

Faculty from The University of Oklahoma are teaming with Goddard Space Flight Center to develop the Ecological Synthetic Aperture Radar (EcoSAR). This system makes challenging measurements related to Earth's ecosystem structure such as wetlands, forests, and permafrost. The Science Investigator partners with Space Grant integrating this research into STEM pre-service teacher education using radar guns to teach velocity and speed.

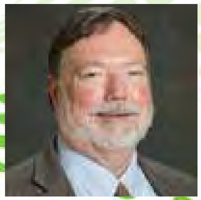
A Nanostructured Energy Harvesting and Storage System for Space and Terrestrial Applications

The University of Tulsa/NASA Human Exploration & Operations Mission Directorate/Glenn Research Center

In collaboration with the Oklahoma Jurisdiction, the NASA EPSCoR research team organized an annual research symposium with the purpose of career development, development of personal and professional skills, improvement of technical communication skills, and outreach to students from underrepresented groups. The "Oklahoma NASA Energy Symposium" highlighted the research accomplishments of Oklahoma-area student researchers in the topics of energy generation, storage, and management for NASA-relevant terrestrial and orbital missions. The symposium not only served as a mechanism for students to present their research, but it also served as an outreach mechanism to encourage these students to attend graduate school and participate in the proposed NASA projects as future graduate students or affiliated undergraduate researchers. Graduate school recruitment was emphasized, by all the universities involved. This symposium is a new endeavor for the Jurisdiction in collaboration with the research team. This new evolution of STEM education and research by Oklahoma NASA EPSCoR has been well received by the engineering and science communities. Now in its second year, over twenty five students from across the state have participated including several minority students. ✺



Graduate student, Indu Jayasekara, presenting her research at the Oklahoma NASA Energy Symposium.



Dr. Dale Teeters,
Science PI,
The University of Tulsa

Dr. Al Hepp,
NASA Technical Monitor,
Glenn Research Center

OK

Radiation Smart Structures with H-rich Nanostructured Multifunctional Materials

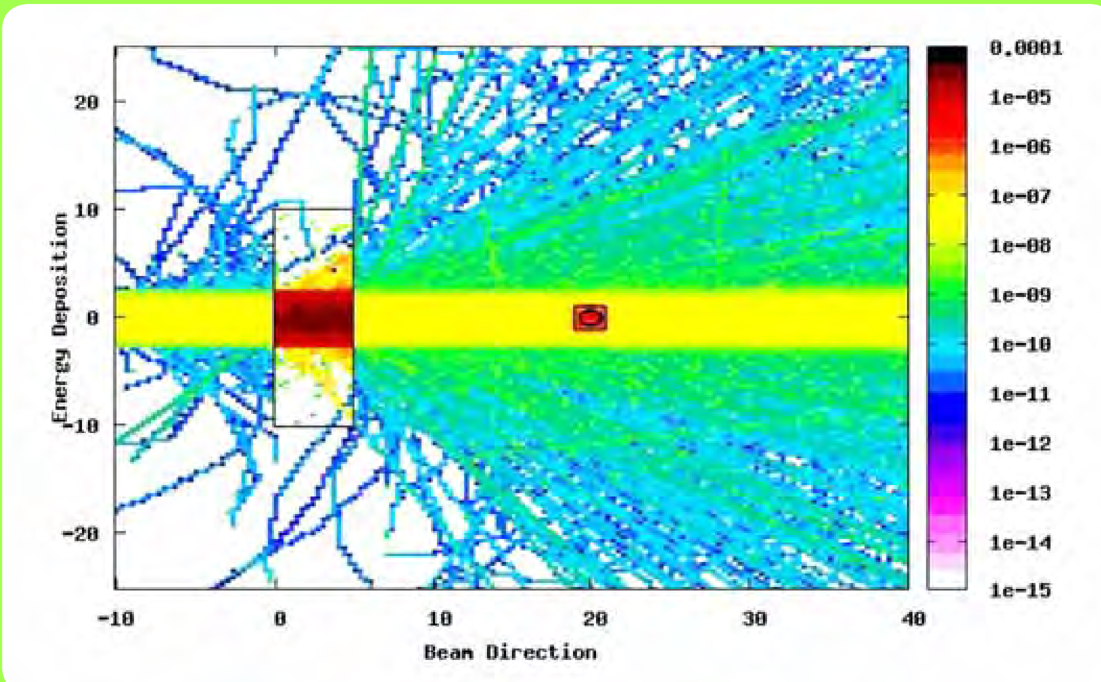
Oklahoma State University/NASA Marshall, Johnson and Langley, Human Exploration & Operations and Space Technology Mission Directorates

Living on the Moon could become a reality through new research from engineering and physics faculty at OSU. "With fewer and fewer places left to explore on Earth, our attention is turning toward outer space," says Dr. Ranji Vaidyanathan, Varnadow Chair and OSU-Tulsa professor of materials science and engineering. "Living in space is the next frontier for us."

An interdisciplinary team is working to develop a new radiation-shielding material that could be used to construct habitats that protect astronauts from prolonged exposure to galactic cosmic radiation.

The material will shield astronauts from ionizing radiation during missions to asteroids near Earth, the Moon and Mars and could also be used in the creation of lunar and Martian habitats. Using 3-D printing technology and contour crafting, astronauts will be able to create the parts and construct igloo-like habitats in space, instead of building units on Earth and transporting them.

The team is collaborating with scientists at NASA Langley Research Center in Virginia, Marshall Space Flight Center in Huntsville, Ala., and Lyndon B. Johnson Space Center in Houston, Texas, to find additional applications for the material. ✺



A simulated 2D view generated by FLUKA of energy deposition by a 162 MeV proton beam for a 5 g/cm2 thickness of polyethylene. x and y axes are in cm. Color scale is in units of GeV/cm3 proton.

Batch mixture used to mix thermoplastic with different materials.

Image of blended PE + boron carbide (black) and boron nitride (white) after mixing in the lab mixer.

Dr. Ranji K. Vaidyanathan, Science PI

Dr. Sheila Ann Thibeault, NASA Technical Monitor, Langley Research Center, HEOMD

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

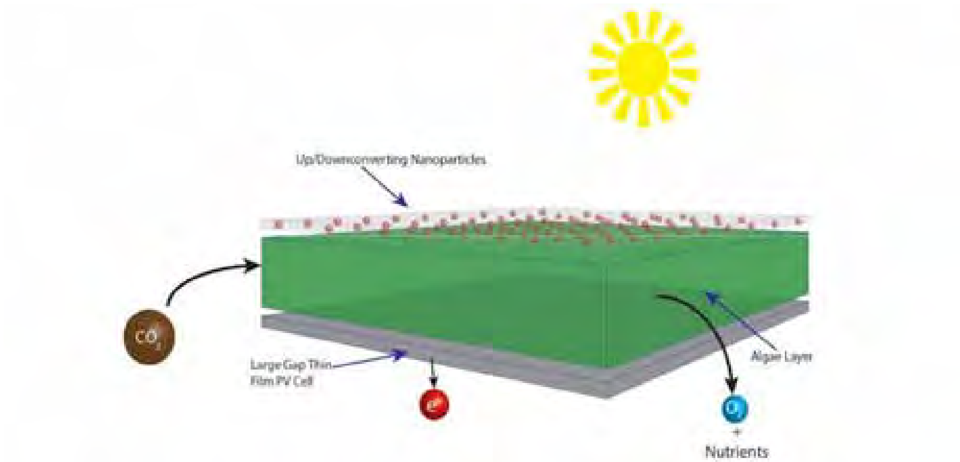
University of Tulsa/Johnson Space Center, Human Exploration & Operations Mission Directorate

The ultimate goal of this project is to design, fabricate and test an autonomous, portable algae bioreactor for long-distance space travel, capable of biomass production from nanoparticles to convert the unused portions of the solar spectrum to wavelengths needed for algae photosynthesis.

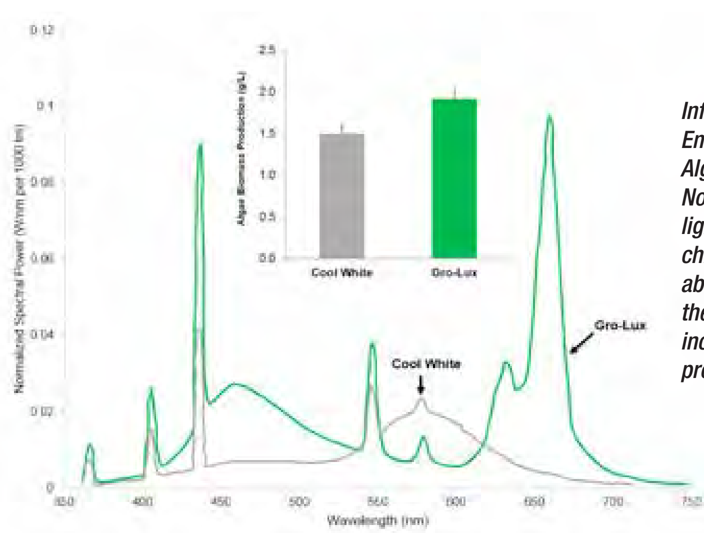
To achieve these goals, we will bring together a diverse group of multidisciplinary, multi-university research teams with established collaborative experience in solving complex interdisciplinary science and engineering challenges and will provide the framework to be highly competitive for funding outside the NASA EPSCoR program.

This research is a useful synergy between NASA's interests in biologically-supported life support for human deep space missions and other light-harvesting projects exploring technologies such as photovoltaics, quantum dots (Power and Onboard Propulsion Technology, Glenn Research Center) and spectral conversion (Luminescence-Based Diagnostics of Thermal Barrier Coating Health and Performance, NASA Glenn and NASA Ames Research Centers).

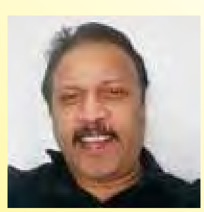
This project will support the Oklahoma consortium in improving science, technology, engineering and mathematics education through building infrastructure in higher education and economic development in Oklahoma. Also promoted will be the involvement of underrepresented groups, specifically Native American, in space research by cooperating with the Oklahoma Louis Stokes Alliance for Minority Participation (OK-LSAMP) program and Oklahoma Space Grant member Southeastern Oklahoma State University. ✺



Hybrid Algae/photovoltaic (PV)/Up and Downconversion System. This system allows for increased biomass production using normally unused wavelengths in the solar electromagnetic spectrum by coupling photosynthesis with up and downconversion of photons. Cultures of microalgae will provide a source of oxygen and nutrients for manned space exploration, while simultaneously removing waste carbon dioxide.



*Influence of Light Emission Spectrum on Algae Growth.
Note that the Gro-Lux light source is close to the chlorophyll absorption peaks, thereby resulting in increased biomass production.*



*Parameswar Hari, Ph.D.,
Science PI,
Professor, University of Tulsa,
Nanotechnology*

*Dr. Aloysius Hepp,
NASA Technical Monitor,
Direct Energy Conversion,
NASA Glenn Research Center*

Marshall Space Flight Center (MSFC) is NASA's rocketry and spacecraft propulsion research center. MSFC's first mission was developing the Saturn launch vehicles for the Apollo moon program. Located on the Redstone Arsenal near Huntsville, Alabama, MSFC is named in honor of General of the Army George Marshall.

PR PUERTO RICO

The Puerto Rico NASA Experimental Program to Stimulate Competitive Research (PR NASA EPSCoR) Program builds in Puerto Rico the core strengths needed to increase competitive research and technology development methods and activities for the solution of scientific and technical problems of importance to NASA in coordination and collaboration with NASA Centers and Mission Directorates and other research centers around the Nation that seek to advance U.S. scientific, security, and economic interests through a robust space exploration program. Contributes to and promote the development of research infrastructure in Puerto Rico in areas of strategic importance to the NASA mission. Improves the capabilities of Puerto Rico to gain support from sources outside the NASA EPSCoR program. In addition to assisting with the funding of NASA aligned viable patent producing research, the Puerto Rico NASA EPSCoR program contributes to the development of partnerships among NASA research assets, academic institutions, and industry established in Puerto Rico and contributes to the overall research infrastructure, science and technology capabilities, higher education, and economic development of Puerto Rico.

Dr. Gerardo Morell, PR EPSCoR Director, University of Puerto Rico, San Juan

Puerto Rico TOC

Representative Pedro Pierluisi (District At Large)

Hyperspectral imaging for Biodiversity Assessment of Coastal and Terrestrial Ecosystems

University of Puerto Rico, San Juan/NASA Science Mission Directorate

If a picture is worth a thousand words, then NASA's remote-sensing cameras can speak volumes about the biodiversity of a particular plot of land or seashore. A good, quick reference guide, a "dictionary" if you will, can help scientists and researchers "translate" those pictures into words.

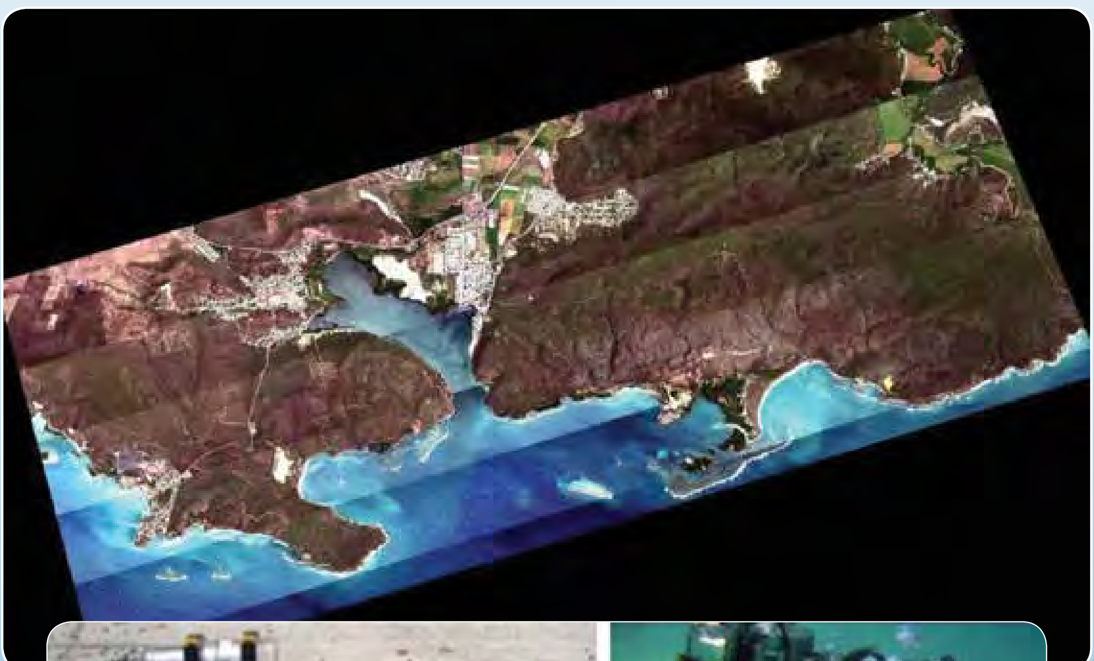
Essentially, that's what this EPSCoR-funded project at the University of Puerto Rico was designed to do: establish algorithms that correlate the colors and densities that remote-sensing space- and aircraft photograph from above with the variety and species types transmitting those signals from the ground or coastal waters below. Such a protocol applicable across different ecosystems can save researchers time, money and effort they'd otherwise need to validate each of any number of specific suppositions and analyses.

This research project focused on designing algorithms which combine multi-temporal and multi-scale NASA satellite (Hyperion), NASA airborne (NASA Glenn Research Center's Compact Hyperspectral Imager and AISA sensor), and other available imagery (hyperspectral and multispectral) with in situ measurements to characterize the distribution, abundance, and phenology of biodiversity in two environments - the Guánica Dry Forest and La Parguera Reefs in Puerto Rico (PR). The data collection served as both the science driver to determine what is useful to be estimated by remote sensing, and also as "ground truth" for algorithm development.

Specific achievements included the identification of specific, high-value spectral indicators of biodiversity and conservation, forest condition, reef condition, and functional diversity for a range of Neotropical habitats from coastal marine to upland forest ecosystems.

Collaborators joining UPR and NASA Glenn were NASA's Goddard Space Flight Center, the PR Department of Natural Resource, the U.S. Forest Service's International Institute of Tropical Forestry, and the University of Virginia.

From this EPSCoR-funded research came a UPR graduate biology course, and numerous undergraduate courses incorporated the newly-developed data methodologies. Also established was a student internship at NASA Goddard. ✷



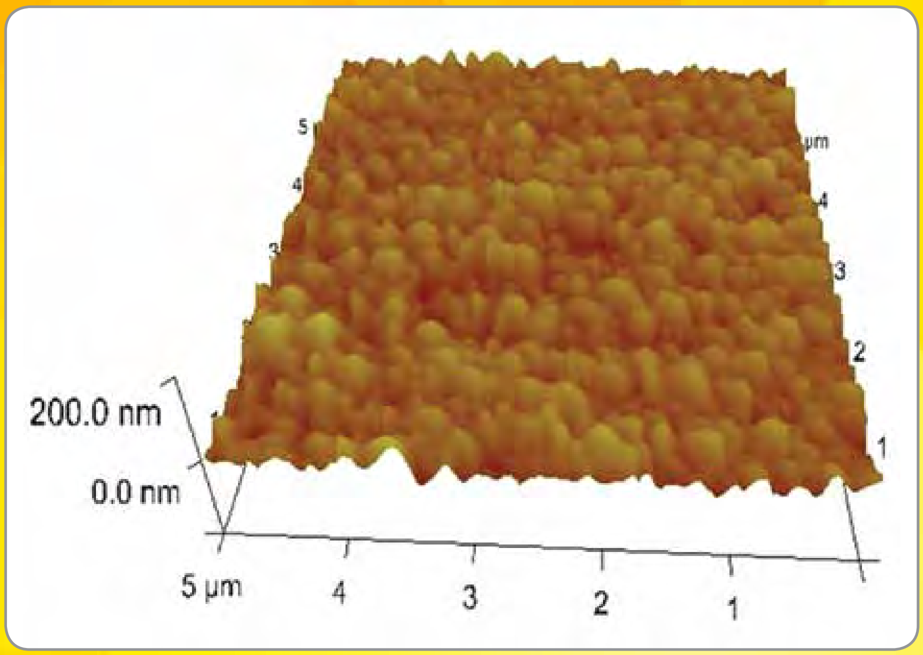
Dr. Shawn D. Hunt,
Science PI,
University of Puerto Rico,
Mayaguez

Dr. Liane Guild,
NASA Technical Monitor,
Ames Research Center

Housing and light source for GER-1500 field spectrometer used to baseline signals from a comprehensive sampling of species amongst the inner shelf reefs of southwestern Puerto Rico, predominantly on Enrique Reef.

Nanostructured III-N Solar Cells for Space Applications

University of Puerto Rico, Mayaguez/NASA Human Exploration & Operations Mission Directorate



AFM images of In0.3Ga0.7N/GaN on sapphire: average grain 4.21 nm.

After the Year 3 report on the growth of InxGa1-xN and GaN by plasma–assisted metal organic chemical vapor deposition (p-MOCVD) on sapphire (0001) and their photoluminescence (PL) responses, additional samples of InxGa1-xN (x = 02, 0.3) were grown at 700oC on sapphire and uniform epilayers were achieved. Low mobility and carrier concentration were attributed to the defects probably due to the presence of oxygen (during substrate transfer) in the reaction chamber. Results were presented at the International Conference on Growth of III-N (ISGN-5) at Georgia Tech. Defects can be minimized using load-lock system. In-Ga-N-As system is expected to have higher carrier mobility and ideal band gaps (1 eV to 2.5 eV for two junction solar cells) and it is lattice matched with Ge and small lattice mismatched with Si. ✺

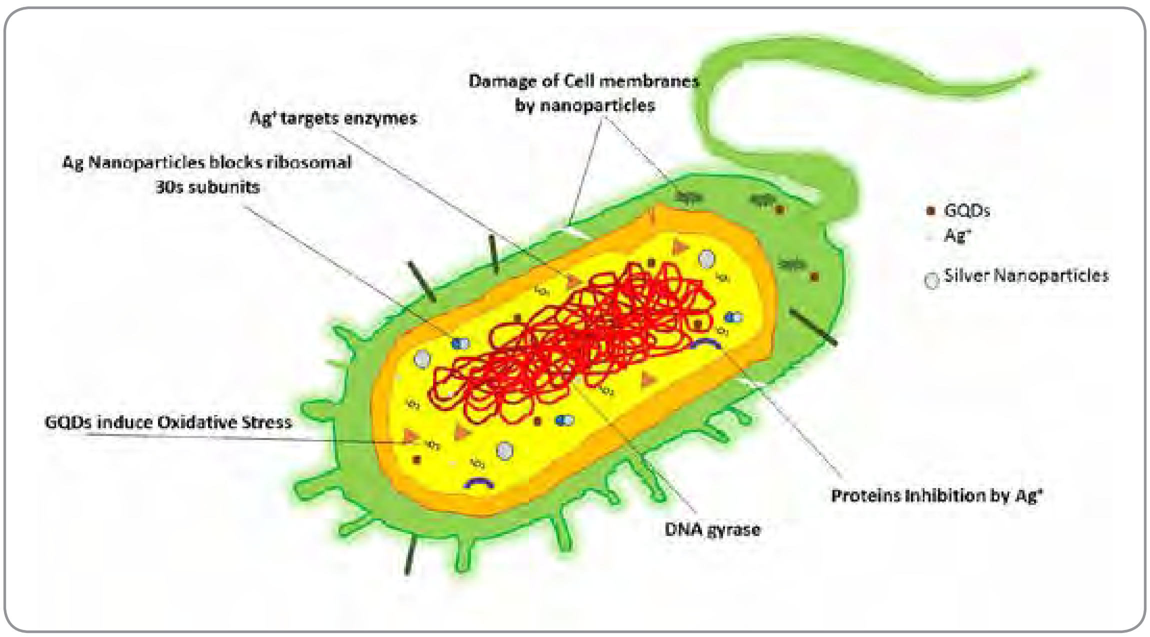
Maharaj S. Tomar, Science PI,
University of Puerto Rico, Mayaguez Campus

Dr. Ravi Margasahayam, NASA Technical Monitor,
Kennedy Space Center

Puerto Rico NASA EPSCoR Research Infrastructure Development Program

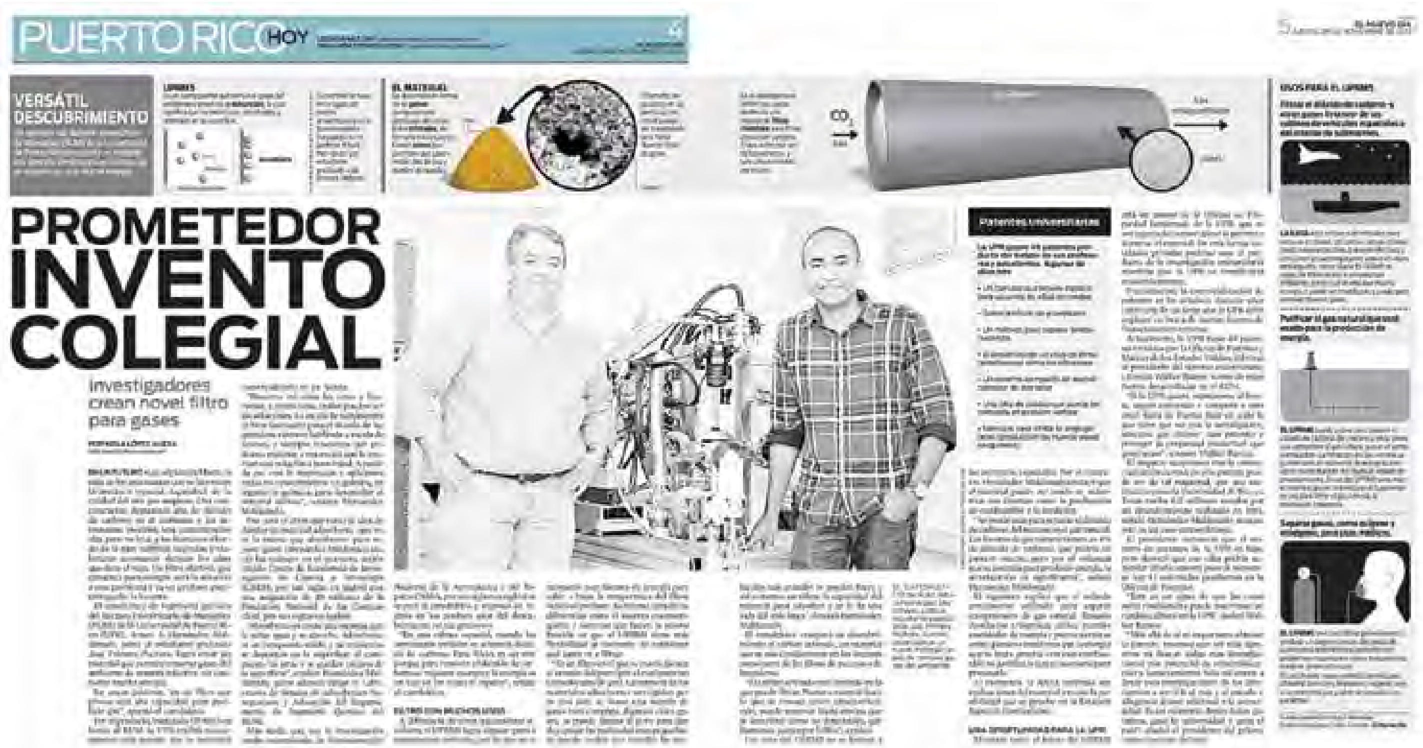
Silver-Graphene Nanocomposite to Combat Drug-resistant Bacteria

Functionalized nanoparticles can offer novel solutions for the post-antibiotic era. In this context, we developed a nanocomposite of silver nanoparticles decorated with graphene quantum dots (Ag GQDs) and functionalized with polyethylene glycol. This nanocomposite inhibits the growth of Gram-positive S. aureus and Gram-negative P. aeruginosa bacteria, which are commonly isolated from microbial infections in wounds. The concentration required to inhibit both types of bacterial strains is well below the concentration that would affect the mammalian cell viability, being therefore biocompatible. The effectiveness of the composite is due to a synergistic effect in which the GQDs facilitate the internalization of the silver nanoparticles into the bacteria, thus reducing the overall concentration of silver required to produce the bactericide effect. These results suggest that Ag-GQDs can be used in the fabrication of antibacterial ointments, self sterile textiles, and sterile personal care products. The next phase is to independently validate the results and develop antibacterial products based on Ag-GQDs. The following provisional invention patent was recently submitted to the U.S. Patent and Trademark Office: “Method for the Synthesis and Functionalization of Nanoparticle - Graphene Quantum Dots Nanocomposites by a Plasma Assisted Approach”, Filing Number 62/145559. Researchers from University of Puerto Rico patented an approach to diamond induction by employing iron nanoparticles to induce the synthesis of diamond on molybdenum, silicon, and quartz substrates. (Patent #: US 8,784,766 B1– Issue Date – July 22, 2014). ✺



Carbon Dioxide Storage and Sustained Delivery by Porous Pillar-Layered Structure Coordination Polymers and Metal Organic Frameworks

University of Puerto Rico/NASA Ames Research Center, Marshall Space Flight Center, Human Exploration & Operations Mission Directorate



PUERTO RICO HOY

VERSÁTIL DESCUBRIMIENTO

PROMETEDOR INVENTO COLEGIAL

Investigadores crean novel filtro para gases

Patentes universitarias

Hernandez-Maldonado contributions to NASA projects were also highlighted by UPRM.

Dr. Arturo Hernandez-Maldonado, Science PI, University of Puerto Rico, Mayaguez

Jay Perry, NASA Technical Monitor, Marshall Space Flight Center

When we breathe, we take in oxygen (O_2) and exhale carbon-dioxide (CO_2). Here on Earth, where the CO_2 goes isn't normally a worry, but it's a different matter outside our atmosphere, in the finite enclosure of a spacecraft.

This EPSCoR-funded project at the University of Puerto Rico is examining the characteristics and capabilities of different substances to absorb and store carbon dioxide for possible use by NASA aboard deep space-faring vessels of the future.

The team's most recent objectives have been to study how certain, specifically-structured polymers and meta-organic frameworks can best "scrub" and transfer CO_2 from an environment. The data generated can help address fundamental questions raised by experimental studies and provide feedback for further synthetic work towards improving the adsorbent-adsorbate interactions in an iterative sequence of experiments. In other words, helping scientists and researchers working in the laboratory to synthesize the best substances possible for the job.

This research project has enhanced and expanded the network of mutually-beneficial research interactions between a multidisciplinary team of researchers in PR and NASA partners at NASA Marshall Space Flight Center and NASA Ames Research Center. Identification by NASA of specific challenges to the successful storage, delivery and conversion of CO_2 onboard led the UPR team to design all the experiments and test beds accordingly. The project also gained support and an endorsement from the PR EPSCoR Committee maintain Nanotechnology and Environmental Engineering as "thrust areas" for the development of EPSCoR-funded research in the Jurisdiction. And, one of the team's doctoral students spent a ten-week internship at NASA Ames performing CO_2 storage and delivery experiments in a collaboratively-developed test bed. ✺

PR

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

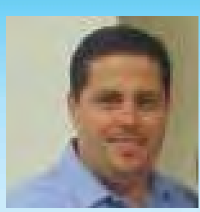
University of Puerto Rico/NASA Ames Research Center, Human Exploration & Operations and Space Technology Mission Directorates

Astronauts drink water made from recycled urine and other wastewater aboard the International Space Station. A new system would turn urine into drinking water and produce energy, a step toward long-term space travel.

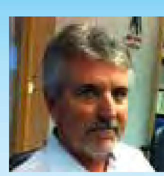
The research goal of this project is to develop multifunctional water purification membranes for the removal of contaminants from wastewater. These membranes are fabricated with dual function to withstand bacterial growth and also serve as a catalytic platform. The purpose of this is to generate purified 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.

With this project we have been able to leverage our previous efforts in the area of water purification while generating electrical current as the next-generation of technologies to support life on earth and abroad. This project has enabled establishing the Laboratory for Water Reclamation and Multifunctional Materials with the acquisition of state of the art instrumentation that is unique in Puerto Rico. This allows for collaborations with other researchers from Puerto Rico and the Mainland. Moreover, the instrumentation acquired is pertinent to the industry, which opens up new venues for collaboration and possible revenues for reinvestment. Last but not least, our students have been able to successfully access other research opportunities such as NASA fellowships and internships. ✺

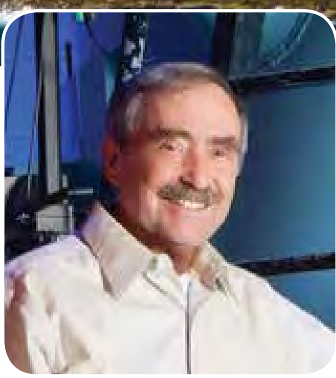


Dr. Eduardo L. Nicolau-Lopez, Science PI, University of Puerto Rico

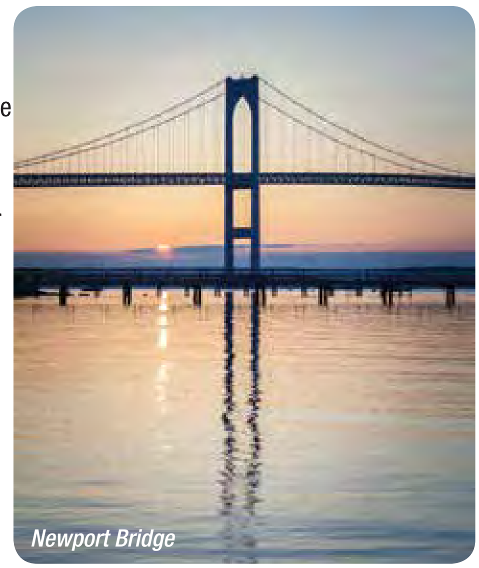


Dr. Michael Flynn, NASA Technical Monitor, Ames Research Center

RHODE ISLAND



Prof. Peter Schultz,
RI EPSCoR Director,
Brown University



Newport Bridge

Two institutions (Brown University and the University of Rhode Island) have nationally recognized PhD programs in NASA-related fields including planetary science, design, ocean science, computer science, physics/astronomy, and engineering. Ongoing NASA-related research programs include planetary exploration, space-related industrial design, astrobiology, cosmology, battery research, and remote sensing. Other institutions in the state engage their students in NASA research through on-campus internships and curricula. Our close proximity to each other stimulates cross-disciplinary and cross-campus research, as well as engaging faculty, students, and researchers from 9 other smaller colleges. Each institution has their own unique strengths that generate students continuing in STEM fields. Through our EPSCoR awards, we have stimulated significant new funding for research in Rhode Island, stimulated new NASA-related curricula, and engaged faculty in new NASA-related research directions. EPSCoR-RID awards also stimulate new research opportunities for their students through new curricula and hands-on summer research.

Rhode Island TOC

*Senator
Jack Reed*

*Senator
Sheldon Whitehouse*

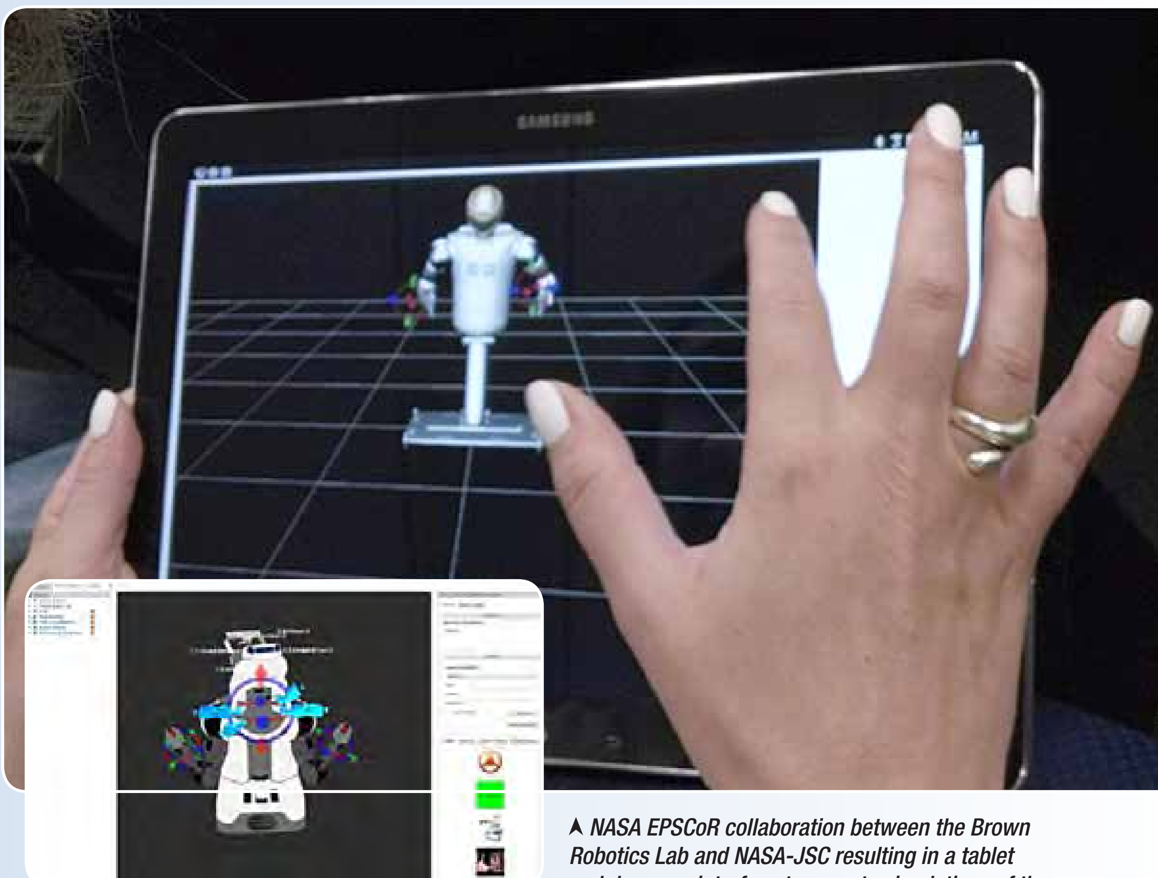
*Representative
David Cicilline
(1st District)*

*Representative
Jim Langevin
(2nd District)*

Web-Scale Assisted Robot Teleoperation

Brown University/NASA Glenn Research Center, Ames Research Center, Goddard Space Flight Center, Space Technology and Science Mission Directorates

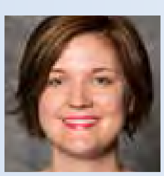
Our goal is to develop web-based interfaces for assisted teleoperation of robot manipulation systems to both study questions of adjustable autonomy and broaden participation in robotics. We aim to make cutting-edge autonomous robots available at the fingertips of students and citizen scientists, both to advance robotic technology and make it more usable by people. In collaboration with NASA's Dexterous Robotics Laboratory and TracLabs Inc., we have created "remote robot labs" that allow people on the Internet to view and command state-of-the-art robot platforms (such as NASA Robonaut 2 and Willow Garage PR2) simply through their web browser. Granting such widespread access to leading robots provides an unprecedented opportunity to advance human-robot interaction and promote STEM education in service of furthering space exploration and many other applications. Through our web-based robot remote labs, we not only have the ability to rapidly create new interfaces for human operation of autonomous robots but also the ability to test these interfaces at scale, towards truly understanding how people can best command complex robots. Just as important, our efforts allow current generations of students to further their inspiration for robotics through experiencing and exploring the technology first-hand. Towards this end, we have also increased the capacity for informal robotics-oriented STEM education through our founding of the Rhode Island Robot Block Party event, which has become a nexus for robotics across the industrial, academic, and citizen science sectors of the state. With over 2,500 attendees this year, people of all ages were able to see and experience robots ranging from small micro rovers, marine exploration robots, aerial drones, and mobile robot manipulators.



PR2 using a wheel affordance template

NASA EPSCoR collaboration between the Brown Robotics Lab and NASA-JSC resulting in a tablet web browser interface to operate simulations of the NASA Robonaut R2 and Valkyrie robots as well as the physical PR2 robot.

Dr. R. Iris Bahar
Science PI
Professor, Brown University



Dr. Kimberly A. Hambuchen,
NASA Technical Monitor

BROWN

Rhode Island Research Infrastructure Development

University of Rhode Island, Graduate School of Oceanography

THE UNIVERSITY OF RHODE ISLAND

One major issue in determining climate change (whether gradual or sudden) in sediments is the identification of reliable markers. EPSCoR-RID funding allowed the development of biogeochemical proxies for paleo-environmental changes associated with climate and impact events recorded in the loessoid deposits in the Buenos Aires Provence, Argentina. Using sediments returned from Argentina from a separate project, our research established that mid-chain n-alkyl compounds (leaf waxes) and glycerol dialkyl glycerol tetraethers (GDGTs, i.e., bacterially generated compounds) are indeed preserved in sediments spanning the last ~3-4 Myrs. Such biomarkers provide evidence for sudden changes in temperature and hydrology in Argentina spanning an impact event and faunal turnover ~3.3 Ma, as well as temperature changes from the last glaciation to present. Our results resulted in presentations at the American Geophysical Union Fall Meeting (2013), submission of two National Science Foundation (NSF) research grant proposals, preparation of a final paper, and participation in several NSF and The Consortium for Ocean Leadership funded workshops for scientific drilling in South America and its continental margin.

This research contributed to NASA EPSCoR-RID objectives by creating future research opportunities and establishing new collaborations that will address several NASA Science Mission Directorate interdisciplinary focus areas including Climate Variability and Change, Carbon Cycle and Ecosystems, Water and Energy Cycle, and Exobiology. Of particular interest here, however, is to use these new biogeochemical proxies to assess the conditions before and after several major impacts discovered in Argentina (highly relevant to NASA's Exobiology program). These impacts are expressed as widespread impact glasses coincident with sudden endemic faunal turnover (3.27Ma) or sudden climate change (e.g., the Miocene/Pliocene transition). Understanding the severity of climate and landscape change following an impact helps to distinguish between this process relative to other natural (or human) processes as well as informing the potential response to a future collision. ✷

➤ Students in the Industrial Design Course at the Rhode Island School of Design examining the effects of a vacuum on a prototype of a space glove for NASA

➤ Research Specialist Dr. Chip Heil at the Graduate School of Oceanography (University of Rhode Island) with a graduate student sampling a 3 million year old section from Argentina for biomarker and isotopic analysis.

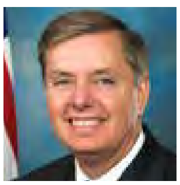
➤ Students in the Industrial Design Department (Rhode Island School of Design) working on a full-scale mock-up of a human habitat on Mars.

SOUTH CAROLINA

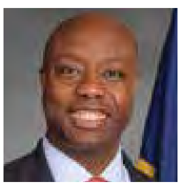
Dr. Cassandra Runyon, SC EPSCoR Director, College of Charleston

The South Carolina NASA Experimental Program to Stimulate Competitive Research (EPSCoR) provides, in addition to the larger research awards, RID seed funding for competitively selected projects that are of benefit to NASA and our jurisdiction (South Carolina and the US Virgin Islands). In an effort to build and sustain a strong research capacity and broaden student engagement in science, technology, engineering and mathematics (STEM) our program requires the participation of student researchers. These seed grants have spawned successful, sustainable research programs and resources for undergraduate and graduate courses at our jurisdiction institutions. For example, one small seed grant ten years ago in materials science led directly to multiple funding awards from NASA and other federal agencies and has resulted in several patents. Additional research areas critical to both NASA and our jurisdiction include: nano-technology, biomedical engineering, fuel cell and battery technology, optics, remote sensing, earth and marine science to name a few. This program engages many students each year through direct hands-on, faculty-mentored research experiences as student participation is a requirement for award selection.

College of Charleston Cistern Yard



Sr. Senator Lindsey Graham



Jr. Senator Tim Scott

Representative James Clyburn

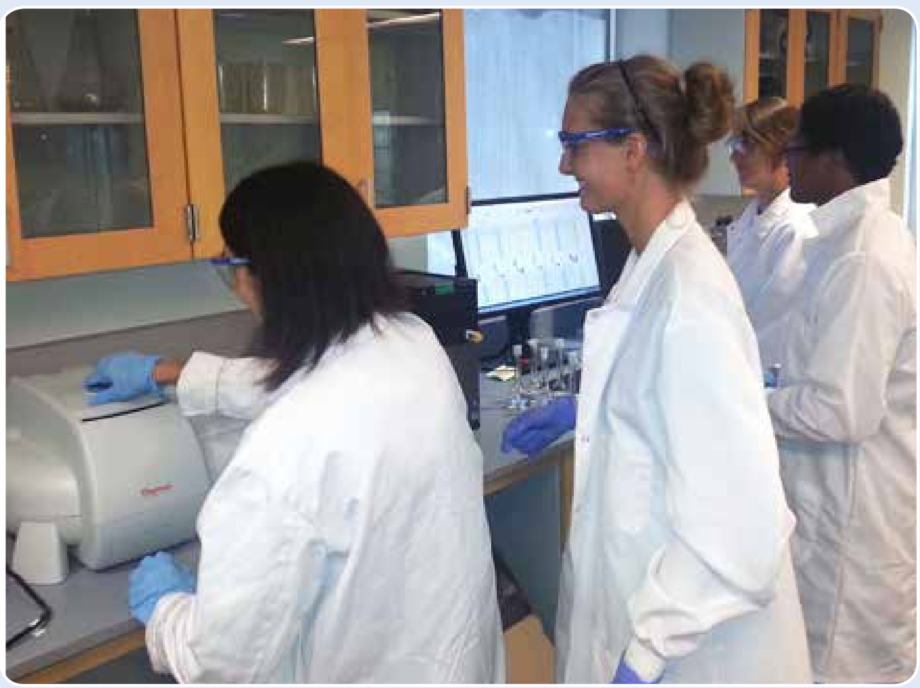
Representative Mark Sanford

South Carolina TOC

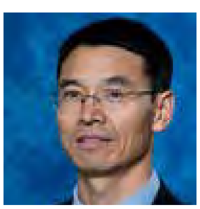
Development of High Power Density Regenerative Bi-electrode Supported Solid Oxide Cells to Support NASA's Planetary Exploration Missions

University of South Carolina/NASA Glenn Research Center, Ames Research Center, SMD & HEOMD

NASA's mission to explore inhospitable environments requires substantial use of electrical power and oxygen for extremely long durations to support manned missions. The unitized regenerative 'closed loop' solid oxide fuel cell (SOFC) cycle is one of the most attractive choices for supplying power for communications, advanced life support, survey equipment and rovers, and oxygen for crew habitats. However, there are several key technical challenges that need to be resolved in order to increase the technical readiness level of the SOFC technology for implementation in the forthcoming missions. The central objective of this EPSCoR project is to establish the underlying science and engineering that can accelerate the SOFC cell development and to increase the technology readiness level of the SOFC technology. This project is a collaborative effort involving four faculty members with complimentary expertise at University of South Carolina (USC). Integrated approach and multidisciplinary tasks are planned to systematically explore strategies for improving specific power density and reducing performance degradation to advance the SOFC technology for unitized regenerative operations. This NASA EPSCoR project has made significant contributions to energy storage and power systems, a strategic research and technology priority of both the Science Mission Directorate and the Human Exploration and Operations Mission Directorate, as well as greatly contributed to the overall research infrastructure, science and technology capabilities, higher education, and economic development of the jurisdictions of South Carolina. ✷



South Carolina undergraduate students engaged in NASA EPSCoR funded research.

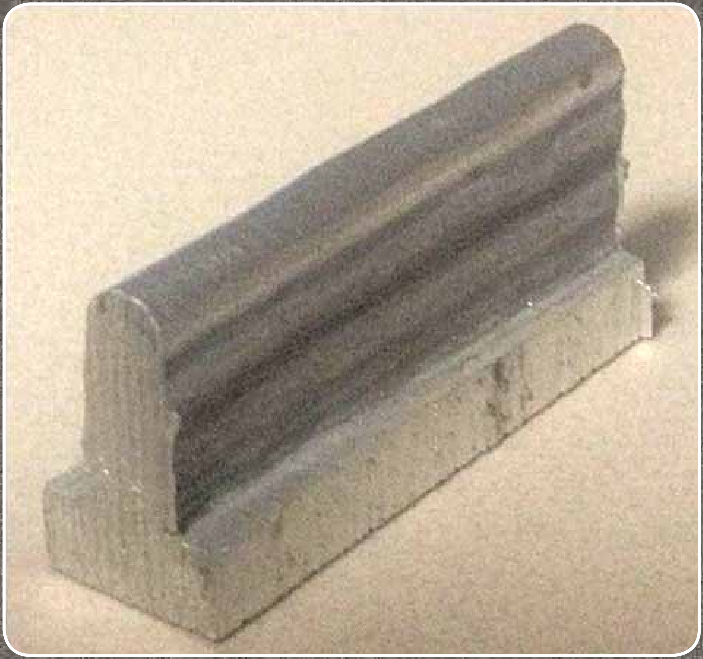


Dr. Fanglin (Frank) Chen,
Science PI,
Associate Professor,
University of South Carolina

Dr. Serene Farmer,
NASA Technical Monitor,
GRC

Fundamental and Applied Studies in Friction Based Consolidation and Extrusion of Finely Divided Metals

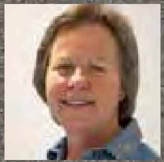
University of South Carolina/NASA Aeronautics Mission Directorate



Figures show 2 mm diameter 6061 wire produced by friction extrusion at the University of South Carolina (top) and a wall built from this wire by wire-arcadditive manufacturing at Cranfield University (UK). The wall is 15 mm high.

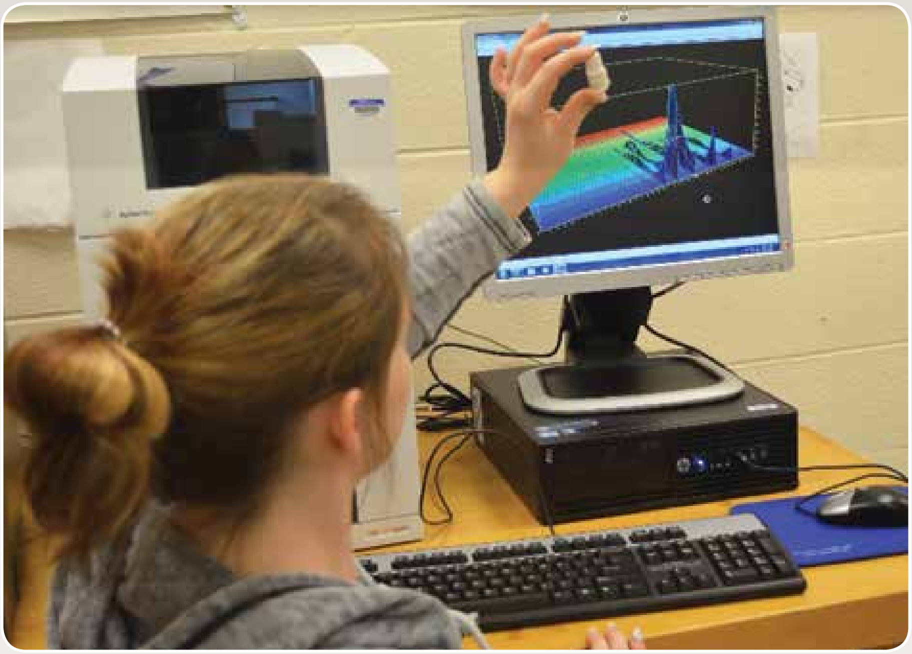
Friction extrusion and consolidation was used to produce 2 mm diameter wires that were subsequently used as feedstock for a wire-arc-additive-manufacturing, WAAM, process. The wires were made from aluminum alloy 6061. This is a wire composition which is not commercially available but, as it is a precipitation hardenable alloy, it may be suitable for additive manufacturing of aerospace components or other applications requiring good strength and ductility. The wire was produced at the University of South Carolina and the WAAM process was performed at Cranfield University (UK). Mechanical testing of the structure produced by WAAM indicates good ductility and reasonable strength. Critical issues for better WAAM structures produced from friction extruded wires include optimized wire cleaning and handling and production of wires sufficiently long for use in automated MIG or TIG deposition processes. Overall, feasibility of using friction extrusion to produce small lots of custom or experimental wire compositions has been demonstrated. Further development of the friction extrusion process will enable rapid screening of various high strength alloy wires to produce high value added, high strength, aerospace components with minimum material waste. ✺

Anthony Reynolds, PhD,
Sctience PI,
University of South Carolina,
Columbia



Maria Domack,
NASA Technical Monitor,
Langley Research Center

South Carolina Minority Serving Institution – Faculty Engagement



Ashley Bryant analyzing salinity data at Denmark Technical College.

Cara York explaining SSS to SRNLS administrator during DOE workshop.

Sea Surface Salinity Study

Based on the NASA Astrobiology roadmap, Dr. Meenu Shukla-Dennis' SC NASA EPSCoR MSI project explored the Sea Surface Salinity project at NASA and used field data to:

- Analyze the available sea surface salinity data and seek patterns of impacts on South Carolina Coasts
- Develop related learning modules for second year students in the Associate in Science program at the institution
- Coordinate a research experience of students at NASA center related to Aquarius project.

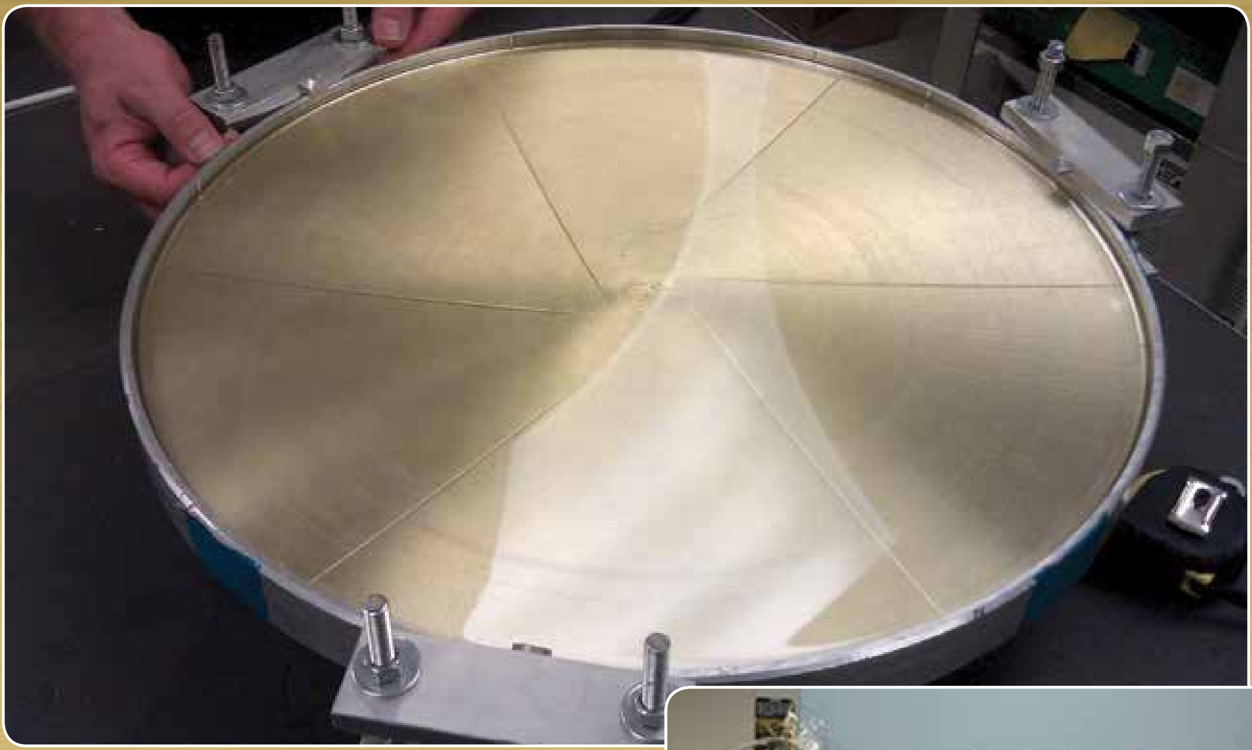
The Aquarius/SAC-D (Satellite for Scientific Applications-D) mission is a joint venture between NASA and the Argentinean Space Agency (CONAE). The mission features the sea surface salinity sensor Aquarius and is the first mission with the primary goal of measuring sea surface salinity (SSS) from space. Data from Aquarius will play a large role in understanding both climate change and the global water cycle.

At Jet Propulsion Laboratory (JPL), we were introduced to a whole new world of research. It was amazing how everyday data is acquired by just one click. Aquarius enabled us to explore the sea surface salinity while comfortably viewing the data in South Carolina. ✺

Dr. Meenu Shukla-Dennis, Science PI,
Denmark Technical College

Theresa Martinez, PMP,
NASA Technical Monitor,
Kennedy Space Center

South Carolina Research Infrastructure Development



NASA is currently developing optical communications to use with its spacecraft—both in earth-orbit and in deep space. The Earth side and ground support mission of such communications links will require a network of low cost, ground-based telescopes. One researcher in South Carolina is developing mirrors that do not require any grinding, polishing, or figuring and therefore have the potential for being low cost and light weight with a short production time.

Funding through the SC NASA EPSCoR RID program has allowed Dr. Lisa Brodhacker to advance her research in spin-cast epoxy telescope mirrors. Dr. Brodhacker, associate professor of chemistry at Lander University in Greenwood, SC collaborates with NASA JPL's optical communications group to develop this technology.

Brodhacker believes the key to producing high quality epoxy mirrors is to focus on the molecular level. Significant progress has been made to control both the chemical shrinkage and thermal expansion. She is also strengthening the overall epoxy by adding functionalized carbon nanotubes. A recently produced 50cm diameter f/2 spin-cast epoxy mirror has been measured to have a 6-8 micron RMS surface figure deviation and approximately 1 nm microroughness (Figure of a mirror).

"Student engagement is a high priority", states Dr. Brodhacker. "Even at the undergraduate level, students complete chemical syntheses, are often in charge of polymer testing, and bring in their own ideas. These "hands on" chemical and scientific activities are not only directly useful to the mirror research but advance student careers via their publications and experience."

Astronomer Russ Genet, director of the Orion Observatory in California and another collaborator with Dr. Brodhacker, says that the astronomical community is "very excited" about Brodhacker's research. "Her quest to produce a mirror that's lighter, more durable and less expensive than its glass counterpart", he said, is "very, very close to success." ✷

The top image shows a 0.5 meter epoxy mirror being mounted so it can be aluminized in the vacuum chamber.

The lower image shows Dr. Lisa Brodhacker and one of her students checking for unreacted sodium metal in a reaction flask.

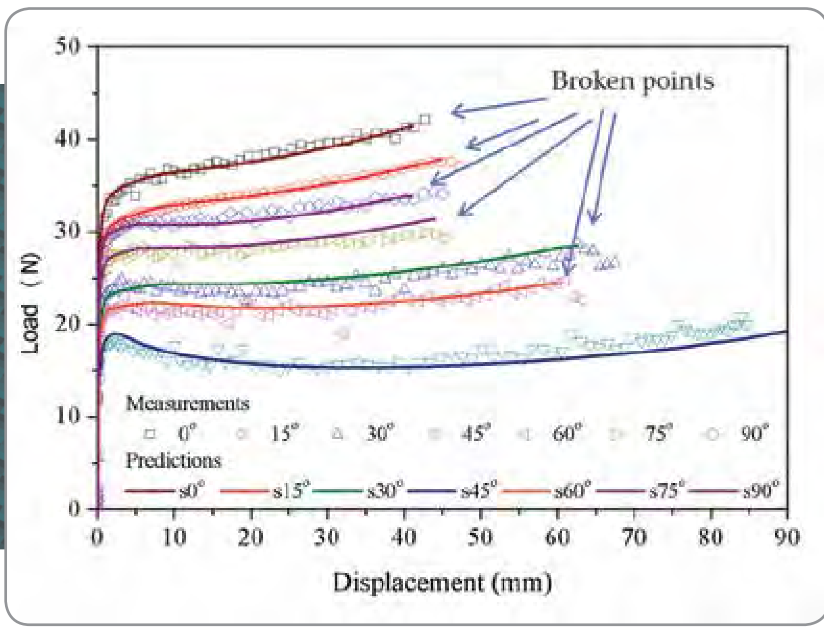
Design, Manufacture, Evaluation, and Multi-physical Modeling of Aerospace Composite Materials for Enhanced Reliability

SC

University of South Carolina/NASA Langley Research Center, Human Exploration & Operations, Aeronautics, and Space Technology Mission Directorates

The program addresses the need to follow, understand, and predict the details of how distributed damage accumulates and combines to reduce the strength, stiffness, and life of composite materials. This is likely to provide guidance in the development of innovative composite materials with enhanced reliability for NASA relevant applications. The specific scientific goals are to develop methodologies that will quantify observed material state changes in terms of variable(s) that are directly sensitive to local changes and capable of carrying the local effects (nano/micro) into global continuum formulations; to visualize and explore physical changes in material state within composites when subjected to synergistic loading conditions; To establish a framework for multi-physical model of damage evolution and life prediction for different applied conditions; and to provide material design guidelines for the development of tailored composite materials with enhanced reliability and survivability in extreme environments.

Prof. Reifsnider delivered 3 key note lectures in international conferences and Dr. Majumdar was invited by the National Academy to speak at the workshop on material state awareness which focused on reviewing the state of the art and discuss future technical needs. ✺



We have launched ongoing work to understand damage modes and mechanisms using non-destructive visualization tools. Broadband dielectric characteristic data will be collected as a function of loading history (static and fatigue). The signature of material response will be validated using X-ray microscopy and correlated with modeling parameters (such as change in stiffness and strength). An example of X-ray image of carbon fiber reinforced composite is shown below and scan parameters can be further customized for each material system to yield best contrast of heterogeneous microstructure.

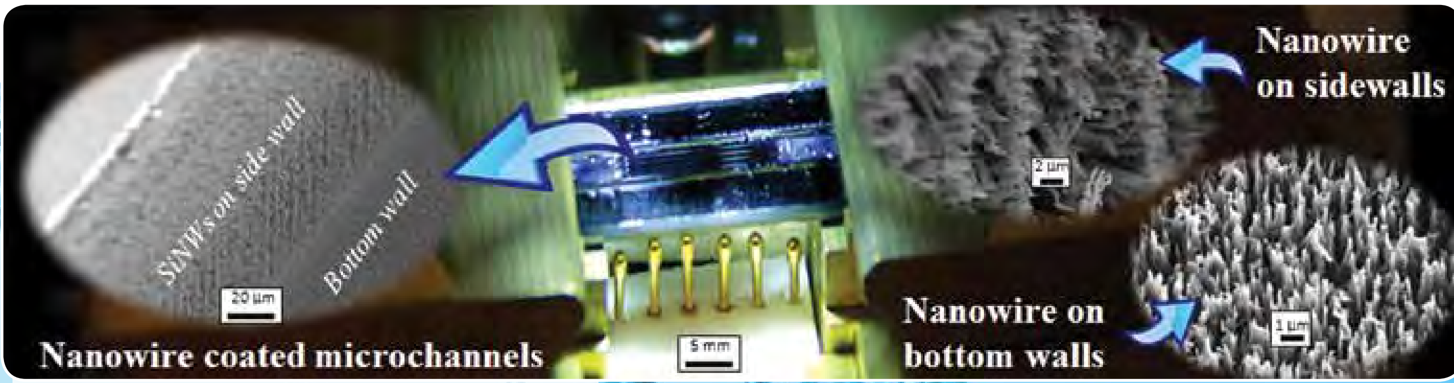
Dr. Prasun Majumdar, Science PI,
Assistant Professor,
University of South Carolina

UNIVERSITY OF SOUTH CAROLINA

Dr. Cheryl A. Rose, PhD, NASA Technical Monitor,
Langley Research Center

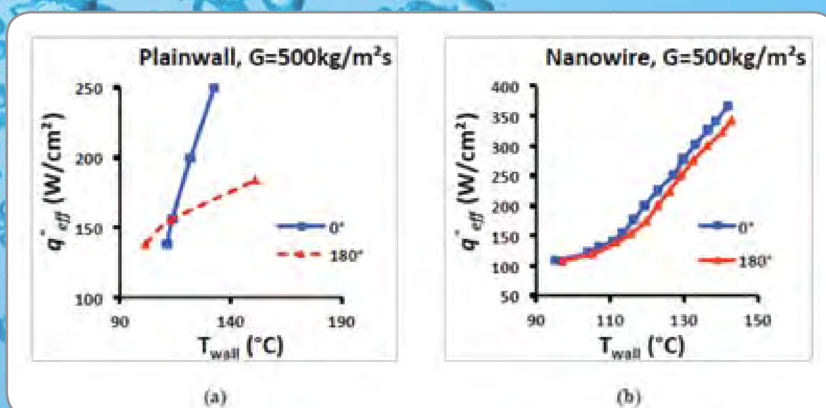
Explore a Unified, Ultra-efficient and Gravity-insensitive Flow Boiling Pattern for Space Missions

University of South Carolina/NASA Jet Propulsion Laboratory, Goddard Space Flight Center, Human Exploration & Operations Space Technology and Science Mission Directorates



A unified, ultra-efficient and gravity-insensitive flow boiling for space missions.

Compared to existing single-phase loops in space missions, more efficient flow boiling loops will result in significantly decreased size and weight of thermal energy systems. However, boiling performs much worse in microgravity than it does in gravity because bubbles cannot be released owing to the reduction of buoyancy force in space. In this project, we are developing an innovative and gravity-insensitive bubble release mechanism to facilitate efficient nucleate boiling and self-stabilized two-phase flow in microgravity using nanowire-coated surfaces as shown in figure to the right. The understandings of two-phase transport at micro/nanoscale developed in this project can advance space power systems, thermal management technologies, liquid handlings in cryogenic and life support systems to support NASA's future space exploration missions. ✺



The dependence of flow boiling on gravity. (a) In plainwall microchannels, and (b) in nanowired microchannels. Note that upward facing (0° Orientation) and downward facing (180° Orientation).

Dr. Chen Li,
Science PI,
Associate Professor,
University of South Carolina

Theodore Swanson,
NASA Technical Monitor,
Goddard Senior Fellow,
Goddard Space Flight Center, STMD

US VIRGIN ISLANDS

The US Virgin Islands Experimental Program to Stimulate Competitive Research (VI-EPSCoR) promotes the development of the Territory's science and technology resources through multi-disciplinary research and educational programs. VI-EPSCoR achieves these goals by supporting research in areas of scientific inquiry linked to the Territory's economic development and by building partnerships between government, non-governmental organizations, and the private sector to create a foundation of research and development for economic growth. VI-EPSCoR's vision is to develop the territory's scientific capacity in support of economic development by drawing upon and strengthening the territory's physical and human resources for scientific study. A key to developing the territory's science capacity is through stimulating research that in turn provides educational opportunities for students and faculty alike.

Dr. David Morris, Campus Director for University of the Virgin Islands

Dr. Cassandra Runyon, SC EPSCoR Director, College of Charleston

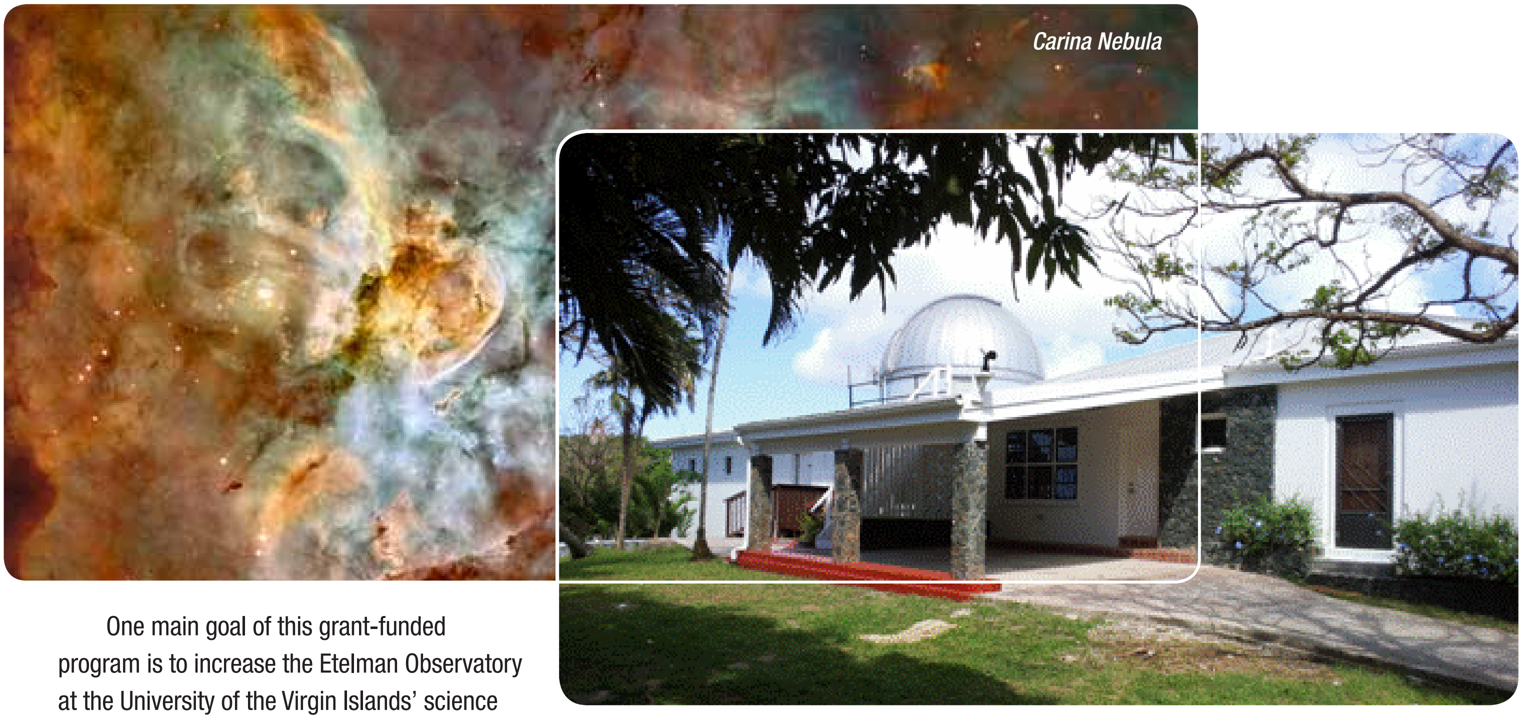
University of the Virgin Islands and Saint Thomas

Virgin Islands TOC

USVI Congresswoman Stacey Plaskett

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

University of the Virgin Islands/NASA Goddard Space Flight Center, Science Mission Directorate



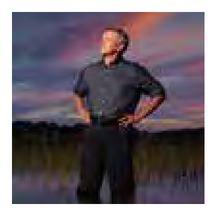
Carina Nebula

One main goal of this grant-funded program is to increase the Etelman Observatory at the University of the Virgin Islands' science capacity in astrophysics. The Etelman Observatory tripled its staff of full-time, professional astronomers by hiring its first resident scientist and negotiating a sabbatical position for another. We've developed and strengthened ties with other astrophysics research organizations. Two UVI undergraduates participated in the NASA Goddard Space Flight Center Summer Intern Program last year; at least several more will have done so by this summer's end.

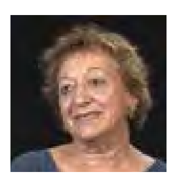
The Etelman Observatory is now part of several NASA-related research efforts, including the KELT-SOUTH monitoring program. Its researchers have submitted publications on NASA's GRB and Swift missions for peer review and plan to present EPSCoR-grant findings at the next AAS meeting. One UVI-GSFC summer intern authored an Astronomer's Telegram detailing the high-energy properties of the Eta Carinae system during its recent periastron period.

The goal of financial sustainability is closer due to a 67+% increase in business and public donations. We also continue seeking support from other NASA and non-NASA grant entities to grow UVI's physics and astronomy course offerings. A four-year degree in physics and astronomy would keep two-year associates from leaving for mainland partner schools to complete their work; it would also keep junior- and senior-class researchers at the Etelman Observatory. A new high-school intern program allows "next-gen" astronomers to work with the science PI on a focused research project. Finally, more than 1,000 guests visited the Observatory last year for lectures, exhibits and/or sky viewing. Thanks to the support of this NASA EPSCoR grant, we are excited by the potential for continued growth in the coming year. ✺

Dr. David Morris,
Science PI,
University of the Virgin Islands



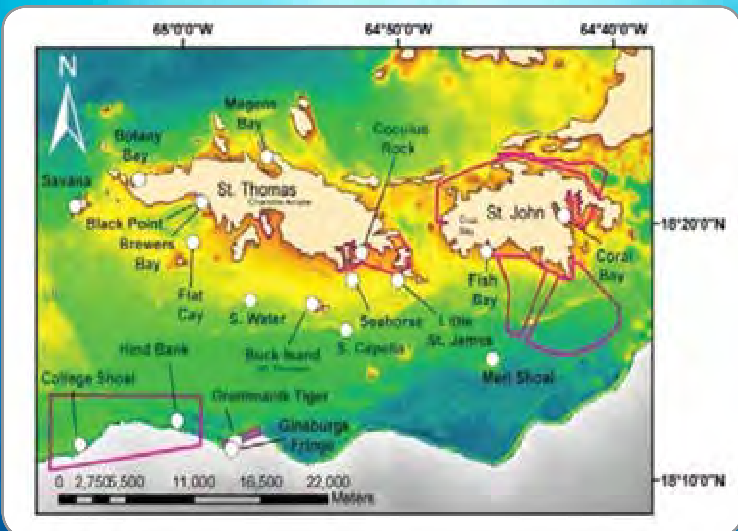
Dr. J. Hakkila,
Co-PI,
College of Charleston



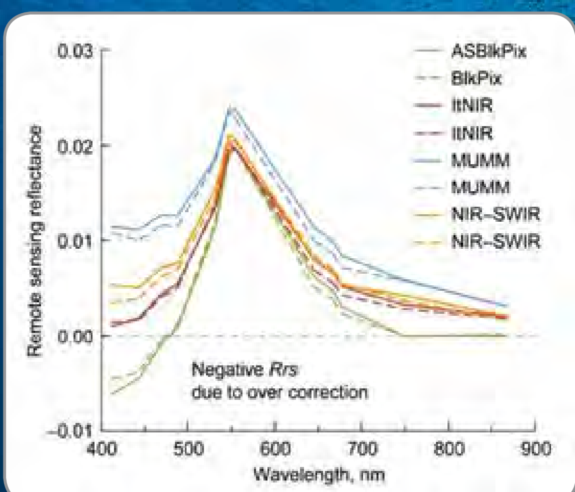
Dr. Chryssa Kouveliotou, PhD,
NASA Technical Monitor,
Marshall Space Flight Center

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

College of Charleston/University of The Virgin Islands/Ames Research Center, Science Mission Directorate, International Space Station



Coral reef monitoring sites of the USVI Territorial Coral Reef Monitoring Program. High-resolution bathymetry to 1m resolution from NOAA and the USGS.



Remote sensing reflectance (Rrs) for turbid waters taken obtained from MODIS infrared (SWIR) atmospheric correction algorithms. The green lines generated using the standard NIR black pixel assumption result in negative retrieved radiances and thus atmospheric correction failure.

Our goal is to quantify the relationship between observations of water optical properties by high resolution Visible and Near - Infrared (VNIR) sensors aboard NASA s space vehicles and Optically Active Constituents (OACs) measured in situ on coral reefs. This relationship will be tested against long-term records and targeted assessments of coral health in order to identify potential water quality stressors on coral reef ecosystem health.

This research effort, a scientific partnership between the University of the Virgin Islands (UVI), the College of Charleston (CofC), Kent State University (KSU) and NASA s Ames Research Center (ARC), is extremely important in the US Virgin Islands where coral reef-dependent tourism is the primary driver of the economy and declines in reef-related services would have significant economic impacts.

Coral reefs have low tolerances to changes in nutrient, sediment, and phytoplankton concentrations. Water quality decline from urbanization may be contributing to their deteriorating conditions. Current assessment methods of water quality are limited to in situ measurements which are labor intensive, costly and lack the spatial and temporal coverage needed to better understand changes in such a highly dynamic environment.

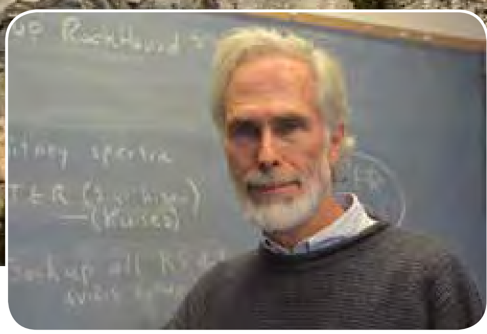
Remote Sensing (RS) technology can provide timely and spatially explicit information regarding changes in the aquatic systems once the data is calibrated using in situ measurements. This capability can further provide possibilities for early warning of detrimental ecosystem changes and can set inputs into decisions about coral reef management and mitigation of negative effects. ✺

Dr. Marilyn Brandt,
Science PI,
Research Assistant Professor,
Member, Center for Marine and Environmental Studies,
University of the Virgin Islands

Liane S. Guild, PhD,
NASA Technical Monitor
Research Scientist,
Ecosystem Science,
Earth Science Division,
NASA Ames Research Center

SOUTH DAKOTA

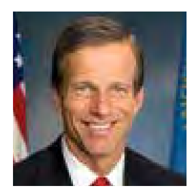
SD EPSCoR
RESEARCH. EDUCATION. ECONOMIC DEVELOPMENT.



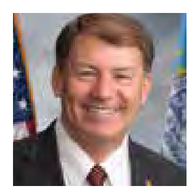
Dr. Edward Duke, SD EPSCoR Director,
South Dakota School of Mines & Technology

As a jurisdiction, South Dakota has relatively limited research infrastructure in traditional disciplines that support NASA and the aerospace industry. There is, however, no shortage of talent and creativity in the state's colleges and universities that can be harnessed to help solve the grand challenges of space exploration and space science. NASA EPSCoR creates opportunities that connect talented faculty and students across the South Dakota with scientists and engineers at NASA's research centers with the goal of building broad-based, sustainable research collaborations among state institutions, NASA, and the nation's aerospace industry. These emerging research partnerships benefit NASA by expanding the resources available to address mission priorities and, at the same time, advance state research and development infrastructure in critical STEM fields such as materials engineering, nanotechnology, energy generation and storage, and satellite monitoring of global change.

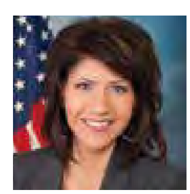
South Dakota TOC



Senator
John Thune



Senator
Mike Rounds

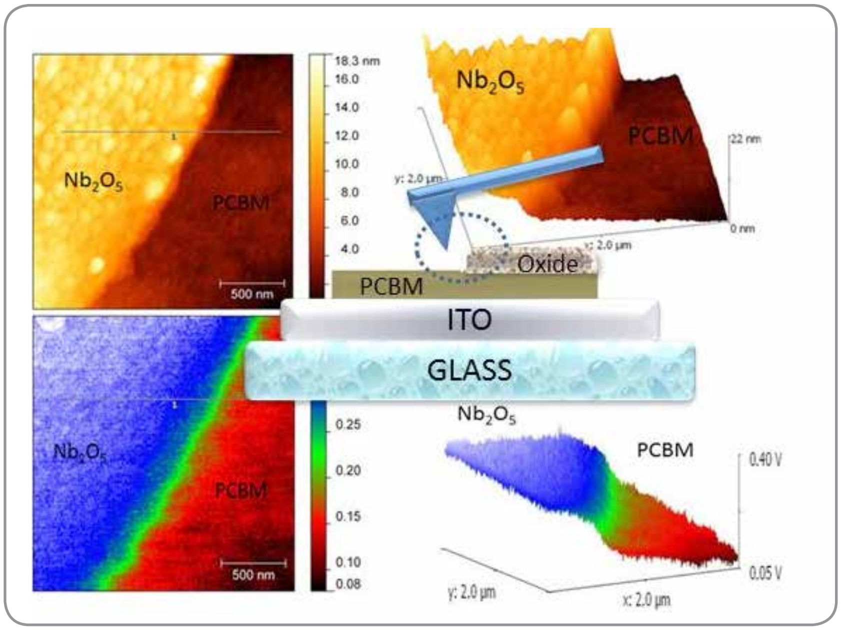


Representative
Kristi Noem
(District At Large)

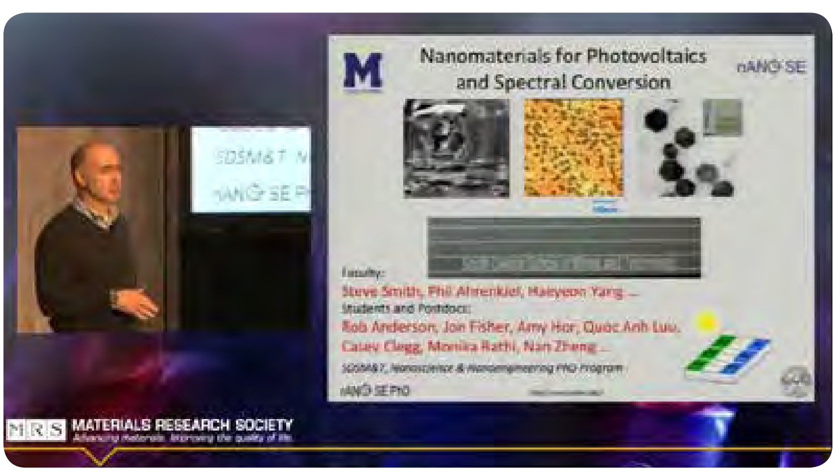
SD

Development of an Advanced Photovoltaic Materials Research Cluster in South Dakota

South Dakota School of Mines and Technology/NASA Glenn Research Center, Jet Propulsion Laboratory, Langley Research Center, Human Exploration & Operations Mission Directorate



Surface topography images of PCBM-Nb2O5 layers and their interface in (a) 2D, and (b) 3D view; contact potential difference images of PCBM-Nb2O5 layers and their interface in (c) 2D and in (d) 3D view.



Science PI Smith giving invited lecture on photovoltaic materials during the South Dakota/ University of California, Santa Barbara IGERT student-organized energy forum at the 2013 Spring meeting of the Materials Research Society.

The overarching goal of the project is to enhance existing photovoltaic materials research infrastructure in the State of South Dakota through a coordinated, statewide effort, and further expand this infrastructure relating to solar energy technologies by forming, and supporting, a photovoltaic materials research cluster. The two main objectives of the project are 1) development of improved organic and inorganic photovoltaic compounds and device structures, and 2) improving photovoltaic materials research infrastructure. The project is shared between two regional institutions, the South Dakota State University (SDSU) and the South Dakota School of Mines and Technology (SDSMT).

The project provides funding for faculty and students to address several parallel challenges in photovoltaic materials development: developing inorganic photovoltaic materials based on epitaxial crystal growth, such as high-efficiency multi-junction solar cells typically used in space, developing organic photovoltaic materials based on organic polymers and composites, with typically lower efficiency but significantly reduced costs, and organic/inorganic composite materials for novel solar cell designs, such as dye-sensitized solar cells utilizing nano-structured electrodes.

The work is being conducted through a collaboration involving Department of Energy CINT (Sandia & Los Alamos National laboratory), Center for Nanoscale Materials (CNM) at Argonne National Laboratory, Zyvex Corporation, MicroLink Devices, IPG Photonics Corporation, NASA JPL, and Langley Research Center. ✺

Dr. Steve Smith,
Science PI,
South Dakota School of Mines and Technology

Dr. Eric Clark,
NASA Technical Monitor,
Glenn Research Center

Improved Thermal Management Systems using Advanced Materials and Fluids

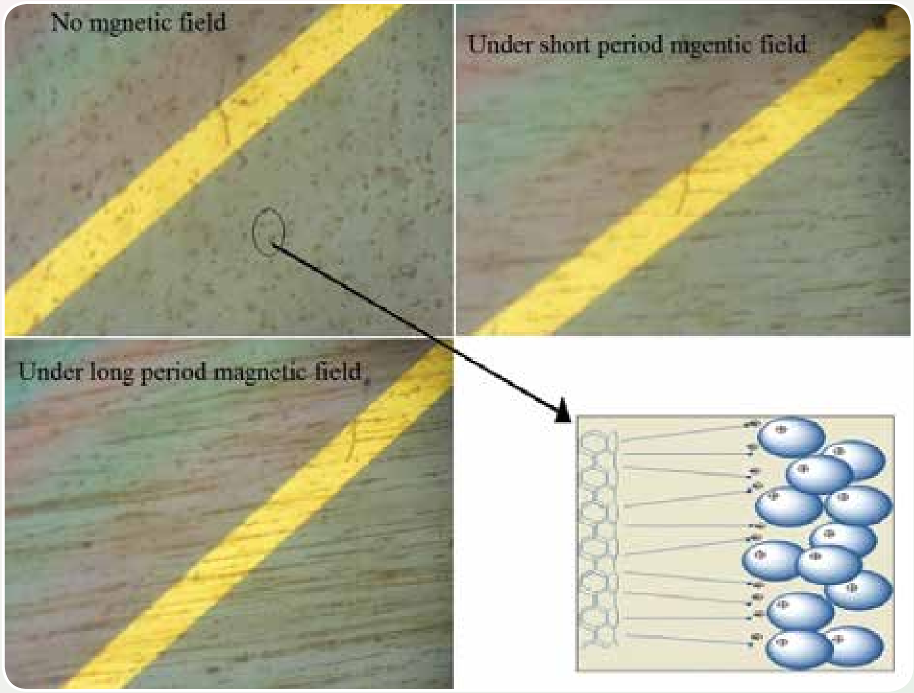
South Dakota School of Mines & Technology/NASA Ames & Glenn Research Centers, Johnson Space Center, Aeronautics Research Mission Directorate

The goal of this project is to develop a nanofluid thermal management system concept and methodology to significantly enhance thermal conductivity (TC) for coolant applications. It is believed that more than 100% stable TC enhancement can be achieved in nanofluids under an external magnetic field. The innovation will lead to significant weight/volume savings in aircraft heat exchangers, including NASA spacecraft and rocket engines, as well as in power generation, chemical production, air conditioning, transportation, and microelectronics.

The work is being conducted through a collaboration involving South Dakota School of Mines and Technology (SDSM&T) and South Dakota State University (SDSU). This project also develops and expands partnerships between the NASA Ames Research Center, NASA Glenn Research Center, NASA Johnson Space Center, Army Research Lab, Argonne National lab, Pacific Northwest National Lab, other universities (Georgia Tech, UC-San Diego, U. Minnesota, Rutgers University, Rice University, MIT, Louisiana State University, Villanova University, University of South Carolina) and industry (NCH, Aegis Tech and Waterford Battery).

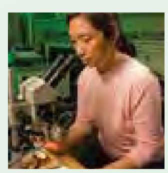
Patents awarded: Alignment of carbon nanotubes comprising magnetically sensitive metal oxides in nanofluids, US Patent Number 8,652,386.

Technology Transfer: One US company, Waterford Battery Inc., has already signed a license agreement with SDSM&T to use our patents (issued and pending). They will work with us for further R&D efforts towards commercialization. ✺



Above are microscope images of alignment of carbon nanotubes in water using Fe2O3 nanoparticles under external magnetic field and a schematic of the possible mechanism for aggregation of metal oxide on the surface of nanotube. Width of reference bar in images: 30µm

SOUTH DAKOTA M SCHOOL OF MINES & TECHNOLOGY



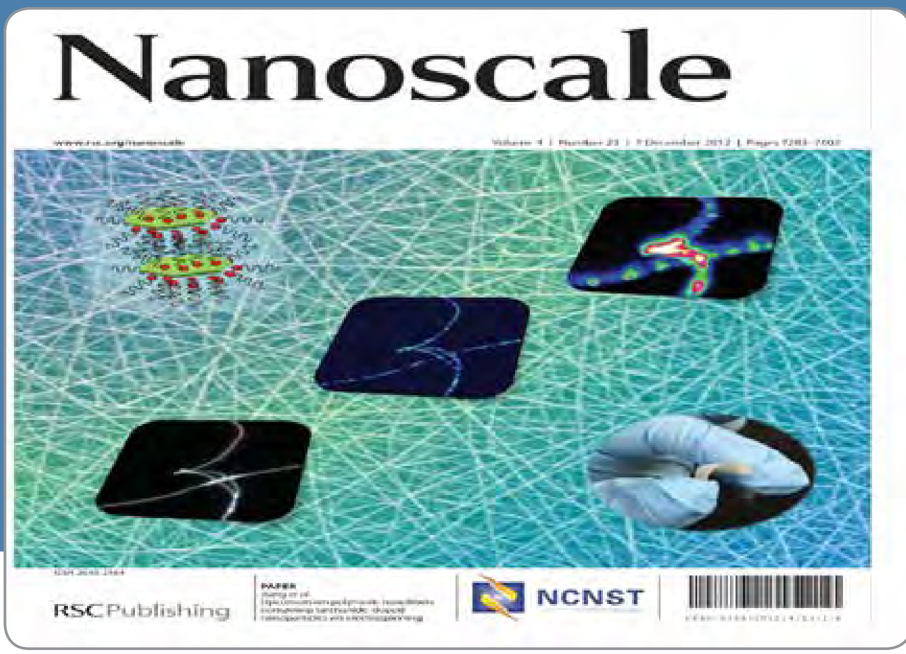
Dr. Jing Li, NASA Technical Monitor, Ames Research Center

Dr. Haiping Hong, Science PI, South Dakota School of Mines and Technology

SD

Enhanced Raman Detection of Minerals, Microbes, and Biomarkers through the Development of Advanced Plasmonic Nanomaterials

University of South Dakota/NASA Ames Research Center, Human Exploration & Operations and Science Mission Directorates

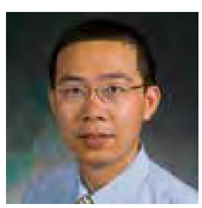


Cover story on upconversion polymeric nanofibers containing lanthanide-doped nanoparticles via electrospinning is featured on the journal cover of the December 2012 issue of Nanoscale, published by RCS publishing.

Researchers from the University of South Dakota and South Dakota School of Mines and Technology reported their novel fabrication of electrospinning nanofibrous thin films with a unique optical property of upconversion, in which the nanocomposite fibrous materials can emit visible light upon the excitation of near infrared light. Lanthanide-doped nanocrystals with a size below 100 nm were embedded in polymer nanofibers with upconversion properties being well preserved when they are embedded in the polymeric nanofibers. Developing novel functional sensing materials with the capability of molecular detection is of central interest for NASAs mission on Mars exploration. The work resulted in 36 published papers and one book chapter with a total citation 285 times, as well as 34 presentations and follow-up grants from various sources such as NSF, DOD, the state of South Dakota, and various universities.

The work is being conducted through a collaboration involving NASA Ames Research Center, Air Force Research Laboratory, University of Minnesota Materials Research Science and Engineering Center (MRSEC), Sinte Gleska University, Oglala Lakota College (OLC), Rice University, University of South Carolina, and Washington University, St. Louis.

James R. Gaier, Ph.D.,
NASA Technical Monitor,
Research Physicist,
Environmental Effects
and Coartings Branch,
Glenn Research Center



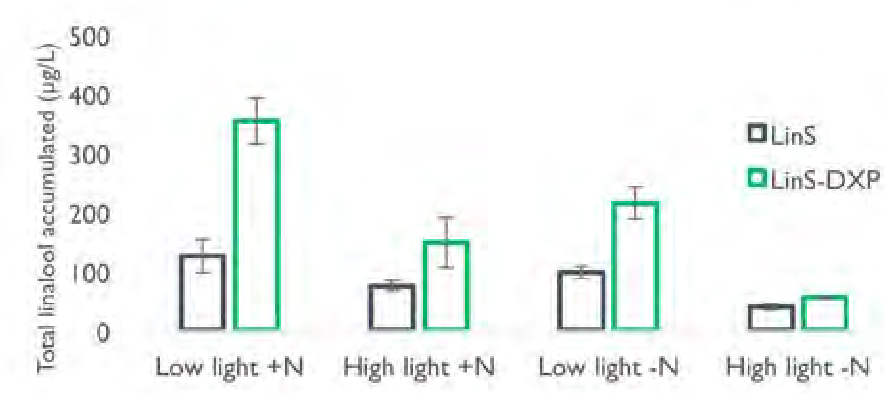
Dr. Chaoyang Jiang,
Science PI,
University of South Dakota

UNIVERSITY OF
SOUTH DAKOTA

Cyanofactory Platform to Photosynthetically Produce Advanced Fuels and Chemicals, While Providing Bioregenerative Life Support Services

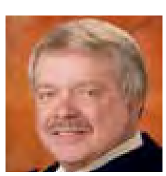
South Dakota State University/NASA Ames Research Center, Human Exploration & Operations Mission Directorate

Bubble-column reactors and Cyanobacteria culture



Total linalool accumulated from LinS Anabaena *(LinS) and LinS-DXP* Anabaena *(LinS-DXP) during 14 days.*

Dr. William Gibbons, Science PI, South Dakota State University



Dr. Joseph Skiles, NASA Technical Monitor, Ames Research Center

South Dakota State University

To enable cyanobacteria to produce linalool or limonene from CO_2 and H_2O, the respective synthase genes have been successfully integrated into the N_2-fixing cyanobacterium *Anabaena sp.* PCC7120. The first reported photosynthetic production and secretion of these biofuel molecules has been confirmed by GC-MS. Subsequent genetic optimization of the underlying metabolic pathway (by over-expressing three key genes) has increased linalool production by 2-3 fold (figure at left) and limonene by 7-9 fold (published in *Green Chem 16 (6), 3175 – 3185*). The maximum linalool productivity was ~1.7µg/L/h when nitrate was used as the sole nitrogen source, and ~1.3µg/L/h when atmospheric N_2 was the sole nitrogen source.

Linalool and limonene produced by the engineered N_2-fixing cyanobacterium is secreted into the growth medium and volatilized into the flask headspace, allowing easier product recovery. To improve productivity, *Anabaena* has been subjected to directed evolution that has resulted in increased tolerance to these chemicals. To improve technical and economic feasibility, we have worked to optimize the design and operation of photobioreactor systems that have integrated product recovery systems. Several bubble column reactors have been designed and tested with specific focus on gas flow and illumination (intensity and light-dark cycles). The optimum conditions for cyanobacteria cultivation were: 24:0 L-D periods, L.I of 68 $\mu mol.m^{-2}.s^{-1}$ and enriched air flow of 4.4 $l.min^{-1}$. The optimum conditions for cyanobacteria cultivation were: 24:0 L-D photoperiods, Light Intensity of 68 µmol/m2/sec and enriched air flow of 4.4 liter/min. At this optimal condition, the growth rate was 2.5 g/liter/day and lipid productivity was 389±5 mg/g biomass.

A company, CyanoSun Energy, was formed in 2012 to commercialize this technology. US Patent 8,993,303 "Genetically engineered cyanobacteria" was awarded on 3/31/2015 to PIs Zhou and Gibbons. ✺

SD

Structural Thermal Insulation Composites

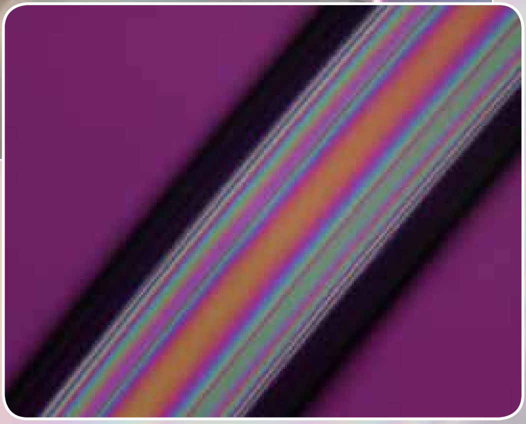
South Dakota School of Mines & Technology/NASA Kennedy Space Center, Human Exploration & Operations Mission Directorate

This project, led by South Dakota School of Mines & Technology (SDSM&T), brings together teams from SDSM&T, the University of South Dakota and the Kennedy Space Center Materials Science Division, to develop lightweight, structural polymer composites with high thermal insulation properties for extra-terrestrial habitat construction, necessary to protect humans from harsh lunar and Martian environments. This project aligns with NASA goals in the "Human Health, Life Support and Habitation Systems" roadmap, as well as addressing the grand challenge of "Space Colonization" set forth by the office of the Chief Technologist.

The materials that have been developed at SDSM&T include micro-channeled and nano-channeled polymers and polymers that are highly loaded with hollow microcapsules and reinforced with nanoscale fibers. The thermal insulation properties of many of these materials have been tested with advanced instrumentation – the Macroflash cryostat - recently developed at NASA KSC, and have been found to have thermal insulation properties within the range of interest, while exhibiting robust properties. Two of the SDSMT graduate students supported by this project have spent a total of about 7 weeks at NASA Kennedy Space Center collaborating with scientists there, and one of these students has recently been awarded an internship at NASA Glenn. The development of expertise in "syntactic foams" and nano-channeled materials arising from this research has resulted in the award of grants in related areas, from the Army Research Laboratory and from industrial clients. The resources developed through the NASA EPSCoR award also significantly contributed the formation of the Composite and Nanocomposite Advanced Manufacturing Center, established by SDSMT in 2013, which includes a consortium of international and local companies.

One aspect of the work was the subject of a NASA Technology Disclosure – KSC 13760; and a provisional patent has been filed on the nano-channeled material, with strong potential for commercial development. ✺

SDSM&T Ph.D. student Eric Schmid developing thermal insulating composite materials at SDSM&T labs and at Kennedy Space Center.



Hollow polymer microfiber for thermal insulating composite (polarized light)

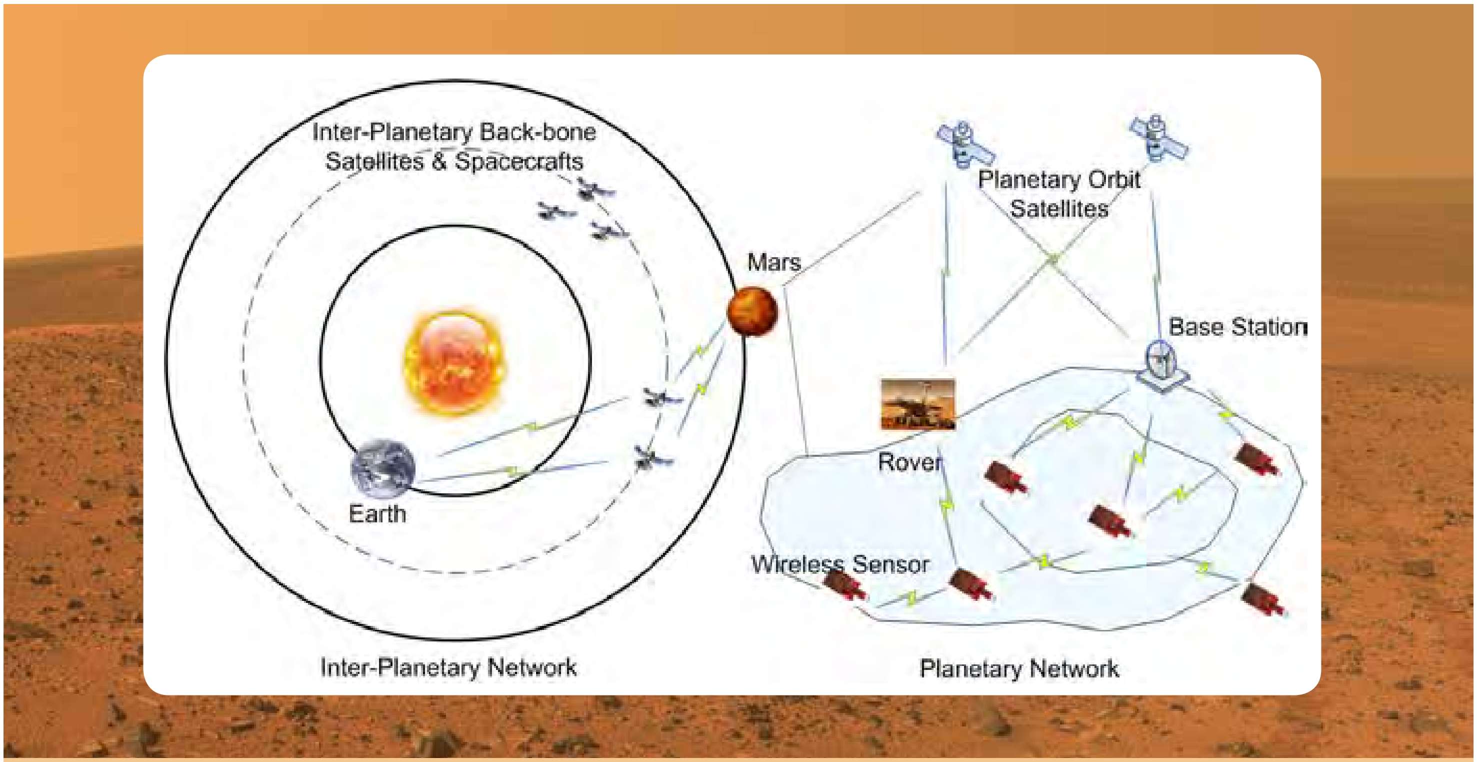
David R Salem, Science PI, South Dakota School of Mines & Technology

NASA Technical Monitor: Robert G. Johnson, Kennedy Space Center

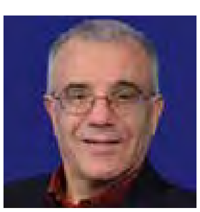
SOUTH DAKOTA M SCHOOL OF MINES & TECHNOLOGY

Minority Serving Institution – Faculty Engagement

Joint Effort of South Dakota School of Mines & Technology, South Dakota State University, and Oglala Lakota College, which is a Tribal College chartered by the Oglala Sioux Tribe and accredited by the North Central Association.



This project developed a systematic energy efficient wireless communication solution for future deep space explorations, such as Earth-Mars communications. The system overview of the research methodology for "energy efficient deep space wireless communication" is illustrated in the figure above. The proposed theoretical investigation and algorithmic development improved research and education collaboration between Oglala Lakota College (OLC), South Dakota School of Mines and Technology (SDSMT), and South Dakota State University (SDSU). OLC is chartered by the Oglala Sioux Tribe and has an average enrollment of more than 1,800 students. Its mission is to provide educational opportunities that enhance Lakota life including baccalaureate degrees in Information Technology and other STEM education programs that are recognized nationally. This project significantly improved research and education collaboration between OLC, SDSMT, and SDSU. The research was further coordinated with NASA's Johnson Space Center (JSC) and Jet Propulsion Laboratory (JPL) and the Minority University Research and Education Program (MUREP) project. A sequence of research proposals and papers as well as the collaboration and education course developments on wireless networking have been achieved. As output of the project, strong ties of research and education and research connections have been established between OLC, SDSMT and SDSU. The PIs in three campuses worked on wireless research coherently and the research activities in OLC have been significantly enhanced. Two NSF research grants have been achieved as the output of this project, and eight papers have been published in various international conferences. ✷



Dr. Kazem Sohraby, Science PI, South Dakota School of Mines and Technology

Theresa Martinez, PMP, NASA Technical Monitor, Kennedy Space Center

South Dakota State University

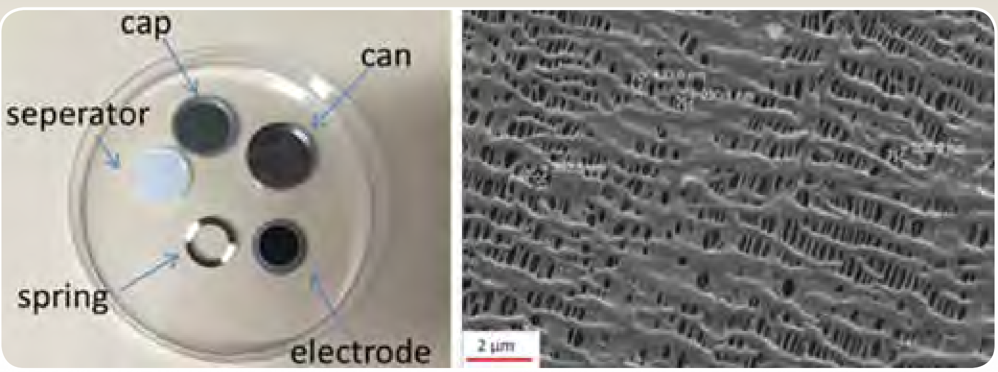
South Dakota School of Mines & Technology

Oglala Lakota College

South Dakota Research Infrastructure Development

South Dakota School of Mines & Technology

Lithium ion battery coin cells developed under South Dakota NASA EPSCoR and Glenn Research Center project.

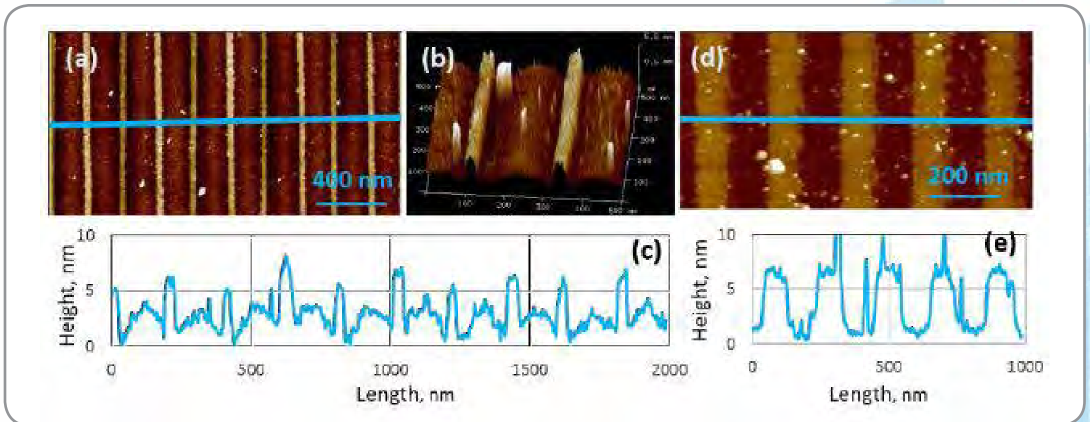


Lithium ion battery components (left) and membrane separator (right).

Research Infrastructure Development investments in South Dakota serve to build sustainable collaborations between state research teams and NASA in the agency's space technology focus areas. As an example of this strategy, beginning in 2013, potential collaboration was identified in the technical area of Space Power and Energy Storage. A statewide, multi-institution battery research interest group was organized. A seed grant of $50,000 was awarded to a team from South Dakota School of Mines and Technology and the University of South Dakota in order to conduct preliminary research on high performance lithium ion batteries, to develop a broader statewide team, and to build strategic partnerships with NASA centers. The South Dakota team established collaborations with five industry partners and two Department of Energy labs, and a NASA Glenn Faculty Fellowship in summer 2013 helped solidify connections with NASA researchers. In addition, three undergraduate students were awarded Space Grant fellowships to support the lithium ion battery research, and four faculty members were awarded NASA EPSCoR travel grants to attend NASA Aerospace Battery Workshops in 2013 and 2014. Further support for the effort came from a major grant from the South Dakota Board of Regents for battery testing equipment. With this broad-based foundation of state, industry, and NASA cooperation, the South Dakota group was awarded a 2014 NASA EPSCoR Research Award of $750,000 supporting seven investigators at three major universities. ✺

Flexible Electronics for Space Applications: Development of New Materials and Device Processing Technologies

South Dakota School of Mines and Technology/NASA Glenn Research Center, Jet Propulsion Laboratory, Langley Research Center, Space Technology Mission Directorate



Laser Interference Patterning of III-V Semiconductor. Atomic force microscope (AFM) images of two different patterns of nanowires produced by a single application of Interferential Irradiation of Laser Pulses (IILP). (a and b) Nano strips ~30 nm wide with trenches 5 nm deep. (d) Wider nanowires (100 nm with trenches 5 nm deep). (c and e) Line profiles for (a) and (c), respectively.

We continue working toward the goal of the project, which is to develop new materials and technologies that enable light-weight, conformable, flexible, and stretchable electronic devices and sensors for space applications. We have made solid progress in research, education, and economic development in this year.

Improvements in jurisdiction research and development infrastructure: Co-I Zhu received an infrastructure improvement grant from South Dakota Board of Regents to acquire an electrochemical system. Co-I Smith received NSF MRI award to acquire an advanced AFM system, and Co-I Qiao received NSF MRI award to develop novel instrumentation to probe nanoscale charge carrier dynamics. Co-I Qiao also purchased an electrochemical testing station with this NASA grant. These awards substantially enhance our research infrastructure.

Increased financial commitment from the jurisdiction, industry, and participating institutions: Co-I's Zhu, Qiao, Zhang, Ahrenkiel and Smith have received Grants from South Dakota Board of Regents, NSF, and industries in 2014.

Response of activities to NASA and jurisdiction priorities: The State Research priorities, as outlined in "2020 Vision: The South Dakota Science and Innovation Strategy" (2013), include Information Technology, Value-Added Agriculture and Agribusiness, Energy and Environment, Human Health and Nutrition, and Materials and Advanced Manufacturing. Co-Is have actively worked on research in advanced materials and energy technologies and submitted proposals to secure funding for their research. Co-PIs are also actively working on the energy-related technologies that have been identified as priorities by NASA, such as advanced battery and photovoltaic technologies.

Reordered jurisdiction and/or institutional priorities: Co-I Ahrenkiel submitted a seed proposal in collaboration with Dr. Jeremiah McNatt from the Photovoltaic & Electrochemical Systems Branch at NASA Glenn Research Center. Co-I's Zhu and Qiao have worked on preliminary research on battery technologies that responds to NASA technology priorities. Co-I's Zhu, Qiao, Smith have successfully received grants from the State of South Dakota, NSF, and private companies to improve their research capabilities in these areas. ✺

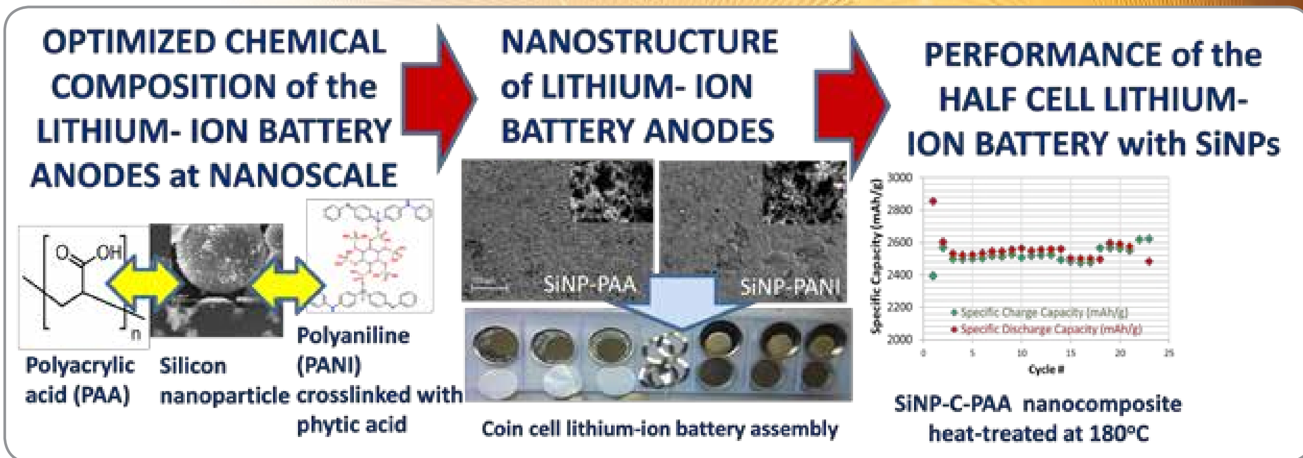
Dr. Zhengtao Zhu, Science PI, South Dakota School of Mines and Technology

Dr. William C. Wilson, NASA Technical Monitor, Langley Research Center

SOUTH DAKOTA M SCHOOL OF MINES & TECHNOLOGY

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

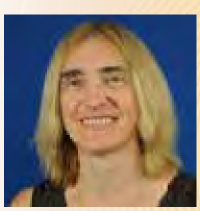
South Dakota School of Mines and Technology/NASA Glenn Research Center, Human Exploration & Operations, Space Technology and Science Mission Directorates



One of the fundamental approaches for silicon-based lithium-ion battery anode at SDSMT

This NASA EPSCoR project focuses on R&D of the next generation of ultra-high power (UHP) Li-ion batteries with high-performance, extended cycle life, and safe operation at elevated temperatures and is the first advanced battery research of its kind in South Dakota. The project features strong research collaboration between three major South Dakota universities, five leading battery companies, and NASA Glenn Research Center. The Yr1 effort resulted in creating a solid foundation for advanced materials manufacturing, battery assembly, and battery performance evaluation. Furthermore, new collaborators, such as NIST and Lawrence Livermore National Lab are interested in participating in this research. More information regarding this project can be found at SDSMT website: www.sdsmt.edu/smirnova-alevtina.

Collaboration between the SD universities and NASA GRC has been reinforced by collaboration with companies. Zyvex Technologies located on the campus of the lead institution provided financial support for purchasing a new argon glove box and provided technical support to SDSMT students. The FCM Corporation, one of the largest companies in the world with interests focused on lithium ion batteries, provided lithium metal stabilized powder that is currently used in ScI's group for anode prelithiation. A new collaboration is developing with a SD start-up, PrairieGold Solar. ✷

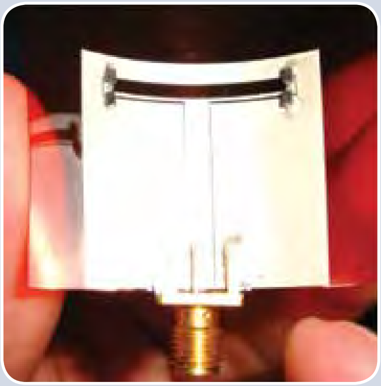


Dr. Alla Smirnova, Science PI, Assistant Professor, South Dakota School of Mines and Technology

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

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

South Dakota School of Mines and Technology/Jet Propulsion Laboratory, Space Technology Mission Directorate



SOUTH DAKOTA M SCHOOL OF MINES & TECHNOLOGY

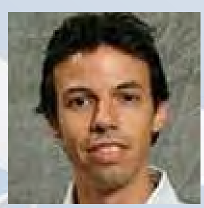
Prior printed electromagnetic devices (Left to right): Uni-planar reconfigurable antenna; PIFA antenna printed on paper; QR code antenna printed on Kapton®; d) Autonomous array that self-compensates for the effect of flexing. This research will enable the printing of a wide variety of critical electronic/electromagnetic and sensing components and modules that perform essential functions of printable spacecraft. These components will move the concept of printable spacecraft much closer to deployment.

The objective of this project is to develop the necessary research base that will enable printable spacecraft to become a reality. Printable spacecraft is a futuristic, potentially game-changing endeavor envisioned by NASA Jet Propulsion Laboratory (JPL) for use in future space exploration missions. The printable spacecraft vision is for the creation of thin, ultra-lightweight, and flexible substrate sheets with customized, embedded sensors and electronic modules for data gathering, communication, and micro-propulsion.

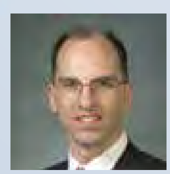
Various electronic components and devices will be printed on these sheets, which, when deployed, will flutter like falling leaves to a target surface, collecting data throughout their journey. Deployment in this manner would eliminate the need for complex landing systems. Upon reaching their destination, the sheets will act as a large wireless network of sensors that transmit collected data back to the host spacecraft. A multi-disciplinary team of ten subject experts from five disciplines (materials science, electrical engineering, chemistry, chemical engineering, and physics) and three South Dakota (SD) universities will collaborate to achieve this ambitious goal.

This project will also contribute to the state's research infrastructure, support five PhD programs (out of which three are new) in STEM areas in SD, support two early-career faculty, facilitate undergraduate research, and train six graduate students, including a graduate internship where students will work side-by-side with NASA researchers at JPL and the Glenn Research Center.

Finally, the project will deliver NASA-relevant outreach activities to Native American high school students in SD through visits to the Pine Ridge and Rosebud Reservations. ✷



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



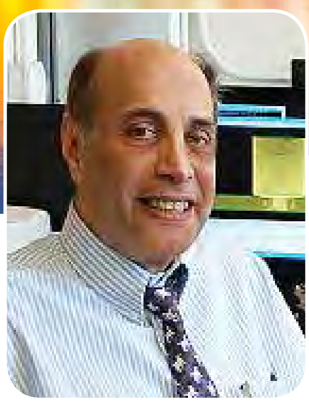
Dr. George E. Ponchak,
NASA Technical Monitor
FIEEE, NASA Glenn Research Center

The Armstrong Flight Research Center, formerly Dryden (DSFC), is located inside Edwards Air Force Base. The facility was renamed on March 1, 2014 in honor of Neil Armstrong, the first human to walk on the surface of the moon.

TENNESSEE

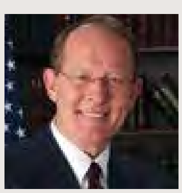
Tennessee's research capabilities have greatly increased as a result of our brief time as a NASA EPSCoR state. The seed money we have provided through the Tennessee NASA EPSCoR program has allowed both new and experienced researchers at colleges and universities throughout our state to begin innovative research projects that likely would not have come to fruition otherwise. Our researchers have capitalized on the opportunity to leverage their awards into larger grant from several different government agencies, ensuring that their relatively small NASA EPSCoR awards are carried a long way forward. Additionally, our research awards have introduced NASA to researchers who have had no prior NASA interactions. They and their student research assistants now have a working knowledge of what NASA involves and how it functions; this is great news and represents huge possibilities for our awardees, their institutions, our state, and NASA.

This NASA EPSCoR Jurisdiction is one of EPSCoR's success stories. In 2013 Tennessee "graduated" from EPSCoR by exceeding the National Science Foundation's research funding percentage eligibility line as shown on their FY 2013 and subsequent eligibility tables.

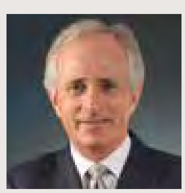


Prof. Alvin Strauss,
TN EPSCoR Director

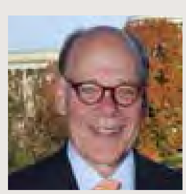
Tennessee TOC



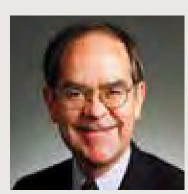
Senator
Lamar Alexander



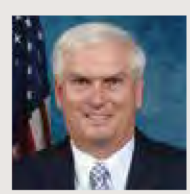
Senator
Bob Corker



Representative
Steven Cohen
(9th District)



Representative
Jim Cooper
(5th District)



Representative
John Duncan
(2nd District)

Heating Rate Sensor and Analytic Tools for Prediction of Surface Heat Flux and Temperature of TPS via In-Depth Sensor Data

University of Tennessee, Knoxville/NASA Human Exploration & Operations Mission Directorate

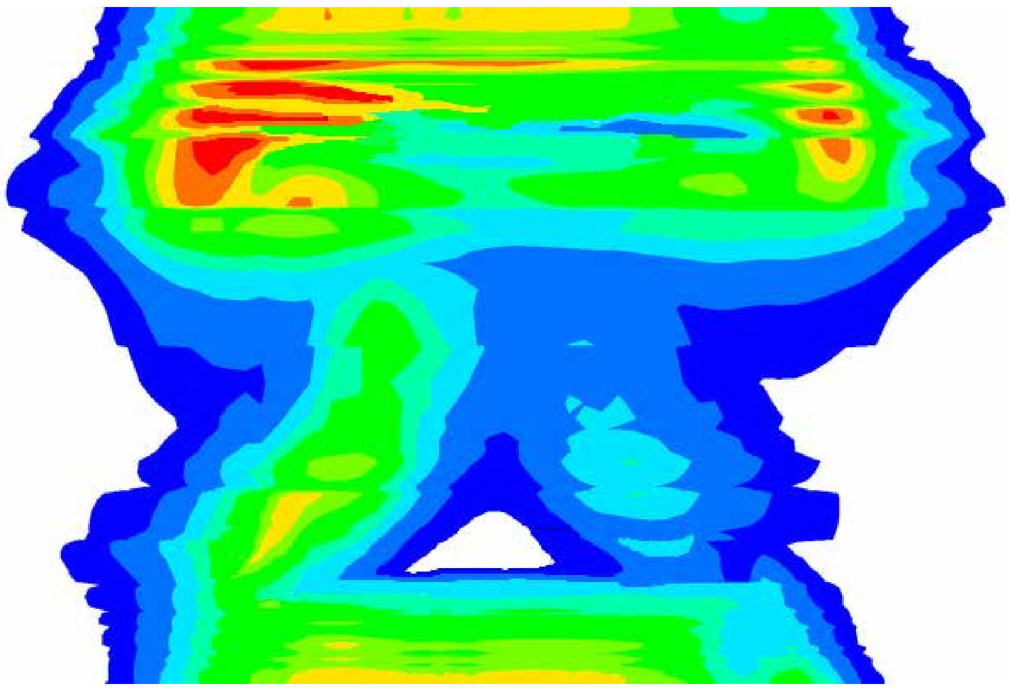
Accurately quantifying surface temperature and heat flux, the rate at which heat goes through a surface, is crucial to the safety and performance of a vehicle flying at hypersonic speeds in hostile environments. This research by the University of Tennessee – Knoxville group aims to significantly improve the estimation of surface temperature and heat flux through in-depth measurements, research of obvious importance to NASA's Ames and Langley Research Centers.

The UTK group has developed in-depth guidelines for instrumentation and controlled laboratory testing for calibration of test coupons before installation and use for ground or in-flight testing.

Both thermal protection systems (TPSs) and structurally-integrated thermal protection systems (SITPSs) are required for maintaining vehicle and propulsion integrity at significantly elevated temperatures and heat fluxes. Hypersonic combustor effectiveness can also be evaluated by accurate estimation of heat losses from the flow to the surrounding structure. In these applications, accurate surface predictions are required for both temperature and heat flux. In-depth substrate measurements require the use of analytic tools for extracting stable and accurate surface predictions. The guidelines will provide analytic tools and procedures for determination of sensor time constants, material properties (if needed), and prediction and verification of the surface temperature and heat flux.

New, experimental test facilities built for this research are unique to the State of Tennessee and will provide significant capabilities for attracting future research funds while providing a model facility for advancing education.

Locally, the UTK group has maintained contact with the U.S. Air Force's Arnold Engineering Development Center, the Department of Energy's Oak Ridge National Laboratory, and several local firms about possible technology transfer and development. ✺



Surface temperature and heat flux

Craig Stephens,
NASA Technical Monitor,
Armstrong Flight Research Center

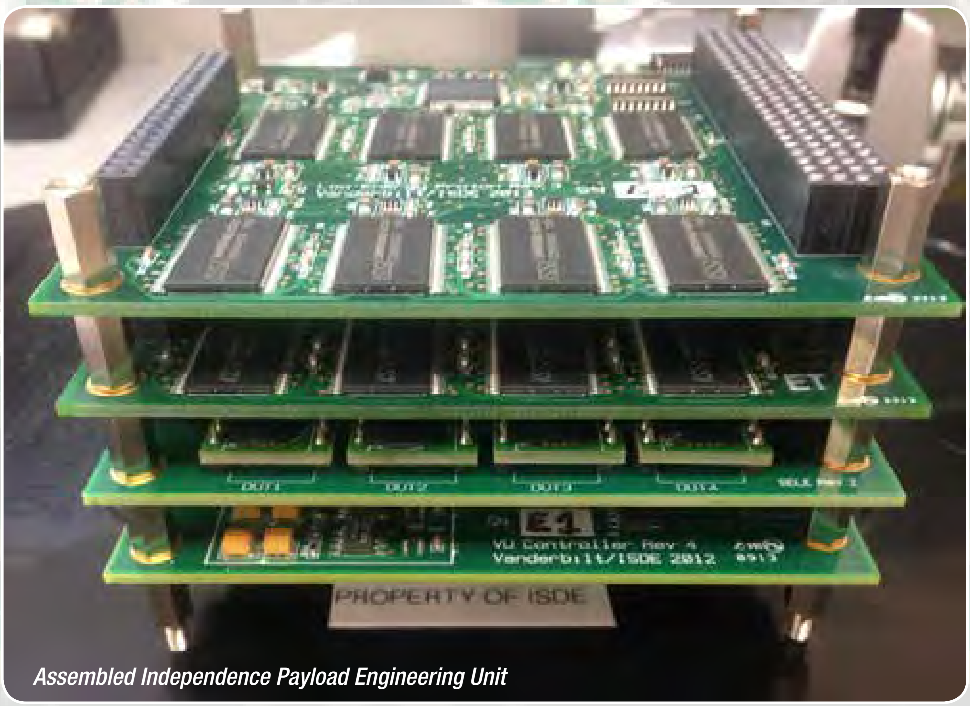
Jay I. Frankel,
Science PI,
University of Tennessee, Knoxville

RadFxSat - A University Based Satellite Program to Study Radiation Effects on Advanced Nanoelectronics

The Vanderbilt University/NASA Kennedy Space Center, Human Exploration & Operations Mission Directorate

Vanderbilt University's School of Engineering has funded development of three laboratories focused on design, development and test of spaceflight hardware. These laboratories didn't exist prior to the EPSCoR award. The School was motivated to provide the space and funds for this development because of the EPSCoR award. All students (undergraduate and graduate) working on the project have access to one of the labs; the other two labs are dedicated to spaceflight hardware assembly and, therefore, have restricted access to US citizens.

Over the past three years, our research group, which consists of 8 professors, 30 graduate students, and 14 full-time staff engineers, wrote several different CubeSat-based proposals valued at over $22M. One of these proposals was led by NASA/JPL. Another was partnering with NASA/MSFC. This is a significant change in the direction for Vanderbilt University's radiation effects research team and it's School of Engineering. To our knowledge, Vanderbilt University has never proposed to build a full CubeSat spacecraft. The willingness of the School to support this effort was a direct result of the EPSCoR funding.

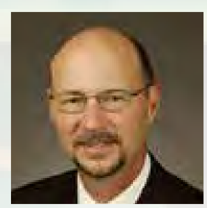


Assembled Independence Payload Engineering Unit

We have developed two independent relationships with NASA Space Grant programs. One with the Tennessee Space Grant Consortium, which has provided ~$18k to improve the undergraduate design experience at Vanderbilt University. The Exploration Space Grant Project provide $5k in funds to purchase the hardware used by the senior design team to build the SELE.

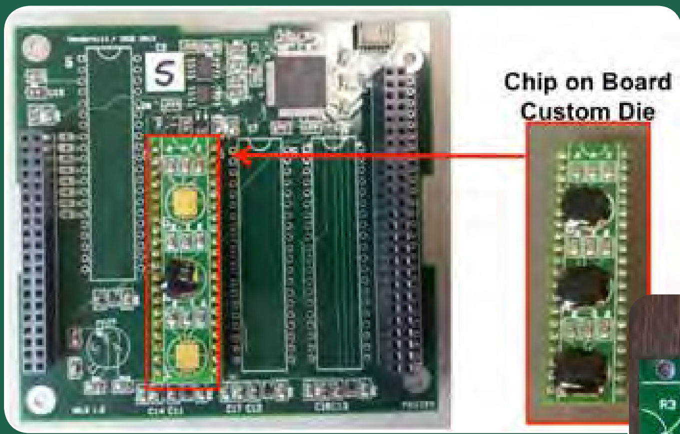
We are currently working on two technology transfer efforts: 1) Microchip Technology Corporation is a leading manufacturer of high-reliability terrestrial-based electronics. We are working with them to better understand the radiation sensitivity of their microcontrollers. We have radiation tested several of their products, some of which show significant promise for use in spaceflight hardware. They are willing to provide details of the process information used to fabricate the microcontrollers, this, along with ground and space data will enable us to make recommendations on which would be suitable for spaceflight. 2) We are working with NASA JSC to understand and improve applicability of the NASA Space Radiation Laboratory (NSRL) for use to qualify electronics for spaceflight. NSRL is widely accepted as the facility of choice for biological radiation-effects research. There is a new effort to use NSRL for electronics testing. We are working with NASA JSC and GSFC to better understand how the data taking on radiation response of electronics can be used to predict the failures when exposed to the space radiation environment.

Texas Instruments and Jazz Semiconductor have provided, at no cost, a large set of test structures that will be flown on our first missions. The estimated cost of those structures is > $375,000. The EPSCoR funding has enable us to interact with these vendors to develop and acquire this test articles. ✷



Dr. Robert Reed,
Science PI,
Science Investigator,
The Vanderbilt University

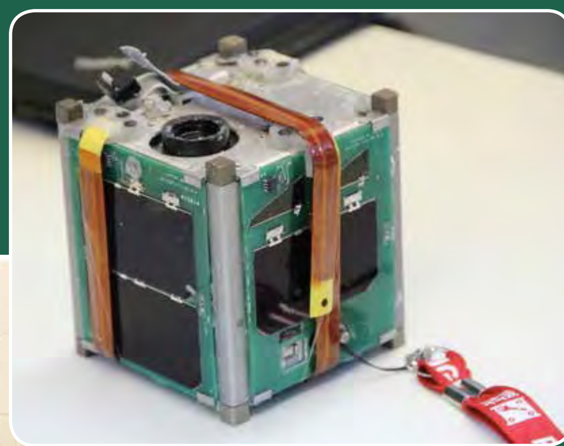
John Wrbanek,
NASA Technical Monitor,
LCSO, GRC



➤ *Chip on board after potting of three die. Example placement of COB onto experiment card (left). Note that there are 4 placements for each COB containing 3 die for a total of 12 latchup die.*

➤ *Jazz die being mounted on custom chip on board substrate prior to potting.*

➤ *The Vanderbilt University Model 140 test chamber used for board and system level temperature testing. It is capable of producing temperatures between -75C and 175C.*



➤ *Assembled SLU CubeSat containing Commodore payload*

➤ *137Cs total ionizing dose test chamber at Vanderbilt University*

VANDERBILT
UNIVERSITY

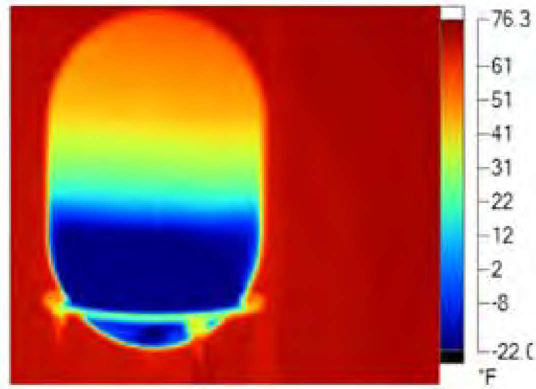
Development, Characterization, and Validation of an Aerogel/RTV Based Cryogenic Propellant Tank

The University of Memphis/NASA Human Exploration & Operations Mission Directorate

Completed half of the prototype cryogenic propellant tank illustrating the layers of the compound aerogel/RTV-655 material

ExperimenSetup for testing prototype aerogel/ RTV-655 cryogenic tank including support frame, cryogenic liquid tank filling/ venting plumbing, and instrumentation.

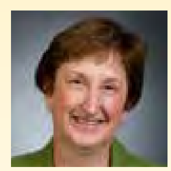
Completed RTV-655 prototype cryogenic tank filled with liquid nitrogen (77K)



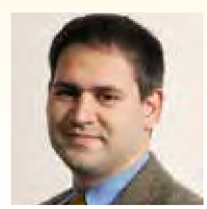
Thermal image of the RTV655 tank with a 50% fill of liquid nitrogen (blue). Temperature scale is only an approximation of the thermal environment.

Long duration space missions will require new, reliable technologies in managing and storing cryogenic propellants. Cryogenic propellant tanks in space, such as an orbiting propellant depot, and on planetary surfaces (e.g. Moon, Mars) are exposed to incident solar radiation causing an increase in pressure as the liquid vaporizes (self pressurization). A novel, low upmass tank design which combines the elastomeric properties of the space qualified polymer RTV 655 with the thermal insulation properties of crosslinked aerogels is being developed. The proposed effort directly supported several goals from NASA's Strategic Plan and the engineering propulsion priorities of Human Exploration & Operations Mission Directorate (HEOMD). To support the effort, the investigators have collaborated with Dr. Mary Ann Meador and Dr. David Chato at the Glenn Research Center. The EPSCoR funding has provided a significant increase in both computational capabilities and experimental infrastructure with a specific focus in material characterization.

In addition to the development of the cryogenic tank, the material characterization data provided justification to collaborate with industry in exploring the use of the compound RTV/aerogel material as an insulation layer in natural gas fired industrial burners. This research effort was ultimately funded by the TNSCORE program. The NASA EPSCoR grant has facilitated opportunities for high school, undergraduate, and graduate students to participate in space related research in West Tennessee and resulted in numerous student publications, presentations, and awards. In addition to the NASA EPSCoR grant, financial support for these students was supplemented through the Tennessee Space Grant and NSF STEM grant programs at the University of Memphis. ✷



Dr. Mary Ann Meador,
NASA Technical Monitor,
Senior Chemical Engineer,
NASA Glenn Research Center



Jeffrey G. Marchetta,
Science PI, Associate Professor,
The University of Memphis

and

Dr. Firouzeh Sabri, Science PI,
Assistant Professor,
The University of Memphis

Tennessee Minority Service Institution – Faculty Engagement

Project PI, Dr. Ali Sekmen, Tennessee State University

This research develops mathematical theory and algorithms for clustering high dimensional data that lives in a union of lower dimensional subspaces. This work conducts balanced research that brings the theoretical foundation of subspace segmentation and high-dimensional data clustering together with practical applications in computer science and engineering. The associated research objectives are three-fold: (1) Develop mathematical theory for modeling signals in terms of union of subspaces and manifolds. (2) Develop algorithms for clustering high dimensional data that can be modeled as a union of subspaces and manifolds. (3) Apply the proposed techniques and algorithms in related computer vision problems.

This research is a bridge between Computer Science and Mathematics and its theoretical findings include first application of subspace segmentation in bioinformatics, a novel approach for improving randomized Kaczmarz's iterative projection method, and a novel approach to solve subspace segmentation problem for general case.

1st Annual Workshop on Data Sciences

This grant generated impactful journal publications in (1) Applied and Computational Harmonic Analysis, (2) Journal of Computational Biology, (3) Journal of Medical Engineering as well as impactful conference publications in (4) 10th International Conference on Sampling Theory and Applications, (5) IEEE International Symposium on Information Theory, (6) IEEE Workshop on Robot Vision.

As part of dissemination of our results, 1st Annual Workshop on Data Sciences was held on April 16-17 in Nashville, TN. The theme of the workshop was "Subspace Segmentation and High-Dimensional Data Analysis". The project PI (Dr. Ali Sekmen) served as the Chair of the workshop. A total of 142 participants attended the workshop. The keynote speakers were Dr. Akram Aldroubi of Vanderbilt University and Dr. Rene Vidal of Johns Hopkins University. NASA EPSCOR was a sponsor of the workshop. ✺

Theresa Martinez, PMP, NASA Technical Monitor, Kennedy Space Center

Research Infrastructure Development (RID)

The establishment of Friction Stir Welding research capability at Austin Peay State University aligns with NASA EPSCoR objectives of developing research capability and infrastructure, improving the ability to gain funding from other sources, and developing partnerships between academia, industrial companies and NASA Centers. In addition to his appointment at Austin Peay, Dr. William Longhurst is a practicing engineer at Longhurst Engineering, PLC. At his professional practice, he performs research and development of industrial automation for both companies and government agencies. He has been awarded a NASA Small Business Technology Transfer contract "Torque Control of Friction Stir Welding" and has established working relationships with researchers at Marshall Space Flight Center and Vanderbilt University.

The welding machine at Austin Peay is beginning to support both faculty and students in research endeavors associated with the automation of Friction Stir Welding as well as general industrial automation, including machine tools and machining processes. Faculty members have new avenues of research open to them. Students can now participate in this research and gain a competitive advantage over other students when entering graduate school and/or the workplace. In addition, faculty members will be in a much stronger position to seek funding from other, outside sources. Both Vanderbilt University and Austin Peay State University welcome the research we are conducting with our EPSCoR RID funding. As a state-supported school, Austin Peay in particular is seeking to improve and grow its research program. We plan to distribute several more awards in the coming grant year to beginning researchers at other colleges and universities around the state. ✺

Dr. William Longhurst, Longhurst Engineering, PLC

TN

Improved Carbon Nanotube Fibers through Crosslinking and Densification

University of Tenneessee/NASA Glenn Research Center, Aeronautics Research, Human Exploration & Operations and Space Technology Mission Directorates

Jimmy Mays, professor of chemistry and distinguished scientist, was admitted as a Fellow of the Royal Society of Chemistry (RSC). The RSC is the largest organization in Europe for advancing the chemical sciences. Mays' name along with other recently admitted Fellows will be published in the Times (London) newspaper.

The Fellow status is awarded to individuals who have "made an outstanding contribution to the advancement of the chemical sciences; or to the advancement of the chemical sciences as a profession; or have been distinguished in the management of a chemical sciences organization."

Prior to this honor, Mays was also named ACS Fellow, Founding Poly Fellow, PMSE Fellow, and received numerous awards such as Herman Mark Senior Scholar Award and Navigator Award.

Three graduate students, a visiting scientist, and a research assistant professor are working on this project. Three of which are women. This project thus provides an excellent environment for mentoring scientists in areas of interest to NASA. One of the other students is applying for a NASA Graduate Fellowship opportunity. ✺

Dr. Jimmy Mays,
Science PI,
University of Tennessee, Knoxville

Dr. Michael A. Meador, PhD,
NASA Technical Monitor,
Glenn Research Center

Jimmy Mays in his lab with students

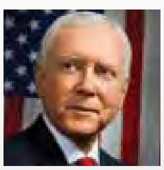
UTAH

NASA EPSCoR of UTAH

In addition to NASA-EPSCoR of Utah's major research funding, our goal has been to expand the STEM research capability of individuals and institutions in Utah. We have done this by providing Research Infrastructure Development funding in the form of small seed grants and research scholarships for Utah graduate students in STEM fields who are working with government and/or industrial partners in the State of Utah. Seed grants have been applied to assisting junior faculty to open up new space research and increase their potential of raising their research programs to nationally competitive levels. NASA-EPSCoR of Utah funds have been applied to promote new capabilities in existing research groups, assist new researchers to begin exciting new avenues of investigation, to encourage research at non-PhD granting 4-year institutions. As of 2014, due to growth in the amount of federally funded research in Utah we no longer qualify for EPSCoR funding. We would like to believe that the EPSCoR program is partly responsible for this growth. In 2013 Utah "graduated" from EPSCoR by exheeding the National Science Foundation's research funding percentage eligibility line.

Dr. Joseph Orr,
UT EPSCoR Director

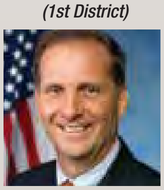
Arches National Park



Senator
Orrin Hatch

Senator
Mike Lee

Representative
Rob Bishop
(1st District)



Representative
Chris Stewart
(2nd District)

Utah TOC

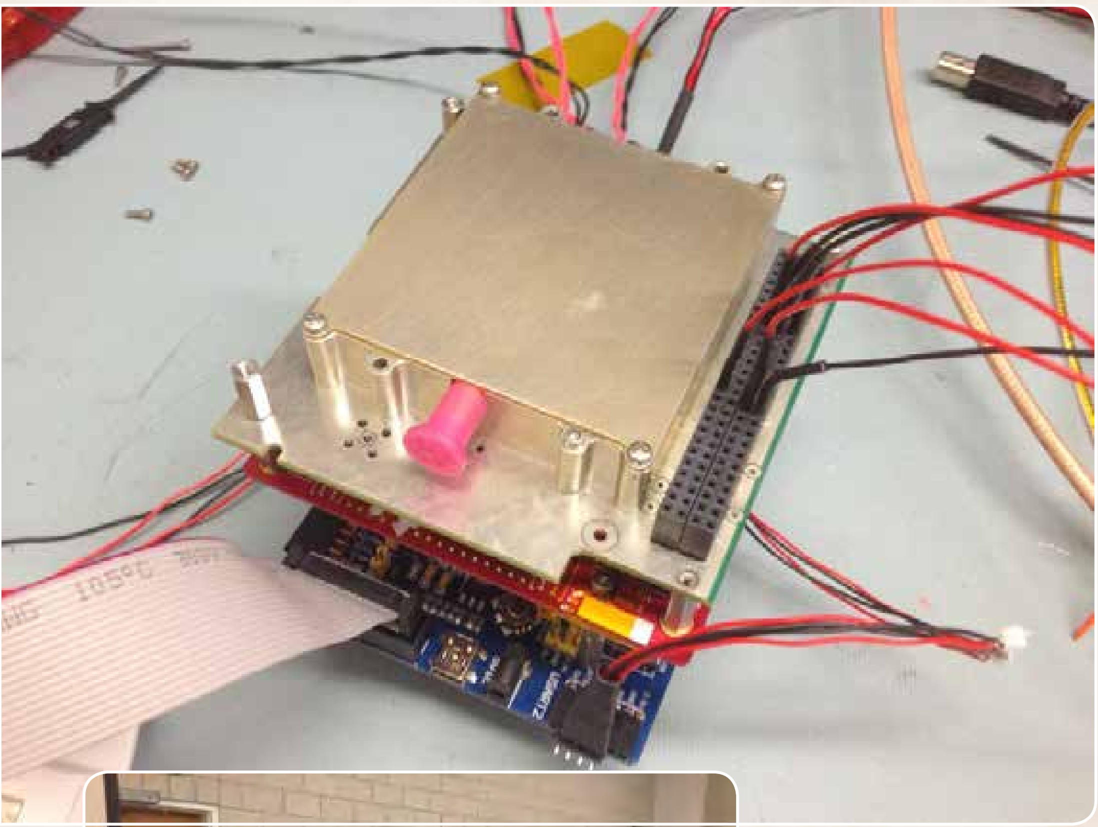
Nanosatellite Constellations for Space Science Applications

Utah State University/NASA Glenn Research Center, Space Technology Mission Directorate

This research addresses issues of sampling and communication strategies to enable constellations of small satellites. The research is aligned with the strategic plans of the NASA Science Mission Directorate, particularly with the Heliophysics Division's (HD) 2009 Roadmap and the NASA Office of the Chief Technologist (OCT) Communication and Navigation Systems 2010 Roadmap.

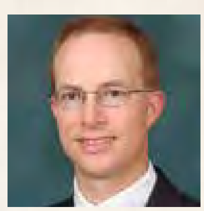
To accomplish the research goals, a team involving industry, not-for-profit, academia, and government entities were assembled. The Department of Electrical and Computer Engineering at Utah State University is leading this effort with team members consisting of L-3 Communications, the Utah State University Space Dynamics Laboratory, and NASA Glenn Research Center. In 2013, collaboration begun between the Naval Postgraduate School (NPS) on the Mobile CubeSat Command and Control (MC3) project.

The efforts of this team to provide high-data rate flight radios and the ground station system for control and communication is having numerous impacts in the small satellite community. MIT/Lincoln Labs is testing and verifying Cadet radios for flight and developing a communications architecture that will go into future proposals. The team is also supporting the community by providing our software using an open-source model. The ground station system known as the InControl Cadet Station (I-CaSt) is being used in or considered for use in a number of upcoming missions: Microwave Radiometer Technology Acceleration CubeSat (MiRaTA), Double-probe Instrument for Measuring E-fields (DIME), Top-side Ionospheric Sounder (TIS), HyperAngular Rainbow Polarimeter CubeSat (HARP), and MIT's MicroMAS CubeSat project. ✺



▲ *Testing of updated Cadet radios for new missions. Using I-CaSt hardware for evaluation of the new radios.*

SDL Demo-Days Presentation



Dr. Jacob Gunther, Science PI, Utah State University

Dr. Rainee N. Simons, PhD, NASA Technical Monitor, Glenn Research Center, SMD

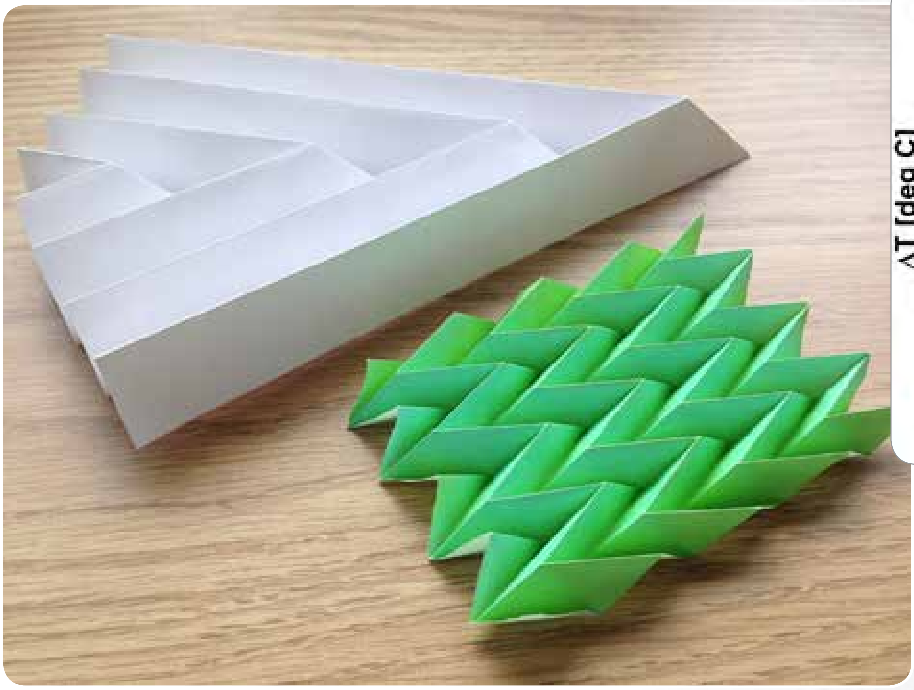
NASA EPSCoR Research Infrastructure Development (RID)

Dynamic Control of Surface Radiative Properties through Actuation of Origami-Inspired Surface Topographies

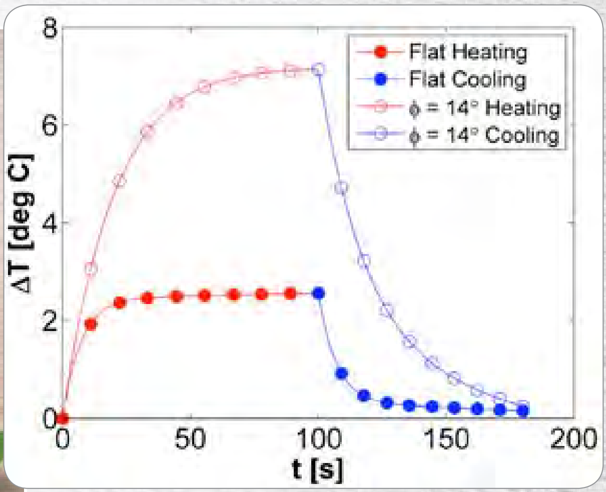
ScPIs: Brian D. Iverson and Matthew R. Jones

The objective of this work is to dynamically control the apparent radiative surface properties through topographical actuation of origami-inspired surfaces. Cavities on a surface increase the absorption and emission relative to a smooth surface of the same material. When radiation enters a cavity, reflections and re-reflections provide additional opportunity for energy absorption. Multiple reflections within a heated cavity also increase the emissive power. This increase in absorption and emission for high aspect ratio cavities has been termed the cavity effect. Origami-based structures such as the miura-ori and even simple accordion folds may be used to create surface topographies comprised of v-groove cavities. Origami structures have been shown to be an effective compliant mechanism for actuation and positioning. This work has investigated the use of origami-inspired surfaces to provide an adaptive surface topology and to achieve dynamic control of the absorption and emission of radiation on a surface. Dynamic control of radiative surface properties is beneficial in many applications, and is especially critical in space where radiative heat transfer plays a dominant role in thermal management.

Two experimental facilities have been designed to measure the apparent absorptivity and apparent emissivity of folded surfaces. Since these radiative properties cannot be measured directly, inverse heat transfer models have also been developed to utilize temperature measurements to characterize the radiative properties. This work has been presented at the 2014 ASME International Mechanical Engineering Congress and Exposition and has been submitted for journal publication. Ongoing work to characterize the net radiative heat transfer for varying cavity angle will allow the indirect measurement of apparent emissivity and will be presented at the 2015 American Society of Thermal Fluid Engineers TFESC conference. With these two facilities, we are poised to investigate tessellated surfaces created by origami fold patterns. ✺



Sample folded surfaces that create cavity-like topographies and can transition to highly absorbing surfaces.



⮝ When exposed to the same radiative heating condition, a folded surface with a characteristic angle of 14° has a much higher rise in temperature (due to higher apparent absorption) than the same surface when it is flat.

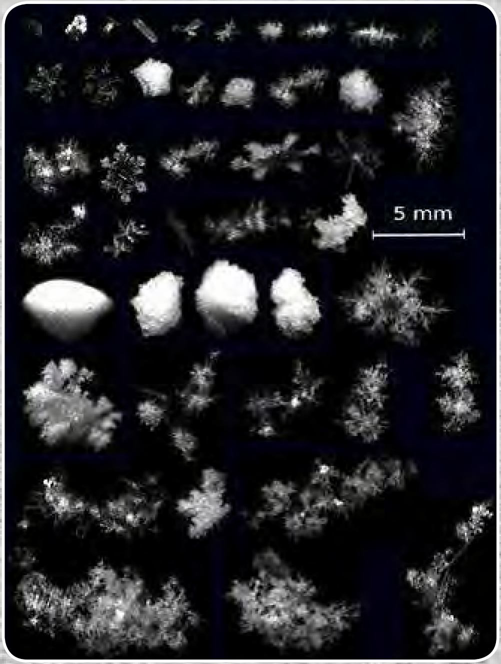
UtahStateUniversity

Background Photo: Betsy Kleba (Microbiologist from Westminster College) and Brenda Bowen (Geologist from University of Utah) work with undergraduate students at the Bonneville Salt Flats, UT to explore the microbial ecology and geochemistry of this dynamic and extreme environment.

UT

ScPIs: Betsy Kleba and Brenda B. Bowen

We hypothesize that there is a diverse microbial community inhabiting the various strata of the Bonneville Salt Flats salt crust and that there are spatial variations in their abundance and/or diversity related to chemical and compositional variations in the salt sediments. Work to date by the geoscience team (Bowen and students) has focused on identifying stratigraphic variations in salt crust composition. We have identified seven different distinct strata types based on texture and composition. Mineralogical and geochemical differences are characterized with visible-near infrared reflectance spectroscopy, X-ray diffraction, and X-ray fluorescence. Salt crust strata include varying amounts of halite ($NaCl$), gypsum ($CaSO_4(H_2O)_2$), trona ($Na_3H(CO_3)_2.2H_2O$), calcite & aragonite ($CaCO_3$), and phyllosilicate clays including montmorillonite ($(Na,Ca)(Al,Mg)_2(Si_4O_{10})(OH)_2 \bullet nH_2O$) and illite ($(K,H_3O)(Al,Mg,Fe)_2(Si,Al)_4O_{10}[(OH)_2,(H_2O)]$), as well as black, green, and orange organic matter. The microbiology team (Kleba and students) is using fluorescence microscopy and culture-dependent techniques to demonstrate the existence of microbial life within each layer and to calculate cell densities. We have documented the presence of viable cells within all subsurface strata tested to date. Moreover, preliminary data indicate that cell density varies between layers suggesting a dynamic microbial community inhabits the crust. We are now using molecular tools to characterize microbial community composition within each layer. This information will be paired with geochemical and mineralogical data as a first step toward examining the relationship that exists between microbial life and chemical composition of the strata of the Bonneville Salt Flats salt crust. Results from this project will inform our understanding of habitable zones within evaporite systems- information with the potential to influence the search for life or biosignatures on other planetary bodies. ✺



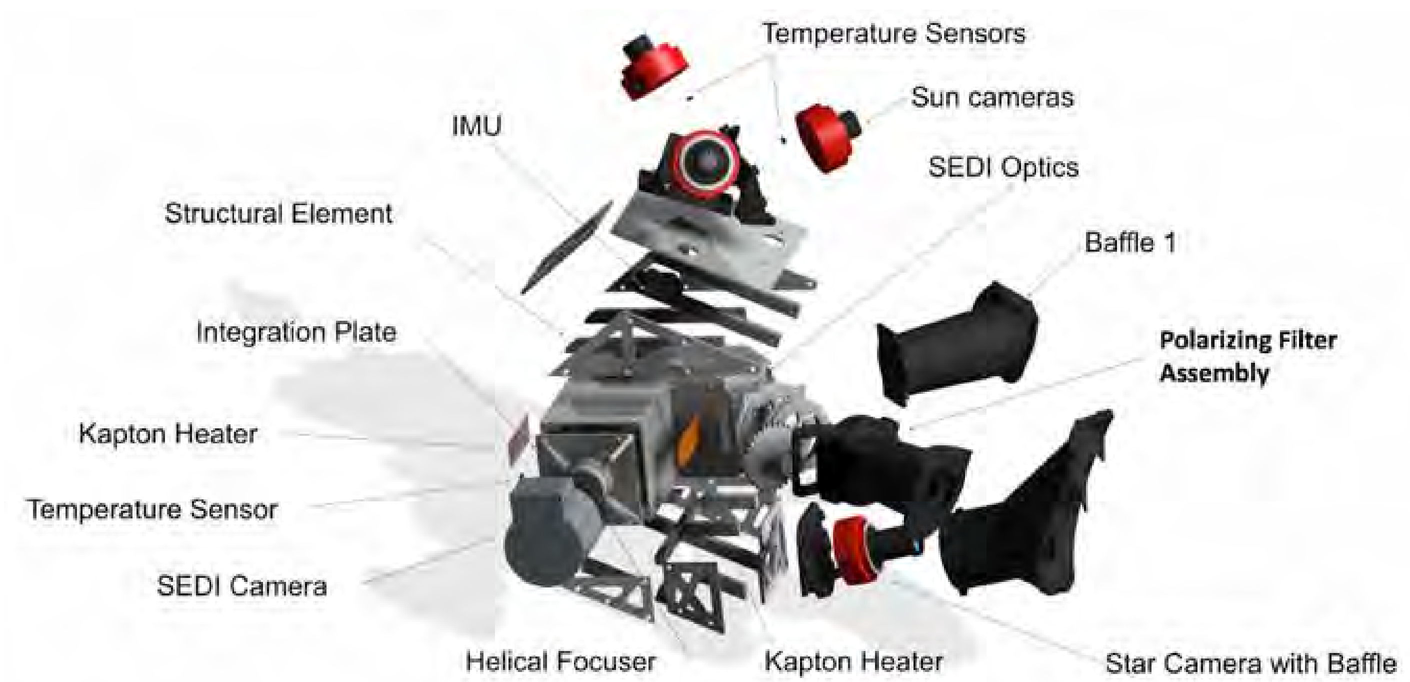
Geomicrobiology of the Bonneville Salt Flats: Interdisciplinary astrobiological characterization of microbial and geologic relationships in an extreme earth environment.

Rydge Mulford and Brian Iverson examining the blackbody cavity and heat flux probes used to provide radiative heating.

Miniature Space Weather Sensors for Pico and Nano Satellites

Utah State University/NASA Goddard Space Flight Center, Space Technology and Science Mission Directorates

Students and professionals from Utah State University prepared and flew a miniaturized space weather sensor on a NASA high altitude balloon on August 24, 2014. The sensor observes the faint chemical glow given off by oxygen atoms high (90 to 130 km) in the Earth's upper atmosphere. By sensing the slight Doppler shift of the spectral line both the winds and temperatures of the upper atmosphere can be detected. The test was supported by the EPSCoR Miniature Space Weather Sensors for Pico and Nano Satellites grant being conducted that the Utah State Center for Space Engineering. The high altitude balloon flight lasted approximately 12 hours and demonstrated the basic functionality of the Split Etalon Doppler Interferometer, which is being developed for future NASA nanosatellite constellation missions. This is the same class of instrument which has flown previous on the NASA UARS and TIMED mission but reduced in size by a factor of 10 such that it can fit within a satellite that is about the size of a loaf of bread. Students integrated the Interferometer into a balloon payload along with star and sun cameras and control electronics. A report on the mission and data results were presented in December at the 2014 AGU conference in San Francisco where two USU students, Landon Terry and Preston Hooser were presented an "Outstanding Student Paper Award" for their work on the project. ✺



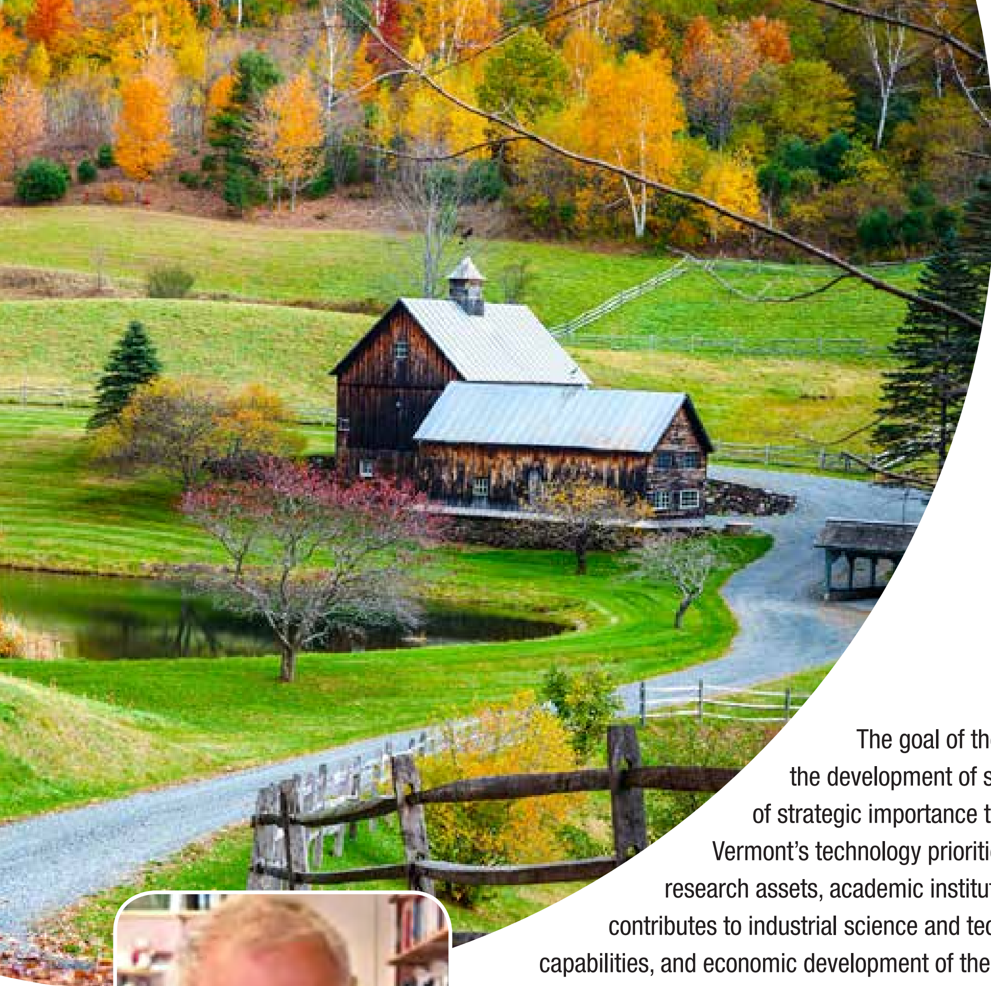
An exploded model of the Red Line Air Glow Sensor and supporting instrumentation.

UtahStateUniversity.

Dr. Lawrence Kepko, NASA Technical Monitor, GSFC, STMD, SMD

Charles Swenson, Science PI, Utah State University

NASA Goddard Space Flight Center (GSFC), located in Greenbelt, Maryland

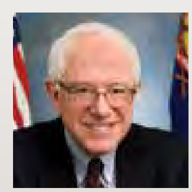


VERMONT

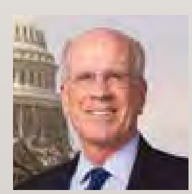
The goal of the Vermont NASA/EPSCoR Program is to promote the development of statewide research infrastructure in areas that are of strategic importance to the NASA mission while concurrently supporting Vermont's technology priorities. By fostering partnerships between NASA center research assets, academic institutions, and local industry, the NASA EPSCoR Program contributes to industrial science and technology capabilities, higher education research capabilities, and economic development of the State. The unique focus of the Program upon NASA-relevant research and technological development resonates with the existing excellence in aviation, aeronautical, and aerospace excellence already present within Vermont. Indeed, the growth of these activities within the academic and commercial sectors in the past decade has been extremely exciting to be a part of, both as a Director and a researcher. In addition to technology development, NASA's focus on Earth science – including climate change – reflects the environmental values of our State.

Prof. Darren Hitt, VT EPSCoR Director, University of Vermont

Senator Patrick Leahy



Senator Bernie Sanders



Representative Peter Welch (District At Large)

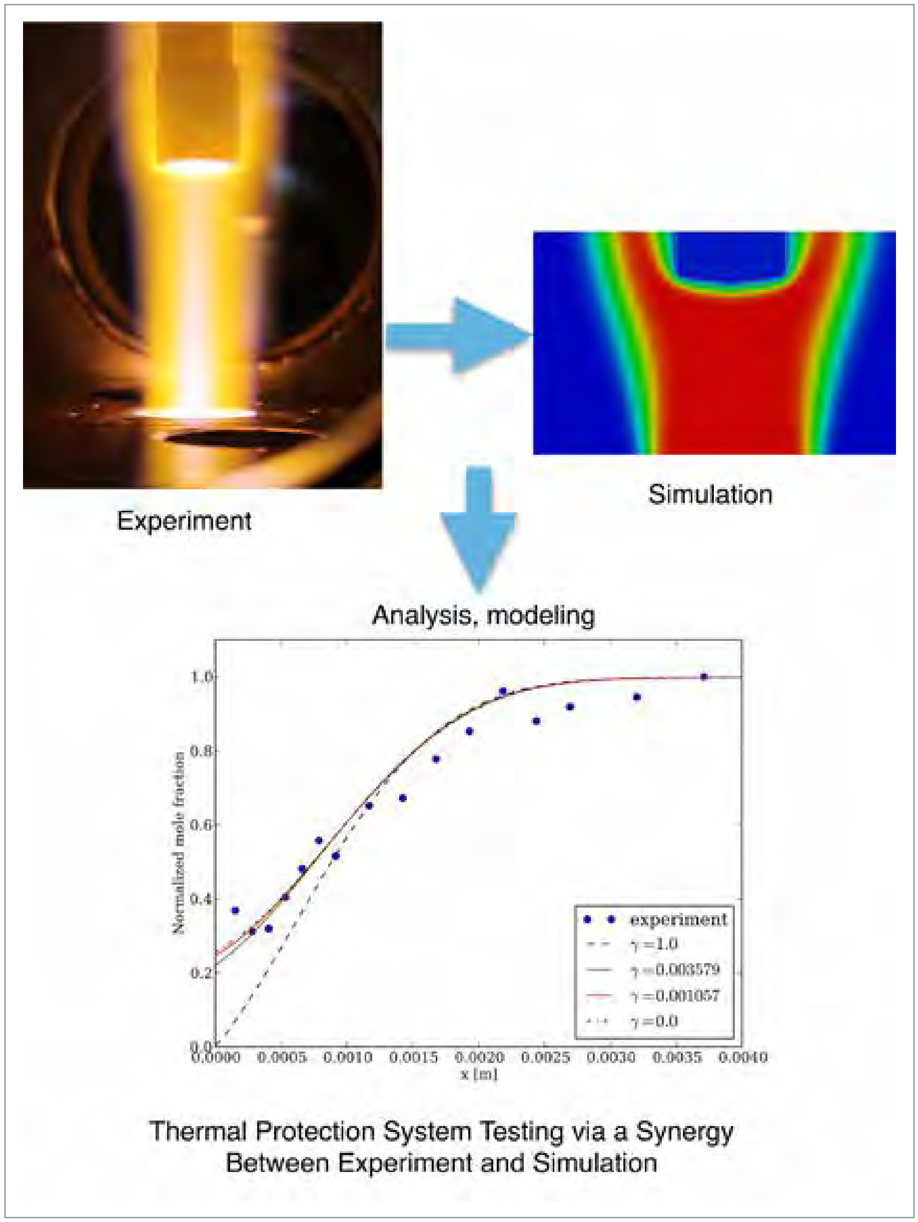
Vermont TOC

Prediction and Monitoring of Ablation of Thermal Protective Systems Under Atmospheric Reentry Conditions

University of Vermont/NASA Ames Research Center, Aeronautics Research Mission Directorate

The University of Vermont

This NASA project is aimed at the simulation of the inductively Couple Plasma (ICP) torch developed by Prof. Fletcher at University of Vermont. The ICP torch uniquely reproduces the atmospheric entry conditions of any planet and allows for the testing of thermal protective system (TPS) of space vehicles. To date, the NASA EPSCOR award has enabled the development of multi scale numerical methods that accurately simulate the gas-surface interactions occurring between the plasma jet of the torch and the surface of the TPS and the development of an algorithm to account for the ablation phenomena at the surface of the TPS. Both algorithms have been verified and validated independently and are being coupled in the last phase of this award. The resulting multi-scale, multi-physics flow solver will be used in synergy with the ICP torch experiments to provide access to physics that experimental measurement techniques cannot capture. The flow solver is developed by two PhD students, Max Dougherty (PhD graduate 2015) and Ryan Crocker. A novel method for in-situ health monitoring of TPS using acoustic waves was developed by David Hurley (PhD graduate 2012) and Stephen Pearson (MS graduate 2014) and validated in the ICP. The development of this method will continue toward its implementation in space vehicle. Other complementary efforts include the development uncertainty analysis for our simulations by Andy Reagan (MS graduate, 2014) and the atomistic to continuum methods (Liv Herdman, postdoc). ✺



Overview of the synergistic experimental and numerical studies of the performance of thermal protection system materials.

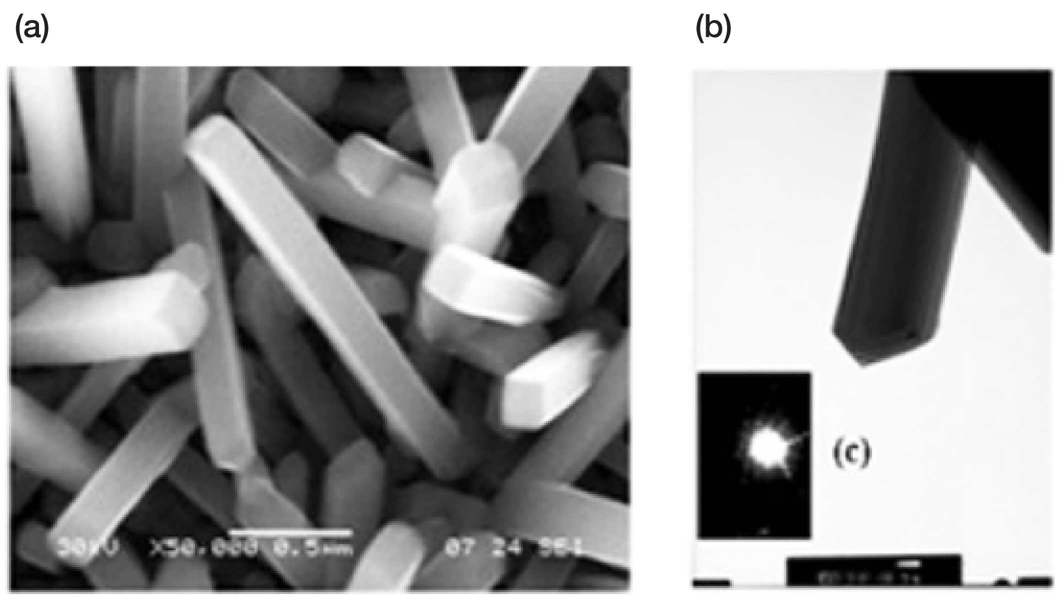
Dr. Yves Dubief, Science PI
University of Vermont & State Agricultural College

Nagi Nicolas Mansour, NASA Technical Monitor,
Ames Research Center

VT Minority Serving Institution Faculty Engagement Competition Award

Optical Characterization of Nano Material Thin Films

The goal of this investigation is to increase the understanding of the optical properties of nano-structured thin films materials and RuO_2 nanorod (NR) material films in particular. The nano-materials used in this investigation have been synthesized through a reactive sputtering process by the project's investigators at the University of Vermont (Walter Varhue and Michael Cross). Such an ambitious effort can only be under taken with the proper characterization of these nano-materials. The optical characterization of these thin film materials is performed by Dr. Roger Dorsenville, of the CUNY Department of Electrical Engineering. On March 6, 2013, Dr. Michael Cross and Co-PI Varhue travelled to CUNY to discuss with Prof. Dorsinville the types of optical characterization that he could provide for the project. Prof. Dorsinville showed us around his laboratory and described the type of characterization that his laboratory could provide.[1,2] Plans were made to measure both the linear and non-linear optical absorption of the RuO_2 NR materials, in the near IR and visible region of the spectrum. Varhue and Cross have remained intrigued by an earlier observation in their lab, that the RuO_2 NR materials were melting on a Si substrate at only 150 oC when exposed to a glowing tungsten filament when in vacuum. It was proposed at that time that the RuO_2 NRs were unable to re-radiate IR photons as a consequence of their dimensions. A TEM image of the nanorod material (RuO_2 NR) proposed in this investigation is shown below. Beyond the physical mystery of a material that cannot lose heat by radiating infrared radiation, little work has been published on the optical properties of RuO_2 NR materials. ✺



(a) SEM image of square RuO_2 nanorods. (b) TEM scan of an individual nanorod, showing an atomically sharp pyramid tip. (c) diffraction pattern indicates crystallinity.

Co-Science PIs:
Walter J. Varhue, Professor,
School of Engineering, University of Vermont and

Roger Dorsinville, Professor,
Department of Electrical Engineering, CCNY

Theresa Martinez, PMP,
NASA Technical Monitor,
Kennedy Space Center

VT NASA EPSCoR RID IV Highlighted Project:

"Planar Laser Induced Fluorescence Measurements of Reactant and Product Fluxes in Re-entry Relevant Flight Environments"

Testing of NASA flexible thermal protection systems material in UVM's 30 kW Inductively Coupled Plasma Facility; the facility emulates Mars atmospheric entry heating and the ICCD camera allows acquisition of 2D field views of atomic species populations present.

Recent results obtained in the University of Vermont Plasma Test and Diagnostics Laboratory (PTDL) have shown that reaction rates for critical gas-surface interactions occurring at planetary entry conditions can be determined by measuring the reacting atomic species diffusion fluxes in the boundary using laser-induced fluorescence (LIF). Planar two photon atomic LIF (TALIF) strategies are technically more challenging when compared to single photon LIF experiments targeting molecular species. To our knowledge, planar TALIF measurements of atomic species have not been demonstrated in ground test environments that simulate planetary entry conditions. A state-of-the-art ICCD camera that allows us to measure LIF signals from atomic species has been acquired recently for testing at the PTDL through the assistance of the Vermont NASA EPSCoR Program. Additional major funding for this purchase was supplied by AFOSR for performing separate and independent experimental projects requiring the capabilities of the camera. This state of the art camera captures the atomic species TALIF signal over the entire front face of a sample and the entire thermal boundary layer, providing simultaneous acquisition of radial and axial diffusion gradients. Significant signal to noise levels have already been demonstrated with this newly installed camera and encouraging results within the thermally reacting boundary layer above sample surfaces have been obtained. Temperature and normalized density trends compare well with previously measured point-wise stagnation line chemically reacting boundary layer profiles. These data will be further analyzed to extract gas-surface kinetic reaction rates using a procedure already developed in our lab. These data will be used to guide the development of new physically based models of the important gas-surface interactions that drive stagnation point heat transfer. Such measurements represent an important advancement in understanding thermal protection material response in trajectory relevant flight environments, with application to a number of planetary atmospheres.

Jason Meyers,
Science PI,
Research Assistant Professor,
School of Engineering,
University of Vermont

Biofilm Mitigation by Ultrasound-Enhanced Targeted Lipisome Treatment

University of Vermont/NASA Johnson Space Center, Marshall Space Flight Center, Human Exploration & Operations Mission Directorate

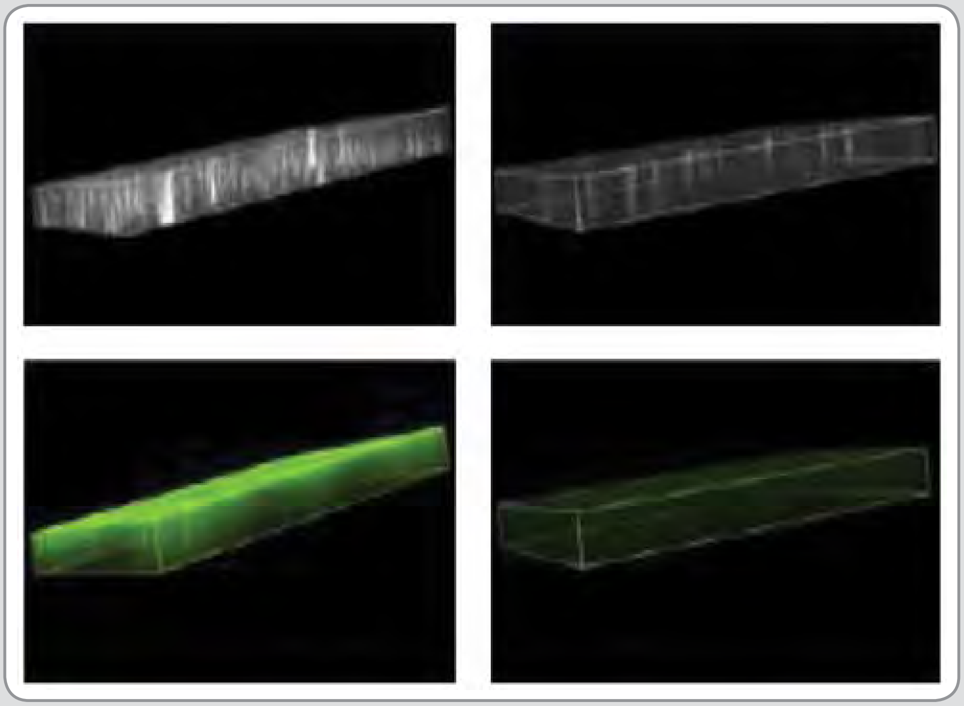
Water is an essential of life. Keeping it flowing for space-faring humans is the basis of the EPSCoR research of physicist, Dr. Junru Wu at the University of Vermont.

Most of us have probably never heard of, let alone become familiar with the term "biofilm," yet, each of us has seen, felt, or perhaps suffered a bad fall due to a biofilm. The plaque on your teeth is one type; another can clog drains. And remember that time you walked joyfully along that beautiful little, gurgling stream, only to tumble into the drink after losing your footing? Blame the biofilm built up on that flat, slippery rock.

Biofilms are formed by glue-like excretions from bacteria and other microscopic creatures, such as fungi and algae, who live in watery environments. That would include vital life-support systems aboard spacecraft carrying humans. In fact, biofilms have temporarily shut down water systems on both Mir and the International Space Station. So keeping the water running – without using too much energy – has been a goal of NASA's.

Taking a cue from medicine, Prof. Wu and his team at UVM have discovered a method that seems to do just that.

For a physical model in their Burlington, Vermont laboratory, Wu's research team immersed a biofilm (alginate hydrogel) in a suspension holding tiny nano-particles. These nano-particles penetrate the porous biofilm to break it up. Professor Wu and his staff then introduced a low-pulse ultrasound into the mix. The results were significant; the nano-particles were now three times more likely to penetrate the biofilm and not merely get trapped at its outer surface. The intensity and other parameters of the ultrasound used in the experiment were within the same range as that used by your doctor to make a diagnosis. Writes Wu, "Therefore the technique is an energy effective (consuming less electric energy), which fulfills the low energy consumption requirement of the NASA long-term exploration project."



Left column: Liposomes carrying fluorescent material are delivered into a biofilm models using very low intensity (0.14 W/cm2) diagnostic ultrasound. Right column: No liposomes carrying fluorescent material are delivered into a biofilm model without application of ultrasound.

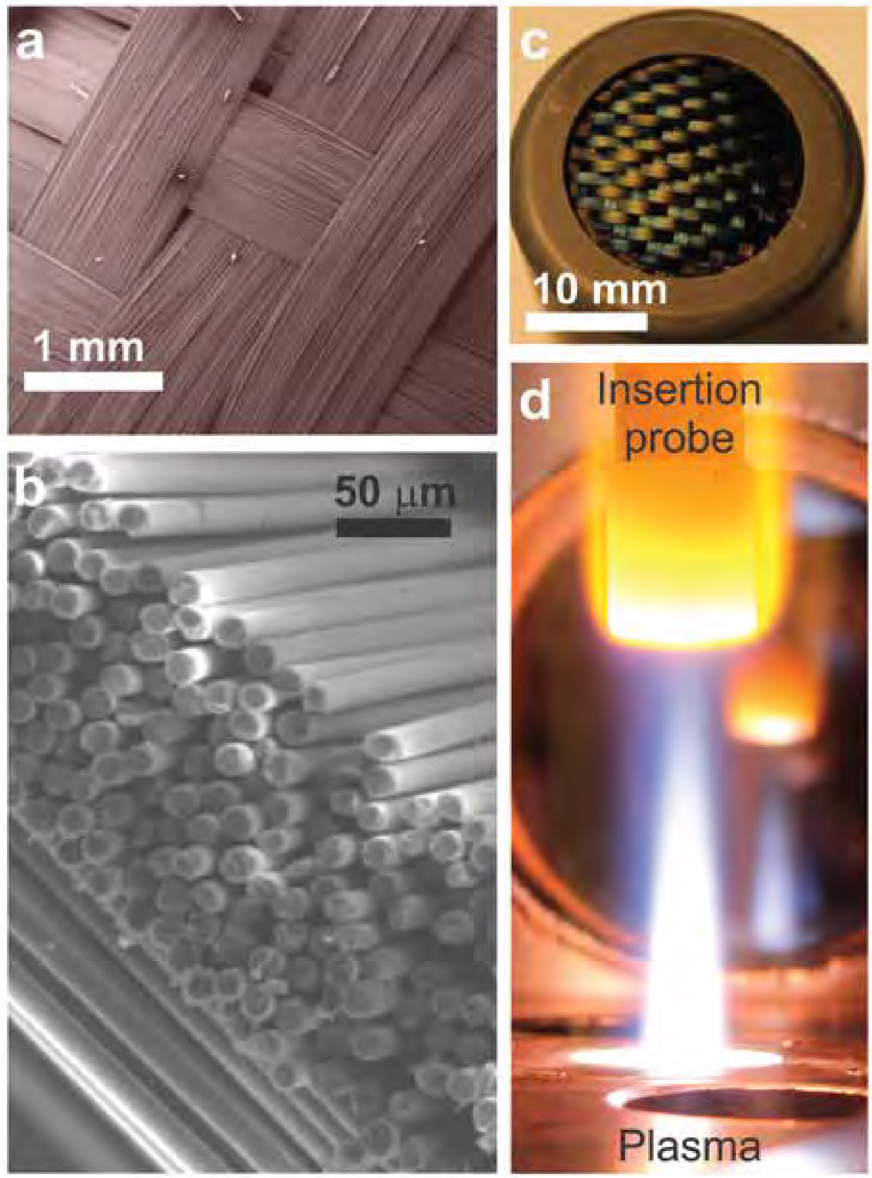
Dr. Junru Wu, Science PI,
University of Vermont

Dr. Duane Pierson, PhD, NASA Technical Monitor
Johnson Space Center, HEOMD

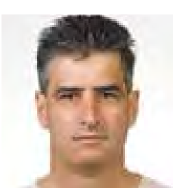
Flexible Thermal Protection Systems: Materials Characterization and Performance in Hypersonic Atmospheric Entry

University of Vermont/NASA Ames Research Center, Langley Research Center, Human Exploration & Operations and Space Technology Mission Directorates

This research used high-temperature aero-thermal heating in a 30 kW inductively coupled plasma torch to replicate the effects of harsh oxidizing environments during hypersonic atmospheric entry on fracture behavior and microstructure of two-dimensional woven silicon-carbide fibers. Silicon-carbide woven cloths were exposed to surface temperatures over 1400°C with different high-enthalpy dissociated oxygen and nitrogen plasma flows, and were mechanically deformed at room temperature. This research demonstrates that oxidizing plasmas play a more damaging role on fracture strength of 2-D woven SiC fibers than conventional static heating at equivalent temperatures. Our experiments showed that exposure to high oxygen atom concentration in air and oxygen plasmas results in a more severe embrittlement over shorter time scales, corresponding to degradation rates up to 200 times higher than those reported for static heating in conventional furnaces where only molecular oxygen is present. The origin of the accelerated embrittlement in oxidizing plasmas was found to be associated with the formation of a viscous silica surface layer leading to the development of gas bubbles, inter-filament adhesion, and critical flaws. These findings pave the way for establishing the viability of woven SiC fibers as an outer fabric material for new flexible thermal protection systems in NASA space applications. ✺



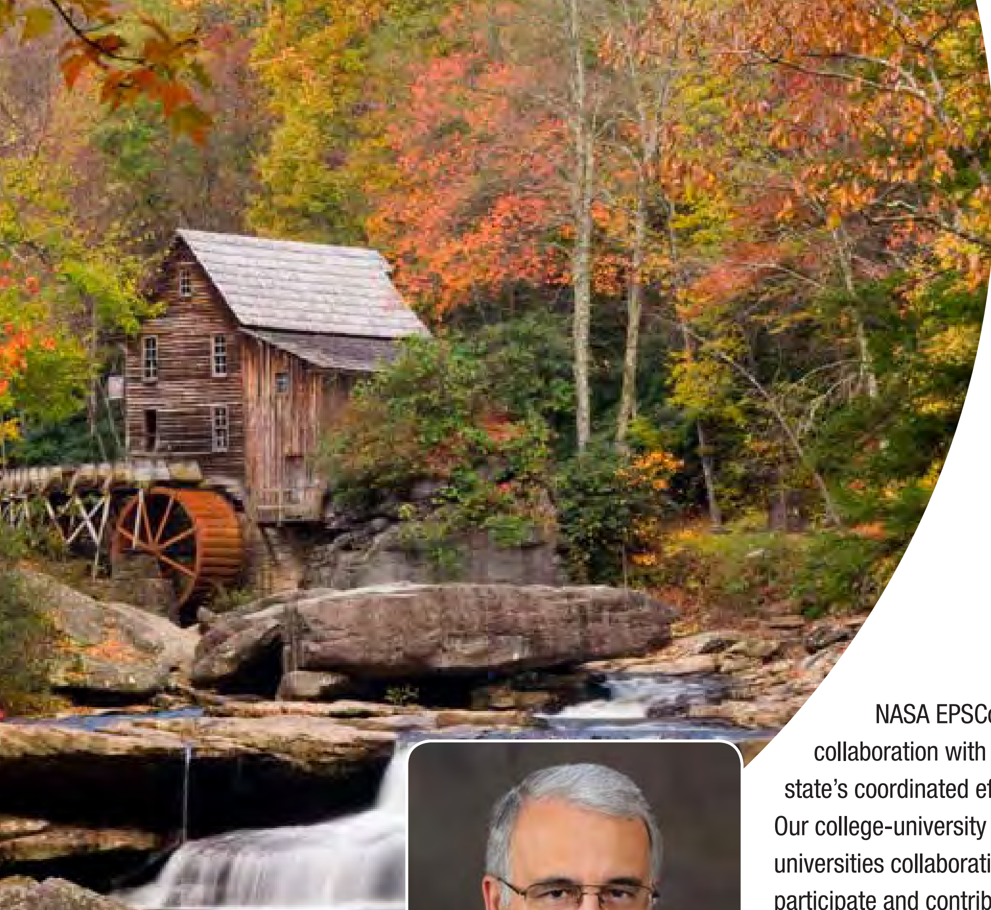
Aerothermal testing of 2-D woven SiC fibers for flexible thermal protection systems in hypersonic inflatable aerodynamic decelerators (HIAD) currently in development at NASA. (a) Cross-sectional and (b) top views of Hi-Nicalon SiC woven fibers. (c) Woven Hi-Nicalon SiC lead-ply coupon in SiC sleeve. (d) Probe insertion in the 30 kW inductively coupled plasma torch facility.



Dr. Anthony Calomino, PhD, NASA Technical Monitor, Langley Research Center

Prof. Frederic Sansoz, Science PI, University of Vermont

The UNIVERSITY of VERMONT



WEST VIRGINIA

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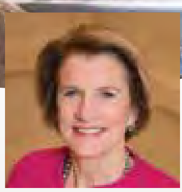


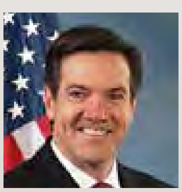
Senator
Shelley Moore Capito

Dr. Majid Jaridi,
WV EPSCoR Director

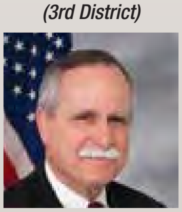
NASA EPSCoR not only provides seed funding for establishing collaboration with NASA, it also fills the gap in the overall mosaic of our state's coordinated efforts in fostering collaborative research in West Virginia. Our college-university collaboration program has faculty from our research universities collaborating with our four-year college faculty to get them to participate and contribute to our state's scientific and economic development plans. West Virginia is working to overcome its legacy as one of the nation's poorest states by directing attention to science and technology. Despite gains made, West Virginia still has a long way to go to achieve national research competitiveness. Because of our EPSCoR research programs, faculty and students across the state have been able to engage in research directly tied to work going on at NASA centers and enterprises, and are increasing their ability to develop further research. We have specifically contributed to increased research activities across the state and increased technical workforce development, which is a high priority program for the state government.

Senator
Joe Manchin

West Virginia TOC



Representative
Evan H. Jenkins
(3rd District)



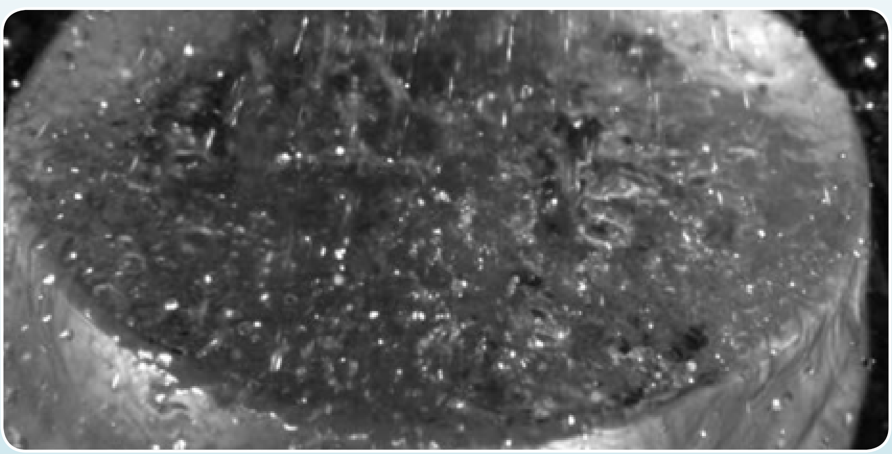
Representative
David McKinley
(1st District)

Spray Cooling Heat Transfer Mechanisms

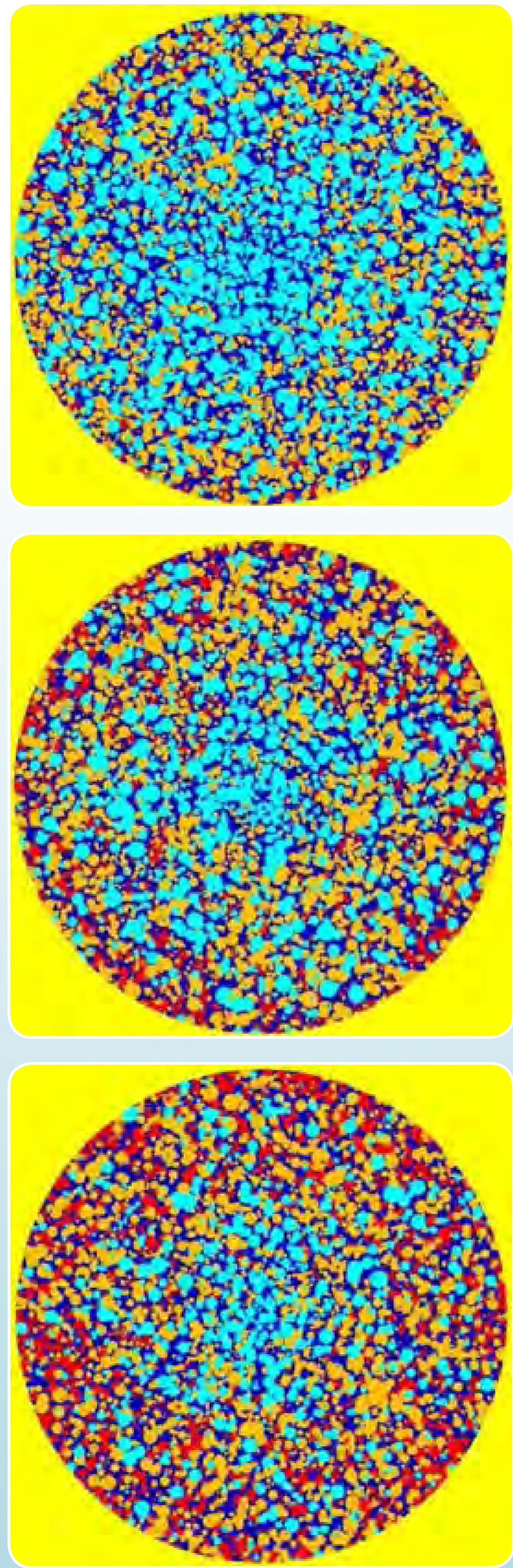
West Virginia University

Development of a Monte Carlo model for spray cooling with boiling, based upon the fundamental physical mechanisms that occur in the process, but simplified so predictions are computed in a reasonable run time was attempted. Impingement of the huge number of droplets onto a heater surface, and subsequent detailed fluid, heat transfer, and phase change processes occurring in the liquid film forming on the heater was modeled via a combination of time scale analysis, experimental data, and Computational Fluid Dynamics results. Monte Carlo modeling of spray cooling is a unique and innovative approach that is far more efficient than first-principles attempts to simulate the fluid flow, heat transfer, and phase change processes that occur when individual spray droplets impinge onto a heater surface and interact with the liquid film, vapor bubbles, and one another.

Within the project component, the experimental study of the dense spray impact and heat transfer, sufficient data has been obtained for use in the Monte Carlo model to account for the influence of the enhanced transient heat transfer in the individual droplet impact cavities. Video data for sprays gave impact cavity lifetimes that were significantly less than the cavity lifetimes measured for single droplet impacts under the single droplet impact studies. This gives us confidence in our time scale estimates for drop impact cavities to be re-covered due to subsequent nearby droplet impacts. ✺



One frame of high-speed video image of surface



➤ Model prediction of heater surface for varying heater power levels:

Top 60 w
Middle 100 w
Bottom 140 w

John M. Kuhlman, Ph.D.,
Science PI,
West Virginia University

Dr. Eric Silk,
NASA Technical Monitor,
GSFC

Coherent Terahertz Acoustic Phonons: A Novel Diagnostic for Erosion in Hall Thruster Discharge Chamber Walls

Marshall University Research/NASA Ames Research Center, Kennedy Space Center, Space Technology Mission Directorate

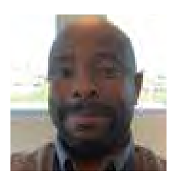
Left to right, Thomas E. Wilson, Ph.D. (Science PI, Department of Physics, Marshall University), and Daniel Crowder (MU Physics Undergraduate student).

Left to right, Thomas Wilson, Sarah Barber (MU Chemistry Undergraduate student), Research Associate, Dr. Konstantin A. Korolev (MU Post-Doc Physics).

The goal of this NASA EPSCoR sponsored research was to develop a novel coherent source of high-frequency sound waves in crystalline solids (the quanta of which are called 'phonons') and to use the source as a new approach to performing diagnostic experiments of the erosion of thin-films of hexagonal boron nitride (h-BN) and/or its composites due to xenon ion impact in Hall ion rockets. The ability to generate coherent nanosecond pulses of sub- through terahertz frequency regime acoustic phonons has been a long-standing goal of condensed matter physics. Dr. Wilson's laboratory is the only one in the world attempting to produce coherent transverse acoustic (shear TA) phonons in the hypersonic sub-terahertz frequency regime by the resonant driving of the alternating space charge layers of MBE-grown superlattices with the electric field of a far-infrared (FIR) laser. The laser radiation is germanium prism-coupled to the superlattice layers and derives from the PI's novel cavity-dumped, optically-pumped far-infrared molecular gas laser.

Interdisciplinary collaborations have been developed between the research team at Marshall University (MU) and researchers from the University of Michigan and Rensselaer Polytechnic Institute (RPI). ✺

http://science.marshall.edu/wilsont/lab.html

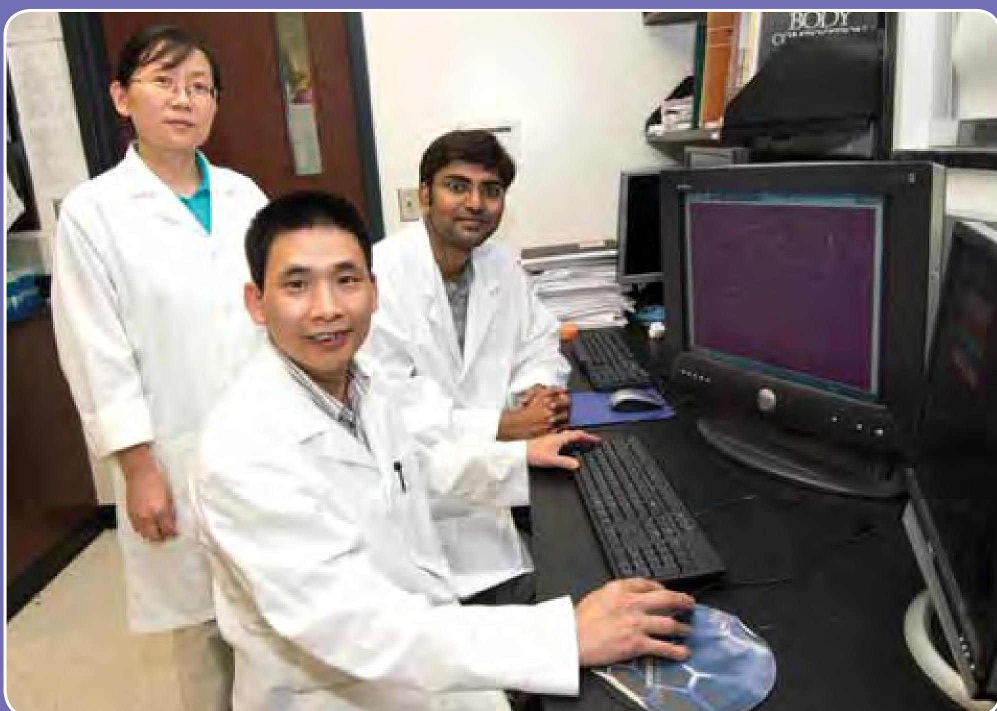


Kyle L. Dixon,
NASA Technical Monitor,
Kennedy Space Center

Mechanical Unloading and Irradiation-Induced Musculoskeletal Loss and Dysfunction: Molecular Mechanisms and Therapeutic Nanoparticles

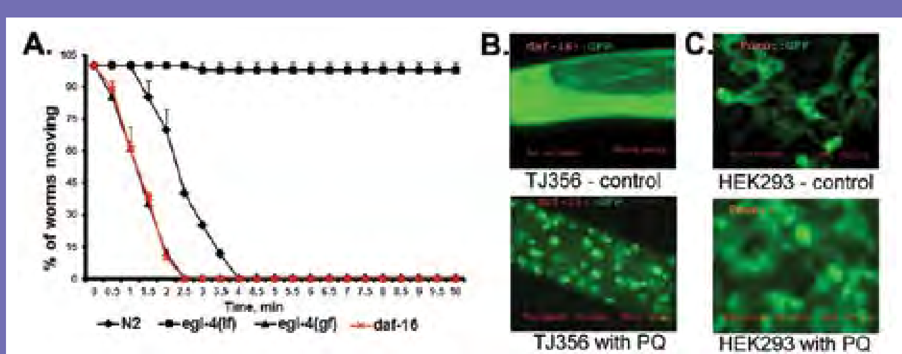
West Virginia University/NASA Johnson Space Center, Marshall Space Flight Center

Space travel is associated with the absence of musculoskeletal loading and exposure to increased radiation. Mitigating the loss of muscle and bone observed with space travel is important, which if not achieved, could impair space mission success and astronaut health. This proposal has been specially designed to investigate the effects of irradiation and mechanical unloading on musculoskeletal loss, and more importantly, to develop novel countermeasures. The deterioration of musculoskeletal structure and function is one of the most significant adverse impacts that accompany long term space travel. The mechanisms regulating how the musculoskeletal system adapts to space factors are not well understood, which has prevented the development of effective countermeasures. This NASA-EPSCoR funded study is investigating the deteriorative effects of irradiation and microgravity on musculoskeletal system, and developing novel countermeasures, such as nanoparticle based interventions. Preliminary findings from this study have been accepted for presentation at the Health Physics Society 60th Annual Meeting. Interdisciplinary collaborations have been developed between our research team at Marshall University with NASA scientists and researchers from the University of Delaware, the Huntington VA Medical Center and West Virginia State University. These collaborations along with an Internal Grant Program funding have allowed investigators to develop four space science and medicine-oriented seed projects. A graduate course "Space Biology and Nanomedicine (PHAR801; 3 or 6 credit hours)" has also been developed in support of NASA s educational mission. ✺



➤ Dr. Miaozong Wu (Science PI, West Virginia University) works with postdoctoral fellow Dr. Cuifen Wang (left) and graduate student Venkata Bandarupalli (right).

Dr. Honglu Wu, NASA Technical Monitor, Johnson Space Center



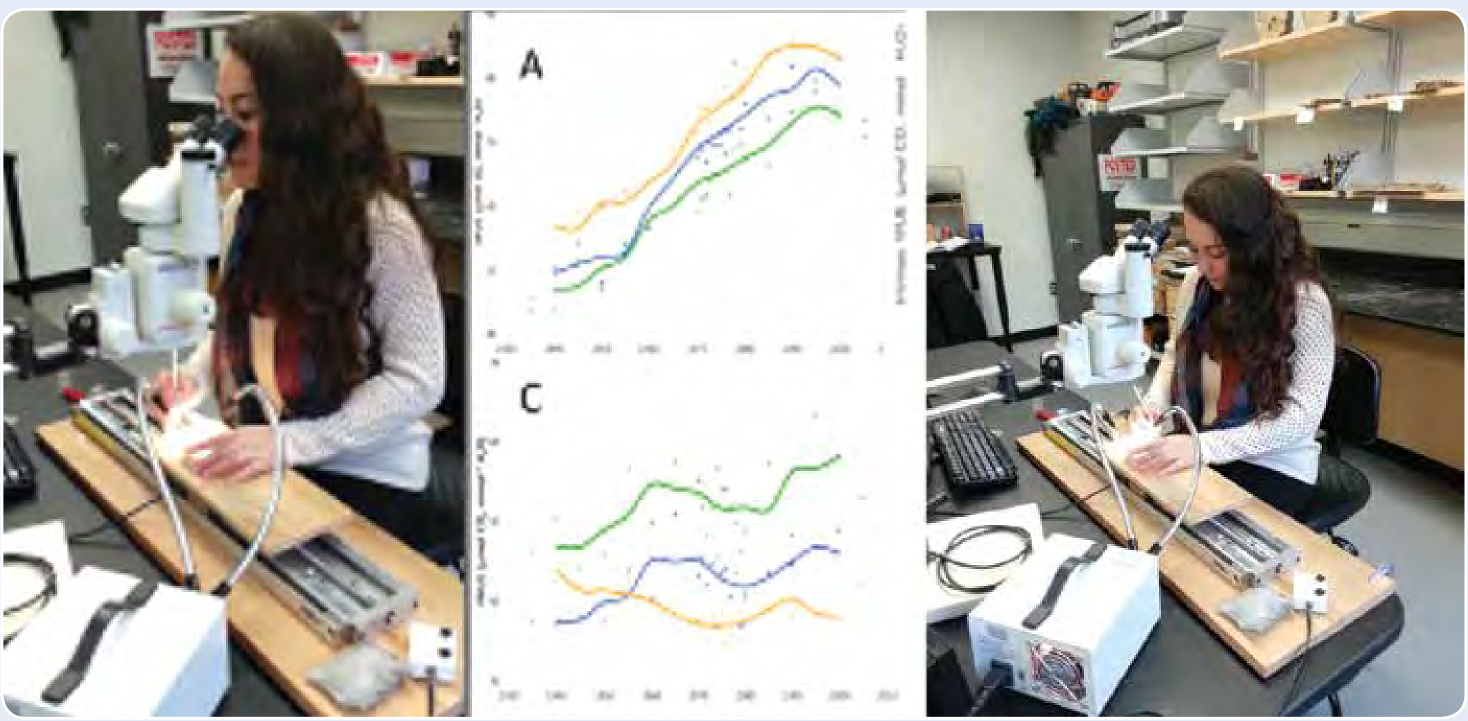
Impaired DAF-16 / FOXO function increases quiescence. B. Paraquat treatment increases nuclear translocation of DAF-16 in C. elegans (TJ356; daf16::gfp). C. Paraquat treatment increases nuclear translocation of FOXO1 (bottom panel) in HEK293 cells stably expressing FOXO1::GFP.

Research Infrastructure Development

West Virginia University, Marshall University/Johnson and Kennedy Space Centers

WV RID fosters and strengthens ties between researchers at all institutions of higher education in West Virginia; and supports a variety of projects to encourage collaboration with NASA scientists, high-tech companies in the state. The impact of WV RID at a number of smaller institutions has been significant. For instance, a representative of a 4-year college in WV writes: “NASA EPSCoR has provided the support needed to help many faculty members in our science departments keep active in research. We have seen a very positive impact that the program has had on science at our institution. It has enabled our faculty to keep abreast of the NASA space work, and has helped to keep the sciences vibrant here. We are most appreciative of this connection. This, then, becomes a significant contribution to promoting and maintaining a high standard in science throughout this state.”

Dr. Brenden E. McNeil, West Virginia University Department of Geology and Geography, was awarded a Research Seed grant entitled “Acid deposition and tree water use efficiency: comparing northern hemisphere tree-ring isotope data with new measurements from unpolluted South American forests”. The focus of the research study is to analyze atmosphere-biosphere climate modeling activities and how increases in atmospheric CO2 will affect the carbon sink provided by the world’s forests. His research will provide a powerful baseline for tree-ring δ13C analyses, thereby greatly intensifying the impact of this interdisciplinary research, as well as enhancing its utility for NASA-funded climate modeling efforts. In 2013, Ms. Evelin Flamenco, a WVU undergraduate student working with Dr. McNeil, applied for and was awarded a scholarship for the Next Generation of Latino Leaders, from the Congressional Hispanic Caucus Institute, Inc. (CHCI). In 2015, under Dr. McNeil mentorship, Ms. Flamenco competed for and was awarded an Undergraduate Fellowship to continue her research work on the project “Comparing Tree Species and Canopy Albedo by Measuring Leaf Angle with a UAV”. She indicated that in her current research that she expects to gain additional skills and knowledge in preparing for Graduate School. ✺



Evelin Flamenco, WVU sophomore geography undergraduate research student, measuring widths of tree-rings for isotopic analysis for Dr. B. McNeil’s Research Seed Grant entitled “Acid deposition and tree water use efficiency: Comparing Northern Hemisphere tree-ring isotope data with new measurements from unpolluted South American forests”.

Dr. Xiaopeng Ning (left), West Virginia University, Industrial and Management Systems Engineer, helping a human subject perform a simulated fetal-tuck posture; this posture is commonly used by astronauts in space to relieve lower back pain. This research was sponsored by WV EPSCoR RID and was entitled "Understand the effects of fetal tuck position on lumbar spine: designing countermeasures to relieve low back pain among astronauts during space flight."

Dr. Tesfaye Belay of Bluefield State College (BSC), a HBCU member of NASA West Virginia Space Grant Consortium (WVSGC), mentors BSC undergraduate student Candice Harris. This research was sponsored by WV EPSCoR RID and was entitled "Effect of Starvation on Protein Profiles of Pseudomonas aeruginosa"

Dr. Jason Gross (right), assistant professor of mechanical and aerospace engineering in the Statler College of Engineering and Mineral Resources, will receive a two-year, $200,000 grant — with optional funding for a third year — as part of our New Investigator Program. In addition, thanks to an Air Force Office of Scientific Research Summer Faculty Fellowship Program award, Dr. Gross will spend eight weeks during the summer at the Air Force Institute of Technology at Wright- Patterson Air Force Base in Dayton, Ohio, working on GNSS integrity monitoring. Seed funding for Dr. Gross' work in this area was provided by Statler College and WV EPSCoR RID and was entitled "Ultra-Wideband Ranging and Communications to Augment GPS Relative Navigation of UAVs"

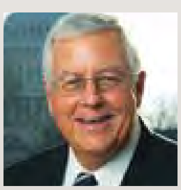
WY

WYOMING

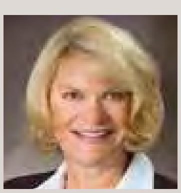
Wyoming NASA EPSCoR Director, Paul Johnson

Wyoming remains the state with the smallest population and its economy is largely driven by extractive and energy-related industries. The University of Wyoming is the only Ph.D. granting research institution in the state and therefore scientific activities that address key areas of state concern are concentrated at UW. One of the main areas that has been identified by the state and university as a high-priority is materials science research. The University of Wyoming, as well as the Wyoming Governor's Science and Engineering Task Force, have made the development of a Materials Science and Engineering (MSE) program a priority in academic planning. Wyoming NASA EPSCoR has been critical to the development of the MSE program at UW, which brings together students and faculty from across campus. Materials science is a multidisciplinary field involving collaborations that go beyond traditional academic programs and the MSE program provides a rich environment for discovery.

Senator John Barrasso



Senator Mike Enzi



Representative Cynthia Lummis (District At Large)

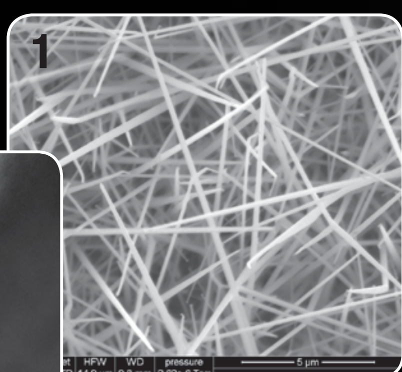
Wyoming TOC

Nanostructured Photovoltaics for Space Energy Applications

University of Wyoming/NASA Human Exploration & Operations Mission Directorate

In this project we investigate quantum dot sensitized solar cells (QDSSCs) based on nanostructures. Solar cells have long been a crucial component for providing the power necessary for human exploration of space, and in order to meet the future needs of space exploration advanced solar cell technologies are required, which need to be more efficient, lightweight, and cost effective. The use of nanostructured materials presents such a possibility and allows considerable flexibility in optimizing light absorption, carrier separation, and carrier transport in solar cells, thus providing the potential for very high performance solar cells. Wyoming is an energy state, and the University of Wyoming is the only research university in the jurisdiction. The research efforts of this NASA EPSCoR project was not only in line with the state wide energy efforts but also has imprvoed local research infrastructures related to the studies of nanostrucutred materials for energy applications. For example, this project provided funding to accquire a major research equipment, a Cypher Atomic Force Microscopy, which has been used by not only the investigators of this project but also other scientists in the jurisdiction for a variety of research needs. In this project we have studied quantum dot sensitization of metal oxid surfaces. We have also sucessfully sythesized oxide nanowires such as Indium tin oxide (ITO) and $Zn2TiO_4$ nanowires. As examples, Photo 1 shows a scanning electron microscope image of the ITO nanowires, and Photo 2 shows an image of quantum dots deposited on ITO nanowire using the successive ionic layer adsorption and reaction method. These nanostructures will be used in the next generation solar cells to improve their performance. ✺

1



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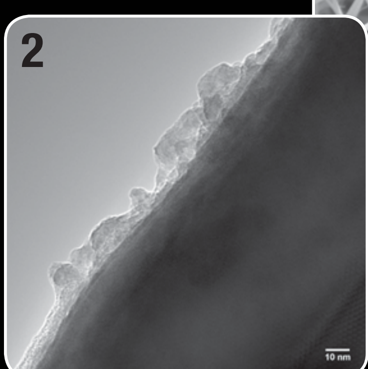
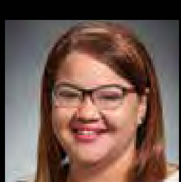
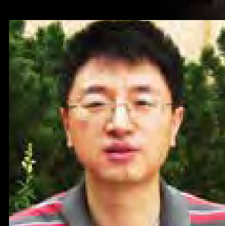




Dr. Dionne M. Hernandez-Lugo,
NASA Technical Monitor,
Glenn Research Center



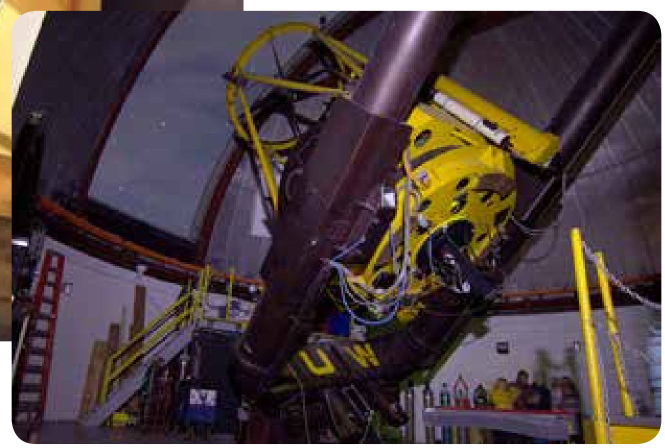
Wenyong Wang,
Science PI,
University of Wyoming

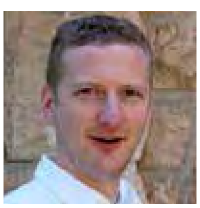
Initiating a Bold New Generation of Astronomical Surveys at the Wyoming Infrared Observatory

University of Wyoming/NASA Goddard Space Flight Center, Science Mission Directorate

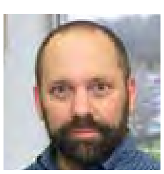
Students from Colorado College using the new Prime focus imaging camera and examining themselves in the 2.3 meter primary mirror (Photo credit Shane Burns, Colorado College).

Interior night dome photo of the Wyoming Infrared Observatory (Photo credit Matt Bryant)





Adam D. Myers, Science PI, University of Wyoming



Dr. Matt Greenhouse, NASA Technical Monitor, Goddard Space Flight Center, STMD

UNIVERSITY of WYOMING

Upgrades to the University of Wyoming's 2.3 m telescope at the Wyoming Infrared Observatory (WIRO) have launched a new generation of science and outreach programs. A new 4096x4096 pixel ultraviolet-sensitive camera images a 39.1 arcminute square field, enabling graduate and undergraduate students to conduct thesis projects across large portions of the sky. Ancillary upgrades to the Observatory's internet link to campus allows astronomers to transfer hundreds gigabytes of data per day even while supporting fast video links for remote telescope operation and public virtual participation with astronomers on site. The project has enabled new collaborations for teaching and research throughout Wyoming and nationwide. WIRO hosted a week-long observing run for the junior/senior observational methods class at Colorado College taught by Prof. Shane Burns. WIRO provided observing experience for four students and Prof. Bill Welsh from San Diego State University while delivering spectroscopic data in support of NASA's Kepler spacecraft science goals.

WIRO was featured in a documentary chronicling a science investigation of close binary stars involving faculty Prof. Larry Molnar and several students at Calvin College. Five high school students and their teacher from a Lander, WY astronomy club visited WIRO to take data with the large-format camera. Secondary science teachers from Wyoming and New Hampshire visited WIRO as part of a 24-participant summer teacher's workshop co-hosted by Prof. Adam Myers in collaboration with UW education professor Andrea Burrows. Eight undergraduate observed 28 nights on WIRO as part of a summer research experience for undergraduates (NSF-REU) program coordinated by UW Profs. Danny Dale and Chip Kobulnicky. Forty eight junior high students from Wyoming and three surrounding states used WIRO as part of a team-based research project during the 10-day ExxonMobil Bernard Harris Summer Science Camp at UW directed by Prof. Kobulnicky. ✺

WY

Research Capacity Building using a new Dual-frequency Airborne Radar System in support of NASA GPM and ACE Ground Validation Experiments

University of Wyoming/NASA Johnson Space Center, Glenn Research Center, Science Mission Directorate, Space Technology Mission Directorate

The project will enable, for the first time, profiling dual-frequency radar measurements (above and below the aircraft) in combination with hydrometeor characterization using in situ optical array probes at flight flight level. The beauty of this is that one can actually assess and thus improve the dual-frequency radar algorithms for median particle diameter, precipitation rate and other hydrometeor characteristics: ground truth is provided by measurements at flight level, sandwiched between the dual-frequency reflectivity estimates above and below flight level.

The Ka-band (1.2 cm) Profiling Radar (KPR), funded by this project, will be combined with the W-band (0.3 cm) WCR (Wyoming Cloud Radar) whose, profiling capability was funded by a previous NASA EPSCoR grant lead by the same science PI at the University of Wyoming. The signal returned to the radar receiver (radar reflectivity) is attenuated differently by cloud and precipitation particles at these two frequencies. The basic principle of dual-frequency radar measurements, as used on the NASA GPM (Global Precipitation Measurement) mission, is that the difference in reflectivity between the two radars is a measure of precipitation rate and other cloud properties along the path between the radar and the target. Our measurements will allow the evaluation and improvement of dual-frequency algorithms, not so much for the NASA GPM DPR (dual-frequency radar), but rather for the future NASA ACE (Aerosol. Clouds, and Ecosystems) mission, which will use exactly the same radar pair (Ka and W bands).

The platform used for this work in the UW King Air (UWKA) research aircraft. It has been used for many years mainly for NSF-funded projects. The WCR nadir port was funded by a previous NASA EPSCoR grant. The KPR will be mounted on the aircraft's right wing. ✺

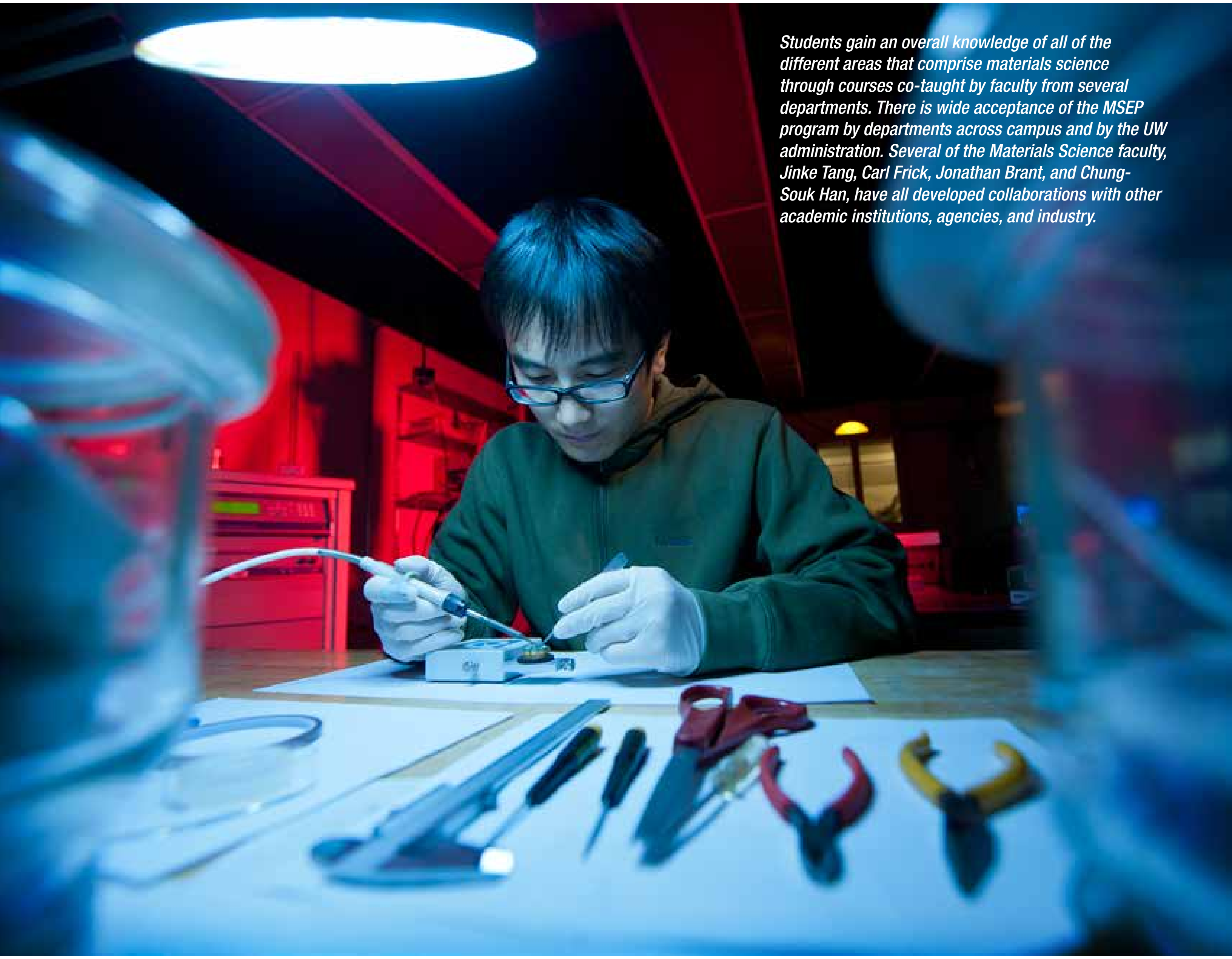
A group of Millersville University students visiting the UW King Air in the OWLeS (Ontario Winter Lake-effect Snow) project in 2014.

A group of Millersville University students visiting the UW King Air in the PECAN project (Plains Elevated Convection At Night) in 2015.

Science PI: Dr. Bart Geerts, University Of Wyoming

NASA Technical Monitor: Dr. Walt Petersen

Wyoming Research Infrastructure Development



Students gain an overall knowledge of all of the different areas that comprise materials science through courses co-taught by faculty from several departments. There is wide acceptance of the MSEP program by departments across campus and by the UW administration. Several of the Materials Science faculty, Jinke Tang, Carl Frick, Jonathan Brant, and Chung-Souk Han, have all developed collaborations with other academic institutions, agencies, and industry.

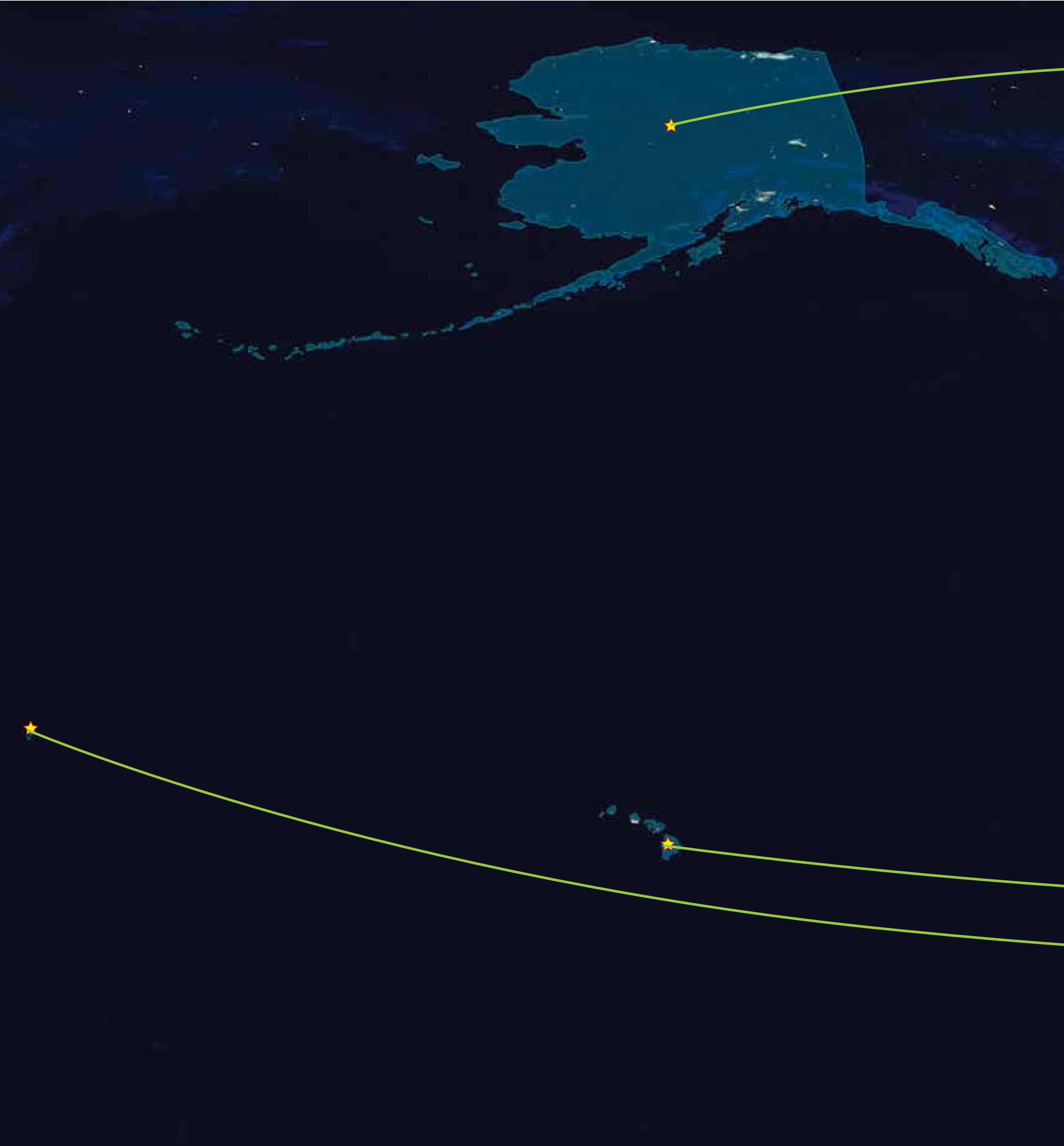
Carl Frick was funded in FY2014 by Wyoming NASA EPSCoR and this support resulted in a manuscript submitted to Applied Physics Letters, a significant portion of the dissertation of PhD student Oscar Torrents, preliminary results for an NSF proposal to be submitted to Metals and Metallic Nanostructures (MMN) Program, and educational outreach related to materials science research through the Engineering Summer Institute for high school students at UW.

Over the last several decades, a substantial amount of research has been performed on B2 intermetallics, in large part because of their relatively large stiffness and strength which remains stable at elevated temperatures. They have been proposed for a wide range of aeronautical applications including turbine blades, high-temperature coatings, and converging-diverging nozzles. Unfortunately, very few of these applications have been realized because of the extremely brittle nature of most high strength B2 intermetallics. Recently, an emerging group of newly developed B2 intermetallics exhibit relatively large ductility. To date, no widely-accepted theory has been developed to explain their behavior. The purpose of this proposed research was to investigate the microstructural mechanisms responsible for the ductility in these emerging B2 intermetallics. Instead of relying on involved

Dr. Carl Frick, Assistant Professor of Mechanical Engineering, holding calibration specimens for the Agilent Nano Indenter G200 he uses for characterizing mechanical behavior at sub-micron scales.

procedures to fabricate bulk single crystal specimens, the proposed approach utilized a focused ion beam (FIB) to manufacture small-scale compression pillars on the surface of a more conventional polycrystal. Pillars were cut from individual grains, allowing for over a hundred "single crystal" compression tests from one polycrystalline sample surface. Compressive testing was performed using a nanoindenter equipped with a flat punch. Representative pillars were sectioned and transmission electron microscopy (TEM) was used for direct investigation of the microstructure. For this pilot work, deformation behavior of ß-brass (CuZn) was chosen. TEM analysis clearly revealed the formation of kink bands, resulting in an "S" shaped deformation observed. This observation is entirely unique, and the subject of our continued research focuses. The proposed research aligns well with the goals of NASA's Aeronautics Research Mission Directorate. Continuing need for higher performance and efficiency in propulsion have created a strong demand better for high-temperature materials. Some immediate applications in spaceflight include combustion chambers for advanced chemical rockets and turbo-machinery for jet engines and power conversion in nuclear-electric propulsion. ✺

NASA EPSCoR



National Aeronautics and Space Administration

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

www.nasa.gov

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