National Aeronautics and Space Administration

NASA EPSCoR

Stimuli

2017–18

NASA
EPSCoR

National Aeronautics and Space Administration

Headquarters
Washington, DC 20546-0001

February 14, 2018

Reply to Attn of: Office of Education

Greetings,

On behalf of the National Aeronautics and Space Administration Office of Stem Engagement, I welcome you to the third edition of Stimuli, a NASA EPSCoR collection of college and university research spanning Earth science, aeronautics, low earth orbit and deep space exploration development.

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

The policy directive states: "Lead an innovative and sustainable program of exploration with commercial and international partners to enable human expansion across the solar system and to bring back to Earth new knowledge and opportunities. Beginning with missions beyond low-Earth orbit, the United States will lead the return of humans to the Moon for long-term exploration and utilization, followed by human missions to Mars and other destinations."

NASA EPSCoR supports this directive through research directed toward the goals of the NASA Mission Directorates. The NASA EPSCoR program directs Congressionally-mandated research and development grants to eligible colleges and universities. The resultant work has consistently proved successful and viable. EPSCoR's impact is long-term and far-reaching. By helping establish state-of-the-art infrastructure needed to conduct the cutting edge research it funds, EPSCoR is contributing to the self-sustenance of U.S. competitive R&D capabilities and stimulating partnerships between government, higher education and industry.

Sincerely,

Michael A. Kincaid
Associate Administrator for Education

National Aeronautics and Space Administration

Headquarters
Washington, DC 20546-0001

February 14, 2018

Reply to Attn of: Office of Chief Scientist
Office of Chief Engineer
Office of Chief Technologist

Greetings,

President Eisenhower signed the National Aeronautics and Space Act on July 29, 1958. In the 60 years since, research funded by NASA has advanced our understanding of the earth, near Earth orbit, and deep space. Many scientists and researchers, teamed with NASA researchers and engineers, have received NASA Established Program to Stimulate Competitive Research (EPSCoR) awards resulting in patents or technical transfer of their basic aerospace-related research; some will see applications of their efforts fly in space aboard the International Space Station. As you browse through this edition of Stimuli, remember that NASA EPSCoR research contributes toward keeping NASA and our nation on the leading edge of aeronautical and aerospace engineering and technology while advancing the goals of America's Space Program.

We are proud of the research you see here as it is the result of collaborations with NASA scientists and engineers in areas that are of high interest to the NASA Mission Directorates. In addition, each research project is evaluated by a NASA Technical Monitor who works closely with the university researchers. EPSCoR researchers follow the NASA lead in developing new research capabilities with assistance from the centers. These capabilities include life sciences and habitation systems, space launch and suborbital technologies and tracking, timing, communications, and navigation technologies.

Sincerely,

Dr. Gale J. Allen
Acting NASA Chief Scientist

Mr. Ralph R. Roe, Jr.
NASA Chief Engineer

Dr. Douglas Terrier
Acting NASA Chief Technologist

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EARTH
Represents Planet Earth and the Terrestrial Environment

LOW EARTH ORBIT
is Research Related to Low Altitude Satellites, the ISS and Re-entry

DEEP SPACE
is Interplanetary Exploration and the Technologies to Get There

Alaska Research Infrastructure Development

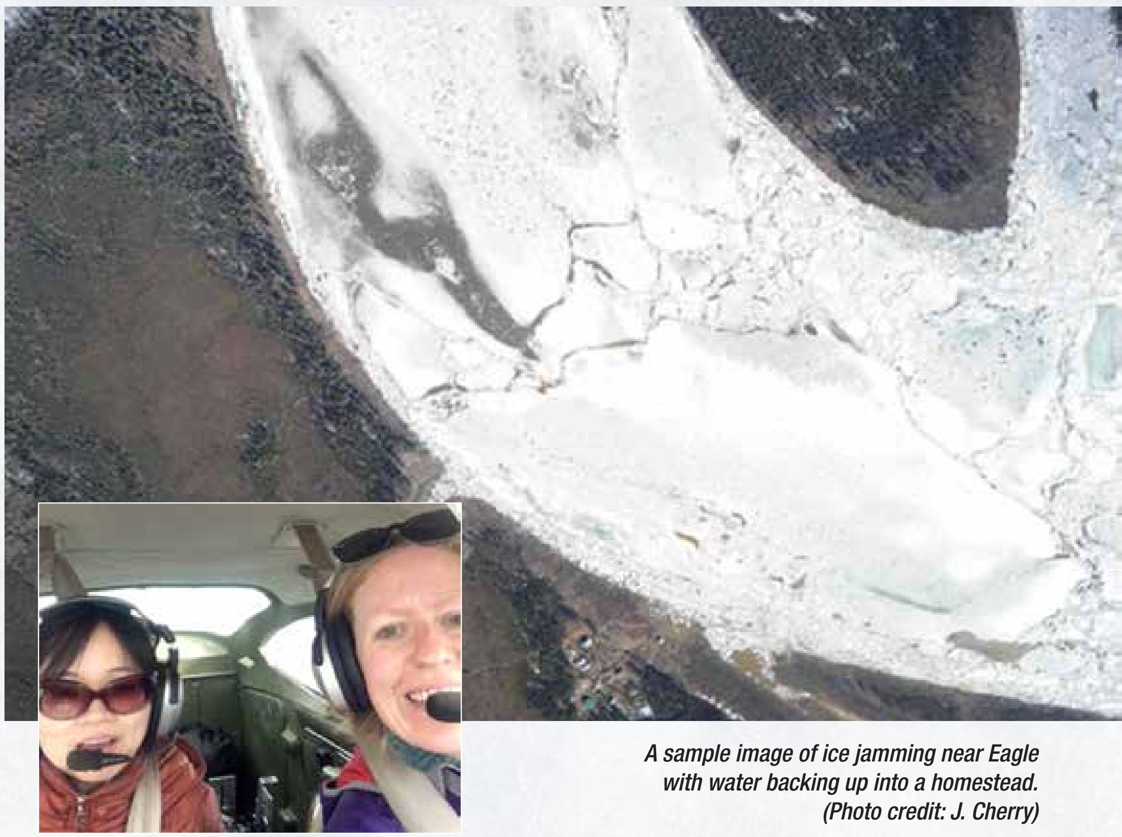
Scientist Uses Low-cost Sensor Systems to Monitor Hydrologic Change

by Jeremia Schrock

During the spring of 2016, Jessica Cherry and a team of researchers (including NASA's Dorothy Hall) investigated how ice and snow conditions in interior Alaska can be mapped and monitored using readily available technology and relatively low-cost sensor systems.

In a broad sense, Cherry's project was about increasing situational awareness while decreasing costs. Alaska is a large and sparsely monitored (let alone populated) place. How can scientists, with limited Earth-observing budgets in remote locations, get the research equivalent of more bang for their buck? With climactic changes being experienced everywhere (especially in Arctic and sub-Arctic regions) developing an inexpensive process to monitor everything from ice jam flood conditions to sea ice thickness is of huge financial and humanitarian concern.

While Cherry's work focused on Alaska, her research process easily carries over to other regions. Research that marries minimal costs with greater data, that can also be scaled to fit a project's individual needs and geographic demands, is the ideal. If a single researcher aboard a Cessna 182 can monitor river ice in Alaska, why can't the same be done for monitoring erosion along India's coast or mapping timber loss in Brazil? While research is infinite, budgets are not.



A sample image of ice jamming near Eagle with water backing up into a homestead. (Photo credit: J. Cherry)

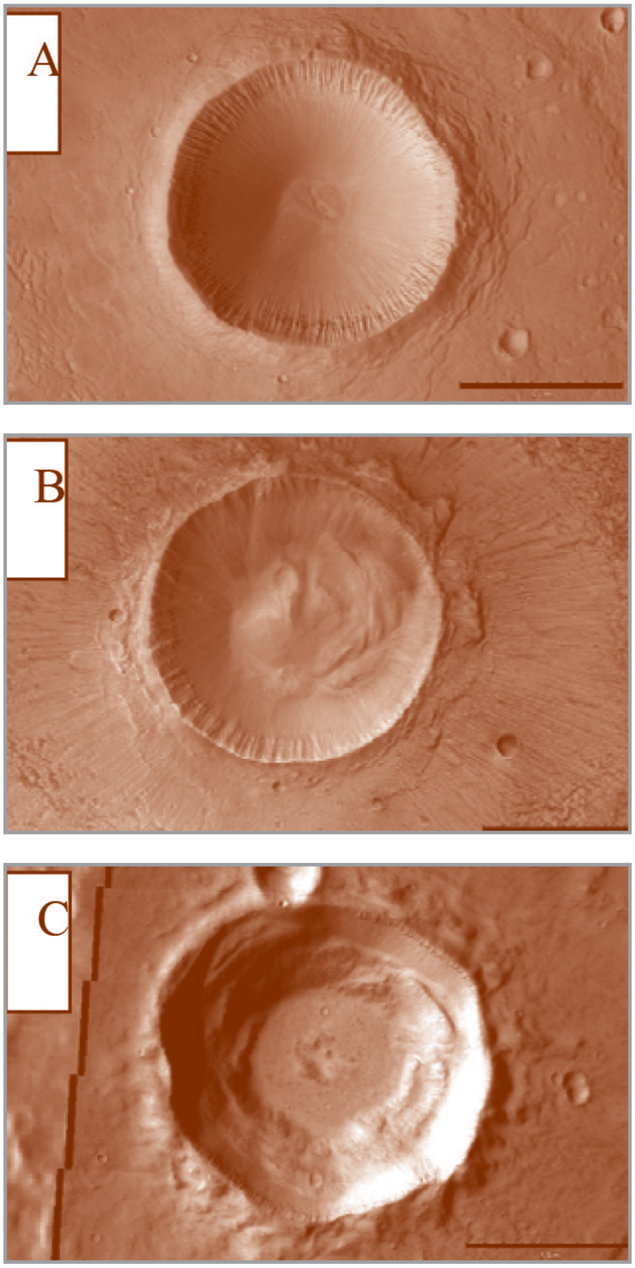
Science PI Dr. Jessica Cherry (right) and Dr. Sanmai Li (left) en route to an ice jam at Eagle Village on the Yukon River. Dr. Li developed a popular satellite algorithm for river flooding but until then had never seen river ice. (Photo credit: J. Cherry)

http://www.airspacemag.com/space/hibernation-for-space-voyages-180962394/

Denise Thorsen
AK EPSCoR Director
University of Alaska Fairbanks

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

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



Three craters of similar size with dramatically different interior structure. Crater A (CTX image; 29.7 N, 116.5 E) is essentially a simple crater with slight floor filling. Crater B (CTX image; 33.3 N, 315.9 E) has a prominent central mound. Crater C (THEMIS Vis image; 19.2 N, 161.6 E) has a flat floor, a hint of a central pit, and terraced walls. Scale bar is 5 km, and craters are ~9 km in diameter.

http://onlinelibrary.wiley.com/doi/10.1111/maps.12884/epdf

Martian Mapping Helps Scientists Understand Earths Topography

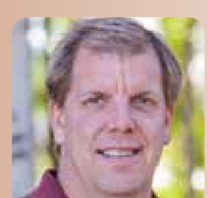
While it's easier to see the contours of geographic features on Earth, it's not easy seeing similar features on other planets. Using an imaging technique called structure from motion (SfM), Robert Herrick has spent decades mapping celestial bodies.

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

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

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

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



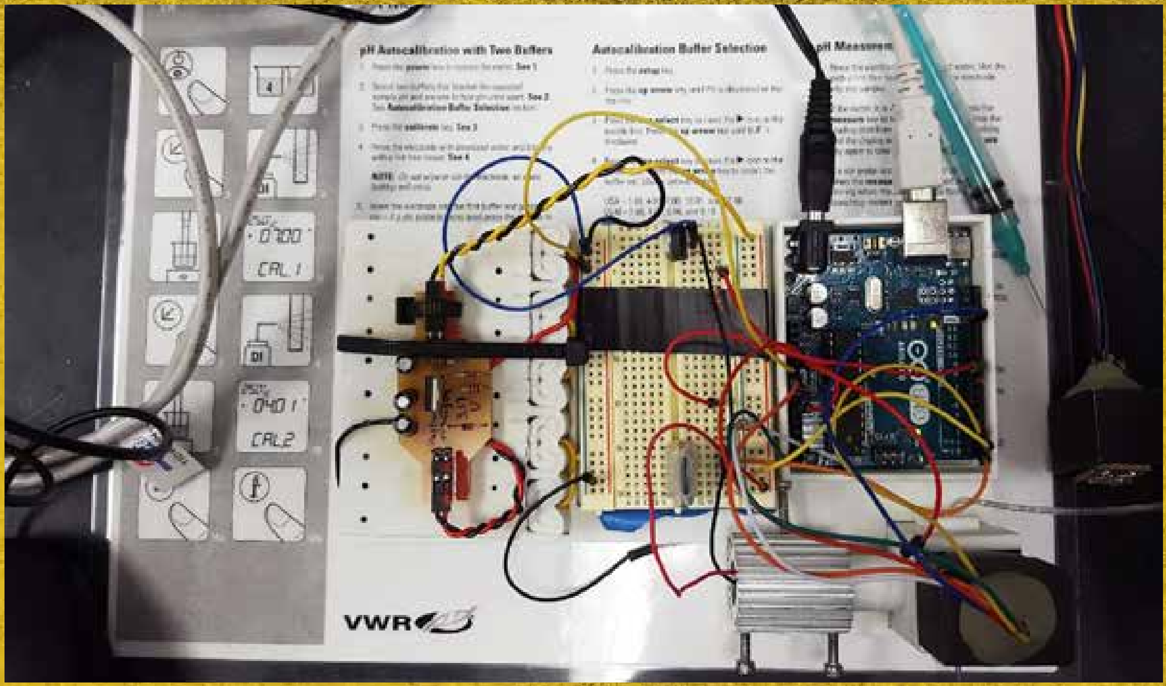
Dr. Robert Herrick
Science PI
Research Professor
University of Alaska Fairbanks
Geophysical Institute

Dr. Lori Glaze
NASA Technical Monitor
Planetary Studies

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

Dr. Cheng-fu Chen's battery-powered prototype.



Alaskan Scientists Develop, Test New Portable Radiation-Monitoring Technology

By Jeremiah Schrock

Cheng-fu Chen
Science PI
University of Alaska Fairbanks

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

It is an understatement to say that excessive exposure to radiation is bad. At its best, it can cause debilitating illnesses while at its worst it can mutate healthy DNA strands into cancerous ones. However, before cells turn rogue, they exhibit signs of change, change that can be detected and (with enough notice) minimized.

Examining the impact of radiation on an individual is time-consuming and currently demands the use of a laboratory. However, Cheng-fu Chen at the University of Alaska Fairbanks is developing portable, time-saving technologies that will allow researchers to measure radiation-causing DNA damage in the field.

In the second year of a three-year NASA EPSCoR research project, Dr. Chen has successfully developed and tested two portable, battery-powered prototypes. He and his team are also working on a technique to better isolate the damaged portion of a DNA strand. The ability to easily and accurately determine the level of damage at the molecular level is crucial across a wide-range of fields from astronauts engaged in long-term missions to technicians stationed at nuclear power facilities. Manufacturing and utilizing such simple and sensitive technologies will dramatically impact industry and research around the world.

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

University of Alaska Fairbanks, Kennedy Space Center, Space Techology Mission Directorate

NASA Gets a Little More Skin in the Game

By Sandra Boatwright

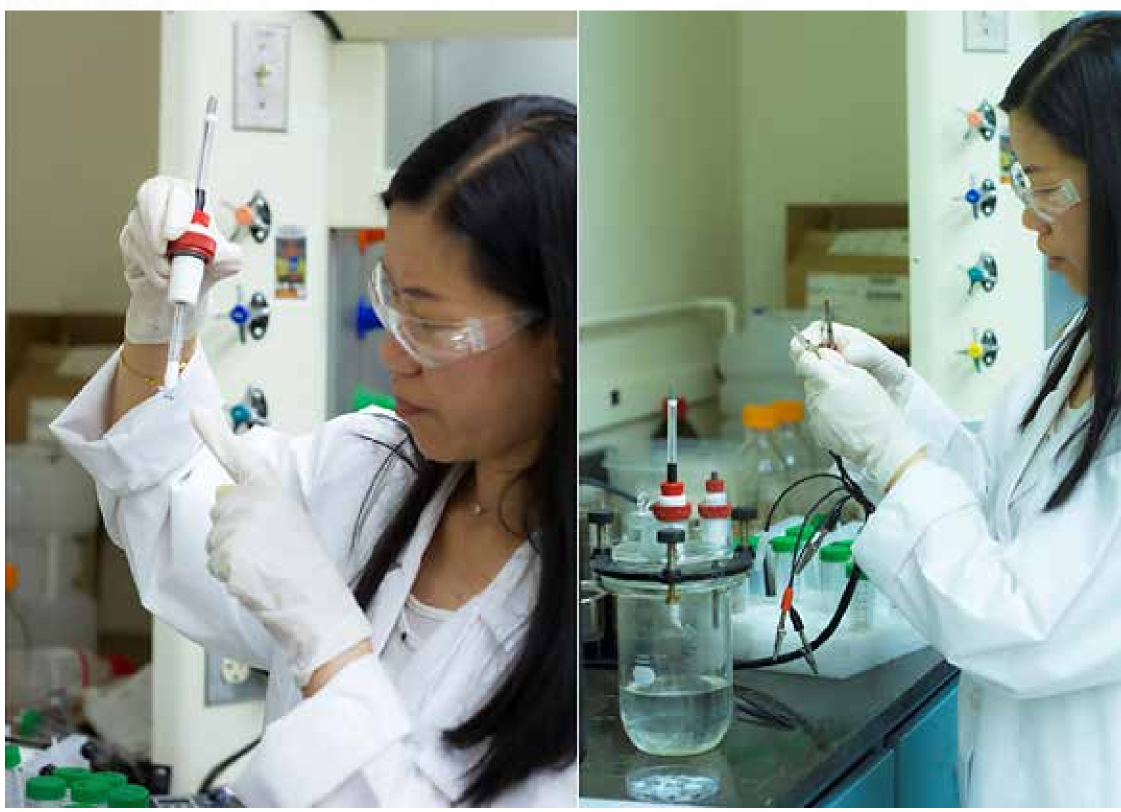
That bottle of sunblock you took to the beach this summer may soon have something in common with NASA's newest spacecraft: A coating of titanium dioxide nanoparticles can protect both you and the spacecraft from the coastal environment.

The NASA Kennedy Space Center launch facilities are located within 1000 feet of the Atlantic Ocean. The salt air combines with acidic rocket exhaust to create a very corrosive atmosphere, which attacks the light, strong metal alloys of spacecraft and other launch vehicles. NASA has been searching for a new environmentally friendly strategy for preventing and reducing metal alloy corrosion.

University of Alaska Fairbanks engineer Lei Zhang thinks a new coating, made of titanium dioxide nanoparticles and polystyrene, can protect spacecraft better, for less money, and cause less environmental contamination than currently used chromate coatings. Zhang is developing a technique for producing a uniform coating where the titanium nanoparticles are evenly spread throughout a polystyrene matrix. She is working with the head of NASA's Corrosion Technology Laboratory, Dr. Luz Marina Calle, to design a tough and easily applied coating.

In the first few months of this three-year project, Dr. Zhang's team has developed this procedure and produced samples of this Polymer Nanocomposite Coating. They have also begun testing its ability to stick to metal alloys. Over the next two years, the team will test the new coating's ability to resist corrosion using their new custom-designed corrosion chamber.

Ultimately, this new coating could benefit other industries as well, from more durable artificial joints for the medical field to tougher equipment for the oil industry to use in marine environments.



Science PI Dr. Lei Zhang describing methodology of characterization of polymer-nanoparticle composite coating. (Photo Credit: Melanie Rohr)

Dr. Luz M. Calle
NASA Technical Monitor
Kennedy Space Center

Alabama Research Infrastructure Development

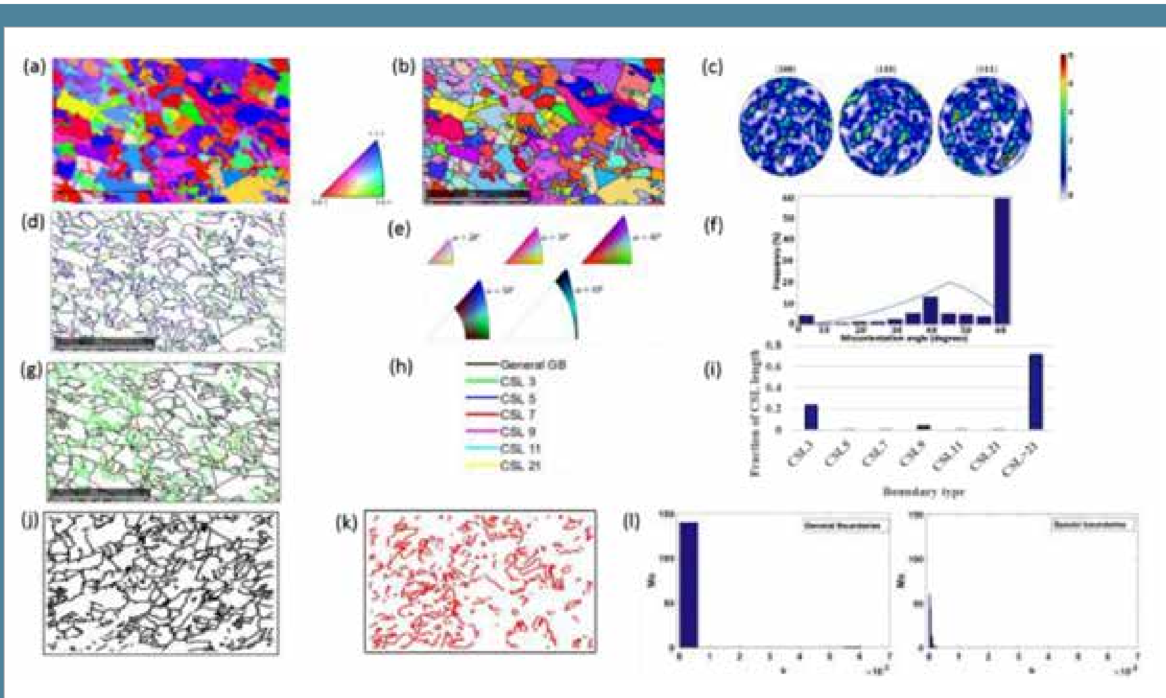


Figure: Heat treated Parallel to Z direction (a) EBSD map via SEM (b) Grain regeneration via Mtex (c) Pole figure (d) Grain boundary misorientation angle with (e) Axis angle sections (f) Misorientation angle distribution (g) Map of color coded CSL grain boundary network (h) Color legend (i) Fraction of CSL length (j) General grain boundary cluster (k) Special grain boundary cluster (l) Quantitative illustration of network topology

Investigation of Microstructure and Mechanical Property Relationship of Inconel 718 Fabricated by Selective Laser Melting Using Coupled Phase Field and Crystal Plasticity Simulations

Additive manufacturing (AM) is a process where digital three-dimensional design data is used to build up a component with complex geometries in layers by depositing material. Selective laser melting (SLM) is a form of AM that uses a high-power laser beam. The extreme processing creates very unique microstructure which can affect material performance. Meanwhile, engineering materials is progressing at an exponential rate with the extension of computer-processing power and the advancement of material theories at different length scales. Grain boundary engineering is a powerful tool used to tailor the polycrystal properties via altering the grain boundary characters and grain boundary network topology. This study focused on applying grain boundary engineering methodology and connecting the extreme processing conditions of SLM with the microstructural changes in grain boundary character of Inconel 718 via characterizing its grain boundary network characters for enhancement of its high temperature mechanical properties. A coupled experimental and computational analysis of grain boundary network characters are shown above.

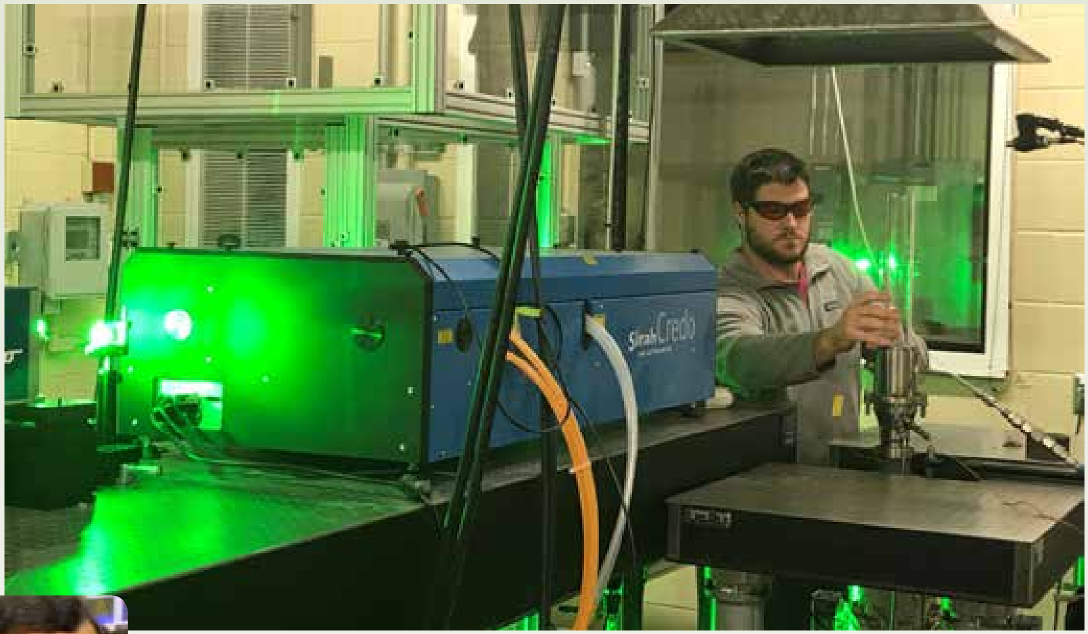
NASA Technical Monitor:
Dr. Terry D. Rolin
Failure Analyst
Marshall Space Flight Center

Science PI Dr. Majid Beidaghi (right) and PhD student Mr. Armin VahidMohammadi (left) examine the fabricated samples and discuss the test methods.

Dr. Dale Thomas
AL EPSCoR Director
University of Alabama

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

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



Combustion Setup in Engine and Combustion Laboratory at the University of Alabama Daniel Depperschmidt, PhD student in Mechanical Engineering.

Dr. Ajay K. Agrawal
Science PI
The University of Alabama

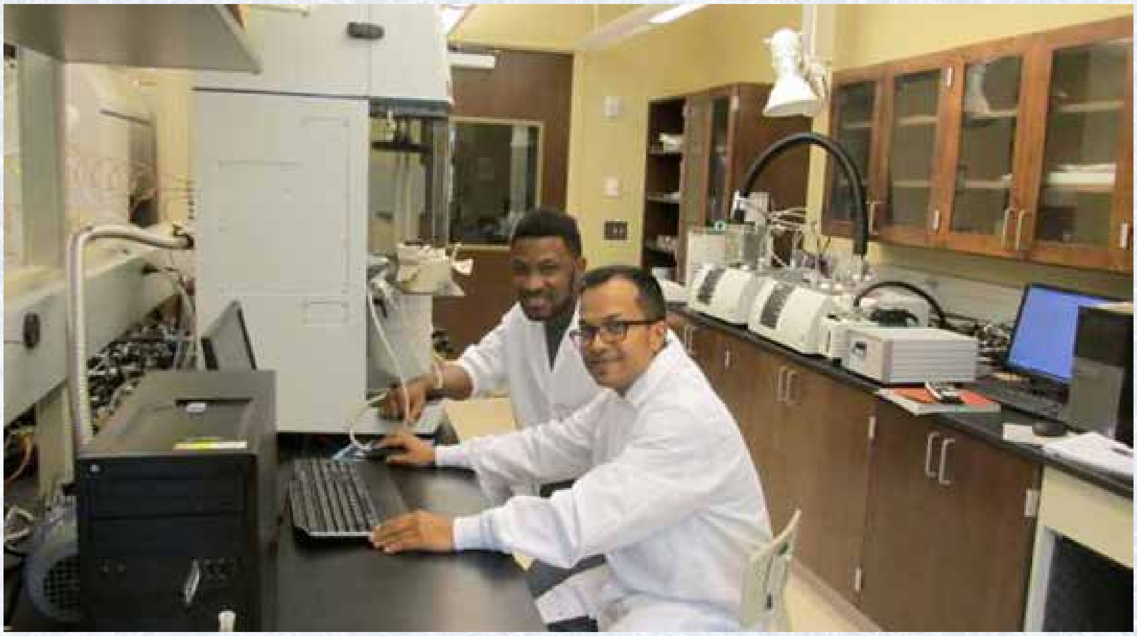
This research in the Department of Mechanical Engineering (ME) at the University of Alabama is producing innovative concepts, supplemented with experimental data, to enable lean direction injection or LDI combustion for next generation aviation gas turbines to meet stringent emissions, noise, and efficiency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

The project is housed in UA's state-of-the-art Engine and Combustion Laboratory (ECL). Key accomplishments of the project are: (1) one of the students supported by this project 12 is not working full-time with a NASA contractor in Huntsville on issue related to rocket propulsion, (2) the project led to winning two major external research grants on related topics; (a) laser diagnostics to improve understanding of rotating detonation engines, and (b) optical diagnostics to understand supercritical combustion at diesel condition. Both of these projects are underway and have resulted in significant increase in PhD, MS, and BS students working in our laboratories, (3) STEP course "Combustion II" was revised and led to record enrollment (twice the normal) of MS and PhD students interested in fuels, energy, and environment, (4) we are able to develop working relationship with at least two major companies in the field, and (5) we have built strong research strength, with the hiring of two new faculty members in combustion/engines area.

NASA Technical Monitor:
Dr. Kathy Tacina, Glenn Research Center

Development of Dust Free Binders for Spacecraft Air Revitalization Systems

University of South Alabama Huntsville/Human Exploration & Operations Mission Directorate, NASA Johnson Space Center, Marshall Space Flight Center



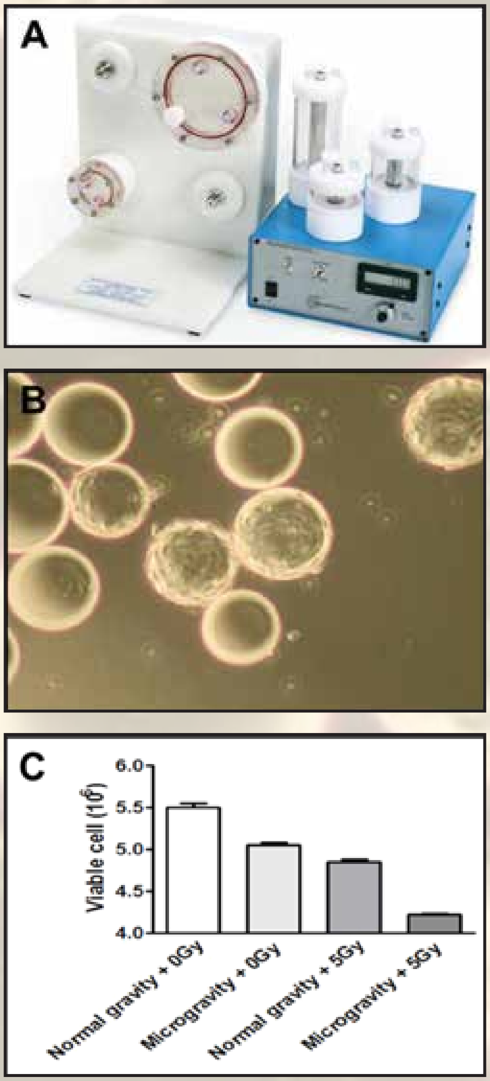
Aniebiet Udoh and Mohammad Hossain analyzing adsorption data. The data details the performance of novel adsorbents that can be used for life support in closed environments.

The removal of CO2 from spacecraft is a mission critical life support objective of any manned space flight. The current CO2 filtration system produces dust during operation, the dust subsequently causes mechanical failures, and therefore the system must be serviced periodically. This project is working to develop a technology that produces practically zero dust when removing CO2. The work is collaborative with NASA Marshall Space Flight Center (SFC), Johnson Space Center, and the NASA Ames Research Center. The outcomes of this project may be relevant to chemical separations that use adsorbents, such as air filtration for chemical weapons defense. The instrumentation purchased by this project is unique in the Southern Alabama Region and has increased the competitiveness of the University of South Alabama when seeking research grants. For example, after this award the Glover Group received funding from the Department of Defense (DoD) and the Group utilizes instrumentation purchased by this NASA grant to help characterize DoD materials. Without this grant, the Glover Group would not have been able to respond quickly to the research needs of the DoD. More broadly, the project has employed a first-generation college student in graduate school and an underrepresented minority in an internship.

Prof. T. Grant Glover
Science PI
University of South Alabama, Mobile

NASA Technical Monitor:
Dr. John C. Graf
Johnson Space Center

Arkansas Research Infrastructure Development



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

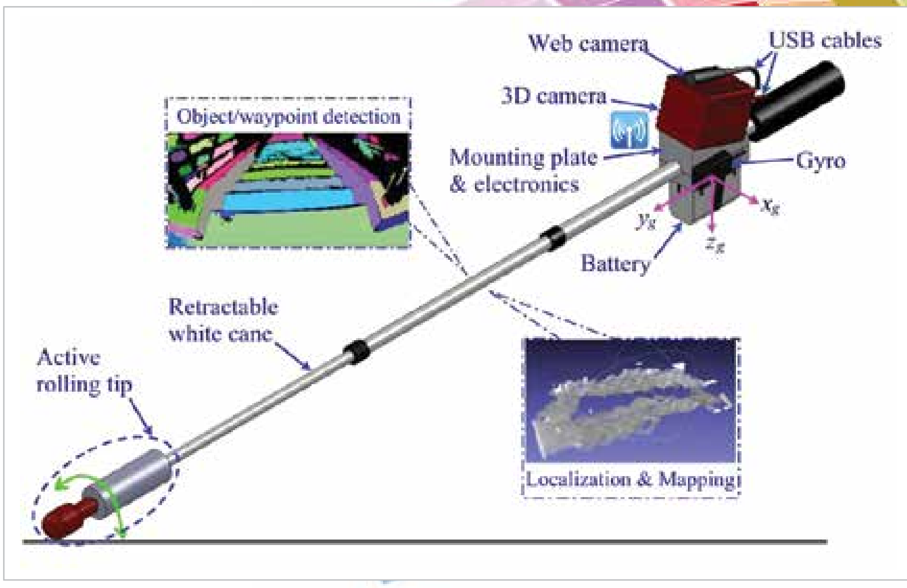
Photographs showing HARV instrument (A), photomicrograph showing HUVECs on beads (B) and Trypan blue assay showing microgravity enhances radiation-induced cell killing (C).

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

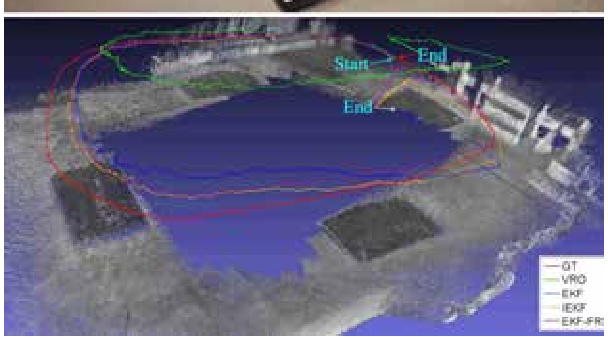
AR

New Computer Vision Methods for NASA Robotic Planetary Exploration

University of Arkansas at Little Rock/NASA Human Exploration & Operations Mission Directorate, OCT, Science Mission Directorate

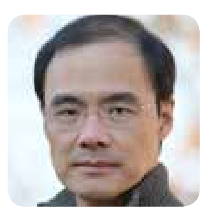


Concept image of the co-robot cane: the computer vision methods allow the robot cane to localize itself, map the environment in 3D, and detect objects and obstacles for wayfinding.

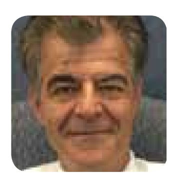


Experimental results: Robot trajectories estimated by the 3 methods on indoor mock terrain (experiment 6). Sand bags are placed on the ground and covered by outdoor mats to create mock terrain.

The research results from the NASA EPSCoR project in robotic navigation have been applied to 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, device pose estimation and 3D object detection, are the spin offs of the NASA EPSCoR research. Dr. Ye received a research grant from the NIH through the National Robotics Initiatives (NRI) program in 2013 to further develop the computer vision methods for reliable and real-time application in the co-robot cane. Recently, Dr. Ye has also extended the computer vision methods and applied them to a wearable assistive device that can guide a visually impaired person in grasping an object and a quadrupedal assistive robot that can assist an older adult in walking. He has been awarded two more NIH grants in 2015 from the NRI program to develop the two assistive robotic devices. The NASA EPSCoR project has made positive impact on robotic assistive technology that has potential in improving the quality of life of people with visual/physical disabilities.



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



Dr. Ali Shaykhian, Ph.D.
NASA Technical Monitor
Kennedy Space Center

http://sun0.cs.uca.edu/~yusun/NASA%20Website/index.php

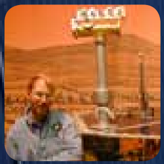
SiGeSn Based Photovoltaic Devices for Space Applications

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

In efforts to improving the conversion efficiency of PV solar cells, one road block is the losses due the imperfections in materials fabricated. In an ideal case, all the atoms in a solar cell material are perfectly aligned and there are no voids or extra undesired atoms in the material. Such imperfections so called "defects" become more prominent at the interface between two dissimilar materials. They behave like potholes on a road and slow down or stop the motion of electrons during their travel from where they are generated in the solar cell to the charge collectors. Therefore, interface defects are an important concern in attempts to enhancing the solar cell efficiencies. One solution is simply filling the potholes. Fortunately, a relatively recent atomic layer deposition (ALD) technique call allows the repair of those defects at atomic scales, which is called "surface passivation". Through a NASA funded project, researchers at University of Arkansas at Little Rock are working on the surface passivation of SiGeSn solar cells produces by their collaborators at University of Arkansas, Fayetteville. By this way, they aim to construct a smooth highway for the electrons.

Researchers Busra Ergul (PhD student, chemistry), Emad Badradeen (PhD student, physics), and Dr. Tansel Karabacak (Co-PI) at University of Arkansas at Little Rock are working on surface passivation of SiGeSn solar cells by atomic layer deposition (ALD) technique.

Science PI:
Shui-Qing Yu
University of Arkansas at Little Rock



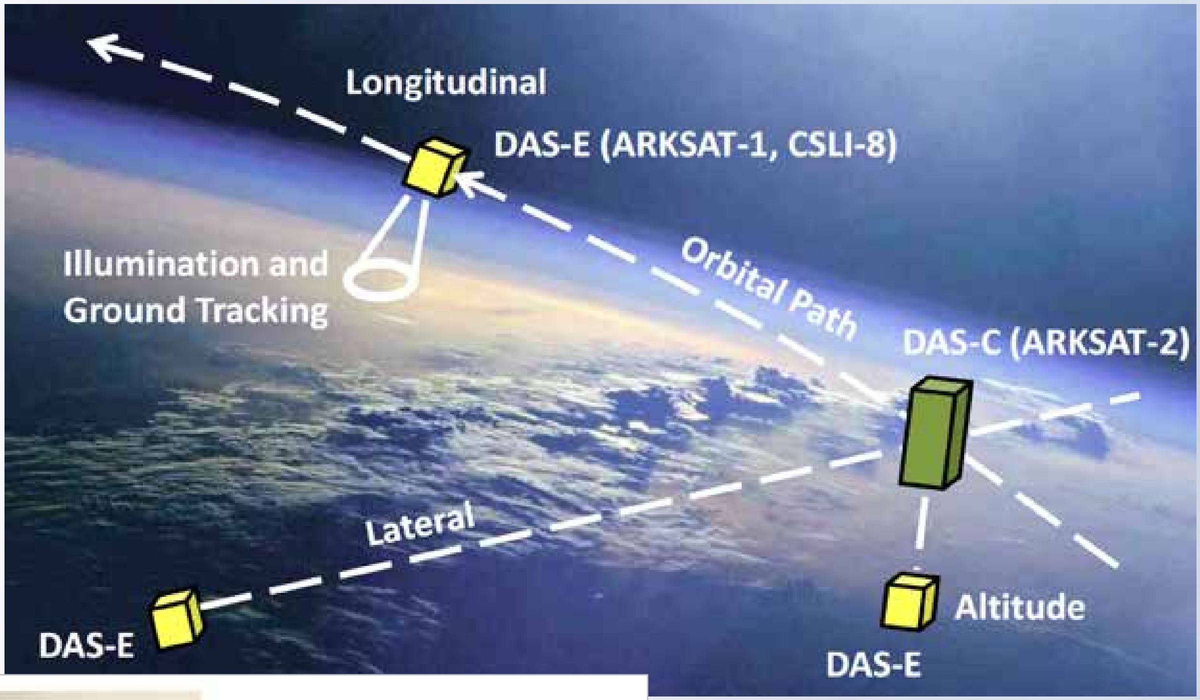
Dr. Geoffrey A. Landis
NASA Co-Technical Monitor
Glenn Research Center

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

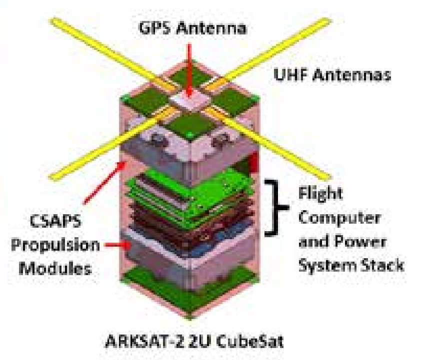
CubeSat Agile Propulsion Technology Demonstrator Mission (ARKSAT-2)

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

ARKSAT-2 is a 2U CubeSat propulsion technology demonstrator and a developmental subset of an innovative free-space spectrometer system using paired CubeSats in formation flight. The paired system is called the Diurnal Atmospheric Surveyor CubeSats (DASCubes), where a light emitting DAS-E (Emitter;das-ee") is followed by a chasing DAS-C (Chaser; "dask"). The DAS-Cubes concept will enable exploring new space science missions such as compositions and dynamics of extraterrestrial atmospheres, asteroid dusts, comet trails, plumes and ejecta. An agile, low-cost, non-toxic, biocompatible, and non-pressurized micro-propulsion system (CubeSat Agile Propulsion System, CSAPS) for DAS-C is currently being developed at the University of Arkansas-Fayetteville (UAF). The inspace demonstration and validation of this propulsion system forms the primary objective of ARKSAT-2. The secondary objective of the ARKSAT-2 will be on raising the TRL from 5 to 7 for the Solid State Inflation Balloon (SSIB) deorbit technology subsystem currently funded as part of STMD's Small Spacecraft Technology Program. The SSIB is a low cost, simple, and scalable deorbit technology designed for the entire range of small spacecraft (from 1U CubeSats to 180kg Microsats).



(Above) The Diurnal Atmospheric Surveyor CubeSats (DAS-Cubes) concept. The propulsion equipped 2U DAS-C chases light-emitting 1U DAS-E. The ARKSAT-2 will demonstrate the CubeSat Agile Propulsion System (CSAPS) designed for DAS-C operations.



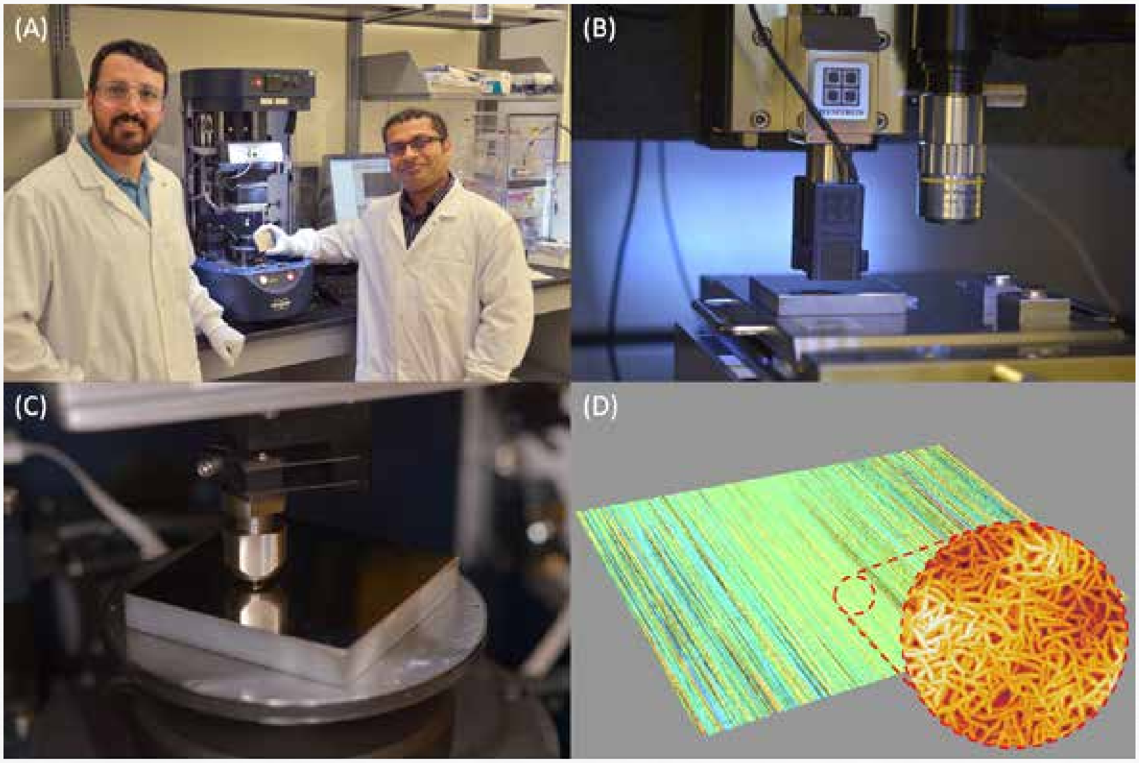
University of Arkansas, Fayetteville, Ph.D. student, John Lee, working on characterizing the thermodynamic properties of water-propylene glycol vapors for use as a non-pressurized cold-gas propellant for the ARKSAT-2's CubeSat Agile Propulsion System (CSAPS).

Science PI:
Po-Hao Huang
University of Arkansas, Fayetteville

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

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

University of Arkansas, Fayetteville/NASA Glenn Research Center, Science Mission Directorate



(A) Research Scientist Josh Goss and Postdoctoral Fellow Dipankar Choudhury in the lab, (B) Mechanical property characterization of Nitinol 60, (C) Tribological testing of Nitinol 60, and (D) 3D laser scanning microscope image of PTFE coated Nitinol surface (Inset: Atomic force microscope image of the surface.)

The goal of this project is to develop bio-inspired polytetrafluoroethylene (PTFE)-based solid lubricant coatings for 60NiTi (NITINOL 60) material. NITINOL 60 is currently under extensive evaluation at NASA due to its unique combinations of physical properties that make it very desirable for NASA's space mechanisms and aerospace applications. However, it has poor friction and wear performances in dry contact conditions. The proposed novel coatings consist of a bio-inspired polydopamine (PDA) adhesive under-layer and a PTFE or a mixed PTFE and graphite solid lubricant top-layer. The coatings are expected to reduce the friction of the NITINOL 60 material by over 85% and its wear rate by 50% during dry contact conditions to meet a range of NASA's critical application needs. Specifically, the novel coatings will enable NITINOL 60 ball bearings and timing gears to be developed for use in the water recovery system of the International Space Station (ISS) to combat current issues with these tribological components.

Dr. Min Zou
Science PI
University of Arkansas, Fayetteville

NASA Technical Monitor:
Dr. Samuel A. Howard
Glenn Research Center-LMT0

Guam Research Infrastructure Development

By John Peterson, PhD

Sokehs Rock on the Island of Pohnpei in the Federated States of Micronesia is a prominent feature seen from the open ocean and aided traditional navigators as they approached Pohnpei. Sokehs Rock is near a significant fish spawning site for grouper, an important reef fish throughout tropical coral reefs around the world (REF). Dr. Douglas Comer and Dr. John Peterson co-lead an exploratory NASA EPSCoR – University of Guam expedition to establish potential ground-truthing stations along the Pohnpei shoreline to correlate with imagery from NASA PRISM, Synthetic Aperture Radar (SAR), and other remote sensing platforms. The research supports the GIS@CIS center at University of Guam along with ocean and coral reef research of the UOG Marine Laboratory in Guam. This research will further an understanding of how ocean currents, erosion and sedimentation in the reefs and changing ocean temperatures and chemistry impact fish spawning aggregations that can provide data for managing ocean fishery resources. For NASA and the Jet Propulsion Laboratory the research contributes to geospatial analysis using NASA and other imaging platforms that in turn will be focused on planets and extraterrestrial bodies in the coming years of space exploration.

Dr. Douglas Comer off Sokehs Rock in Pohnpei Federated States of Micronesia for the University of Guam NASA EPSCoR research program. Photo taken by Dr. John Peterson.

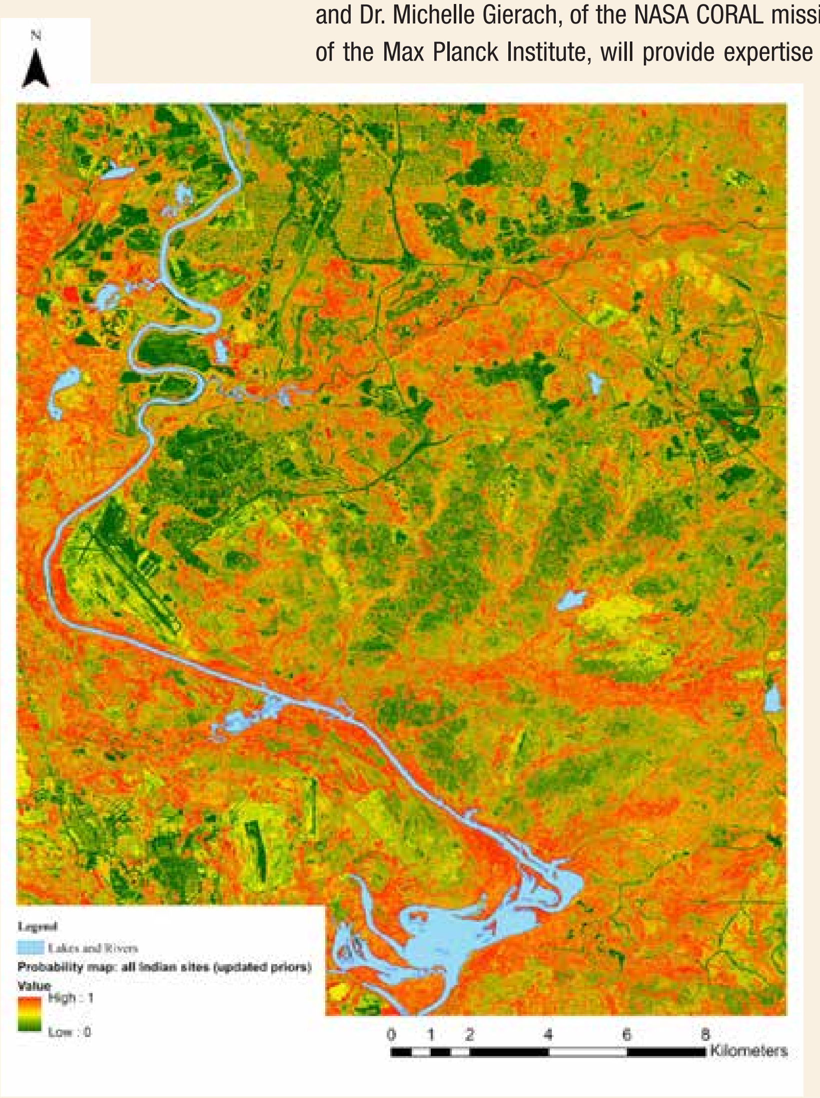
Dr. John Peterson, PhD
GU EPSCoR Director
University of Guam

GU

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

University of Guam, Science Mission Directorate, NASA's Jet Propulsion Laboratory

The University of Guam is at the cusp of a rapid expansion of capacity for scientific research, especially in the areas of marine and geospatial studies. The recent award of a $6 million National Science Foundation EPSCoR program and a NASA EPSCoR Research Infrastructure Development grant provide the focus and the resources to build cyberinfrastructure, STEM education capabilities, workforce development, and coral reef genomic research. For the proposed project, UOG will collaborate with JPL scientists and associates with expertise on NASA science technologies and missions. Dr. Bruce Chapman, of the Radar Science and Engineering Section, and Dr. Ben Holt, of the Ocean Circulation and AirSea Interaction group, will guide the application and analysis of SAR data for understanding landscape change, erosion, and oceanic dynamics. Leo Cheng, a Physicist and JPL Systems Engineer raised on Guam, will perform technical management and educational outreach. Dr. Eric Hochberg and Dr. Michelle Gierach, of the NASA CORAL mission, and Dr. Arjun Chennu and Dr. Joost den Haan, of the Max Planck Institute, will provide expertise on imaging spectroscopy and its use in studying coral reefs and coastal ecosystems. Dr. Douglas Comer, University of Guam Adjunct Professor and Director of CSRM Foundation, will coordinate the engagement of UOG scientists with NASA JPL scientists and oversee the development of a reef fish spawning aggregation site predictive model. Dr. Tom Schils and Dr. Atsushi Fujimora, of UOG, will contribute to the Ocean Science proposed here, and Dr. Terry Donaldson, a UOG Marine Biologist, will serve as Sc-I.

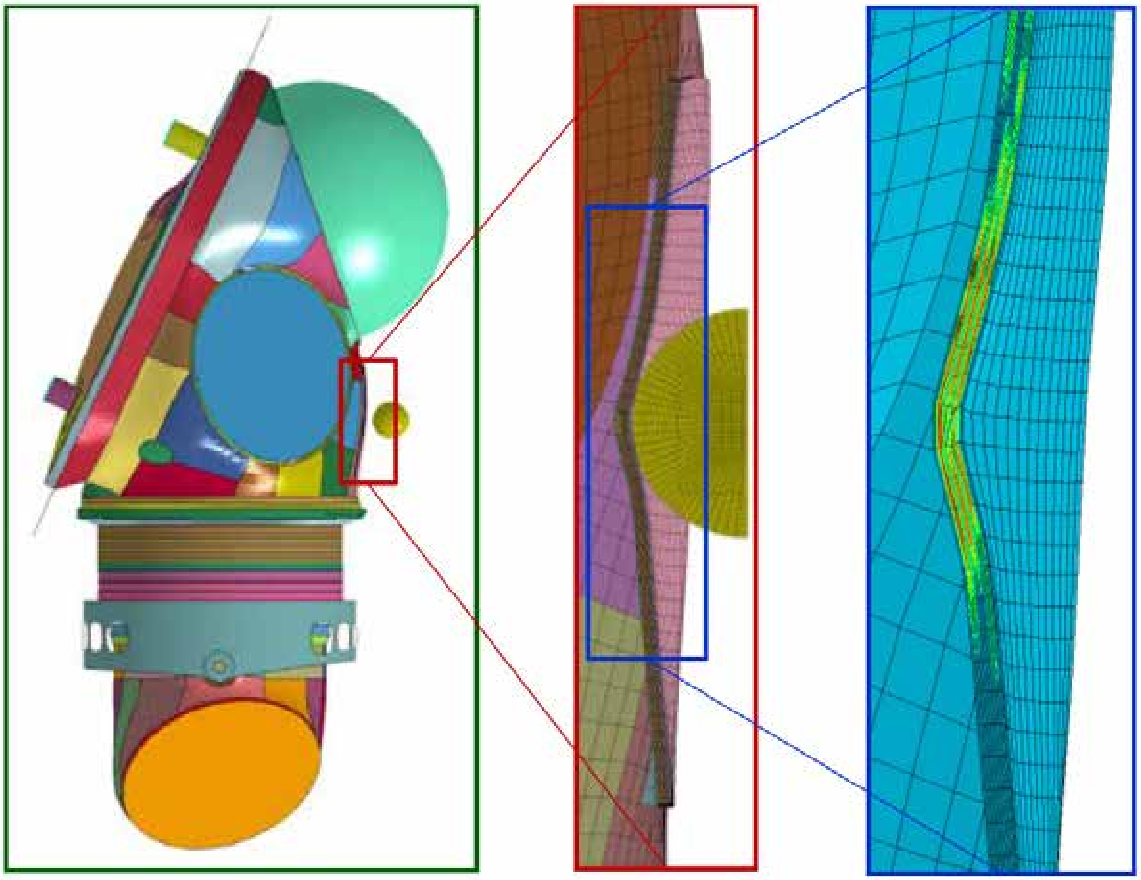


A probability map, which is among the data product types output by CSRM Foundation's predictive models for forecasting and finding areas of archaeological interest. Similar data products and visuals generated by the spawning site predictive model will be made publicly available by GEOCORE.

Terry Donaldson
Science PI
University of Guam

Leo Y. Cheng
NASA Technical Monitor
Jet Propulsion Laboratory

Delaware Research Infrastructure Development



Local-Global Impact Analysis Method for Space Suit Composite Components.

Impact Damage Modeling of Hybrid Composites for Space Applications

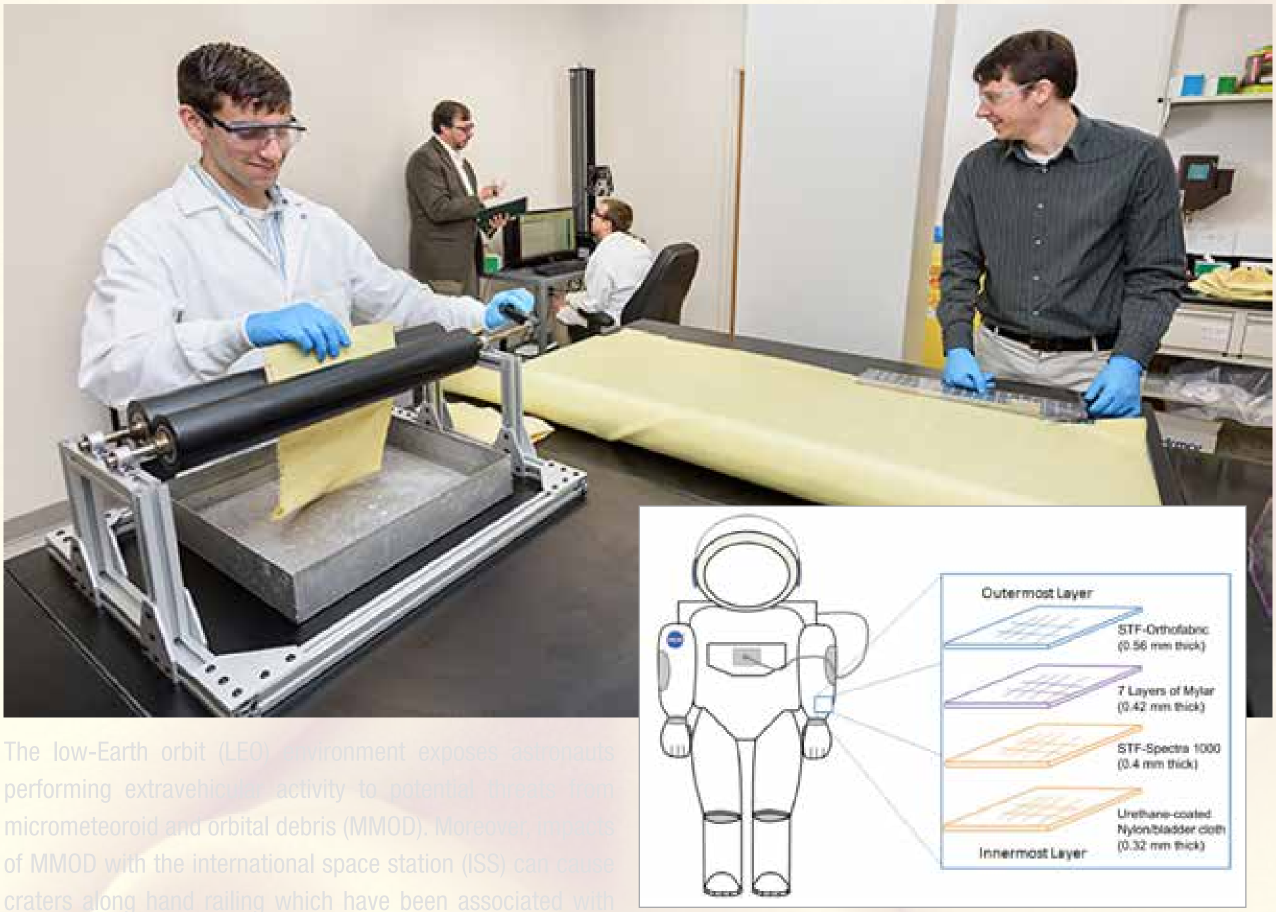
A reverse impact modeling methodology is developed to design composite space suit with internal pressure. A global-local analysis method using local 3D solid elements and MAT162 composite damage model for the impact zone, and global shell elements have been used. The local 3D analysis can capture the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

William H. Matthaeus
DE EPSCoR Director
University of Delaware

DE

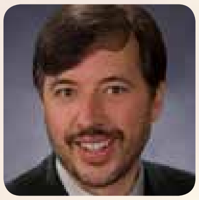
Improved EVA Suit MMOD Protection Using STF-Armor™ and Self- Healing Polymers

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



The low-Earth orbit (LEO) environment exposes astronauts performing extravehicular activity to potential threats from micrometeoroid and orbital debris (MMOD). Moreover, impacts of MMOD with the international space station (ISS) can cause craters along hand railing which have been associated with recent incidents damaging the astronaut gloves. In this research, we are developing advanced nanocomposite textiles based on STF-Armor™ to improve astronaut survivability. The aim of these investigations is the incorporation of the STF technology to improve the protection of astronaut EPGs capable of withstanding extended exposure to the space environment during multiple extravehicular activities. A hypodermic needle puncture test is used to simulate the threat posed by damaged surfaces. STF-ArmorTM-treated spacesuits are two times more resistant to puncture than the current TMG, without sacrificing weight and thickness of the spacesuit.

The longevity and robustness of STF-ArmorTM spacesuit materials in LEO are scheduled to be tested in the forthcoming Materials International Space Station Experiments, MISSE-9, which be delivered to the ISS by SpaceX, resupply mission SpX-13, manifested to be launched in late 2017. The samples will be exposed to extreme levels of solar- and charged-particle radiation, atomic oxygen, hard vacuum, and temperature extremes over the course of a year. The gathered data can be used to evaluate the proposed STF-ArmorTM materials for possible use in planetary exploration beyond Earth such as NASA's mission to Mars.



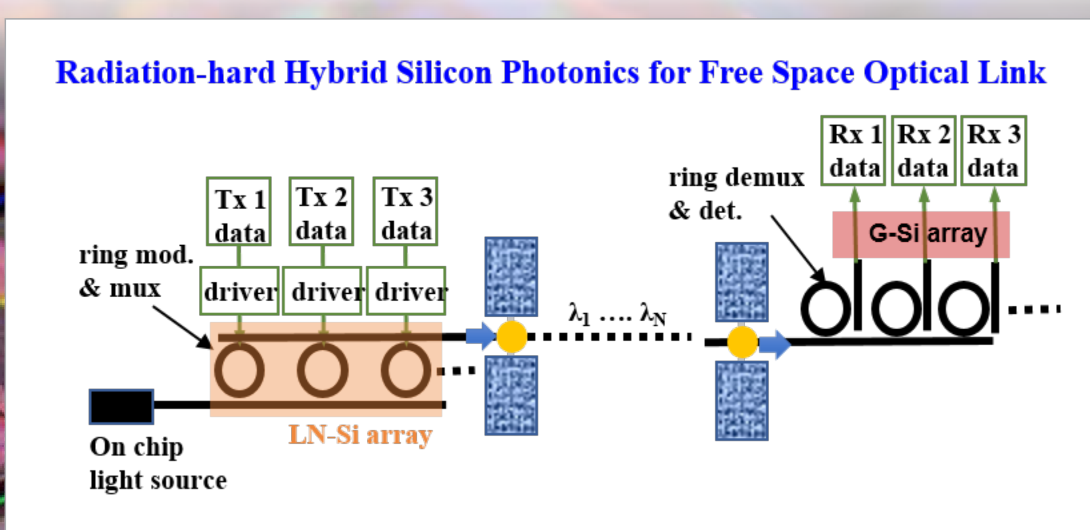
Prof. Norman J. Wagner
Science PI
University of Delaware

Willie Williams
NASA Technical Monitor
Johnson Space Center

http://sites.udel.edu/wagnergroup/

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

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



Free space optical (FSO) communication holds significant promise for use in space due to its large bandwidth, high data rate, easy deployability, low power, and low mass. An optical carrier in the visible band could be used to establish ground-to-satellite or satelliteto- satellite links. Silicon offers high yield, high density, and low optical loss, and compatibility with CMOS electronic systems. The speed of the photonic circuits would be further enhanced by single atomic layer of graphene, which could increase optical absorption and improve electrical conductivity (compared to monolithic silicon structures). Silicon photonic integrated circuits have already been implemented for 100 Gbps of telecommunication bandwidth, and the addition of graphene may allow Terahertz bandwidths.

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

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

Through an established collaboration with Bell Labs Nokia, we hope to further develop graphene-based integrated silicon nanophotonic circuits for use in space applications. Solid state photonic/electronic devices perform stably in vacuum. Nevertheless, the performance of such devices in microgravity and with the extreme radiation exposure of space has not yet been evaluated.

Therefore, we propose a project to evaluate the potential use of advanced integrated graphene-silicon photonic circuits as part of a space-based FSO system. The miniaturized on-chip photonic circuits can be assembled into a 1U CubeSat for radiation test on Materials on the International Space Station Experiment (MISSE). This will allow us to establish how much radiation shielding they require and how the nanoscale design of the circuits can be adjusted to better function in a high-radiation environment.

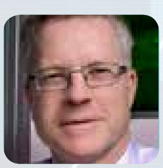
This project relates directly to multiple areas laid out in the NASA Technology Roadmap: in particular, TA 5.1 ("Optical Communications and Navigation") and TA 12 ("Materials, Structures, Mechanical Systems and Manufacturing"). Additionally, this project complements ongoing projects at NASA such as the Optical Payload for Lasercomm Science (OPALS) and the Laser Communications Relay Demonstration (LCRD).

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

Delaware State University, Science Mission Directorate, Goddard Space Flight Center, Science Technology Mission Directorate

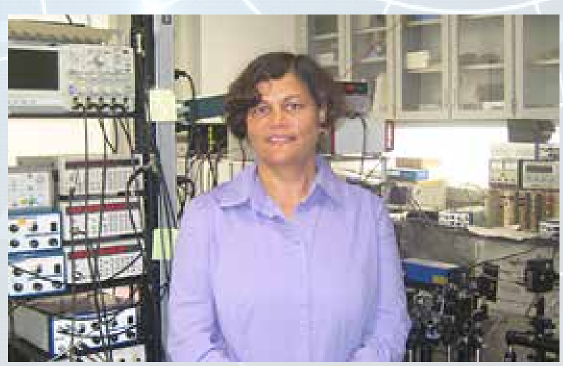
This proposed research will create a unique technological advancement capability for remote magnetic field measurement which is of significant relevance to NASA Science Mission Directorate (SMD) and Science Technology Mission Directorate (STMD). DSU Science team of this project will collaborate with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

(Left) Table-top SFG laser system, and (Right) laser launch at Caltech Palomar observatory.



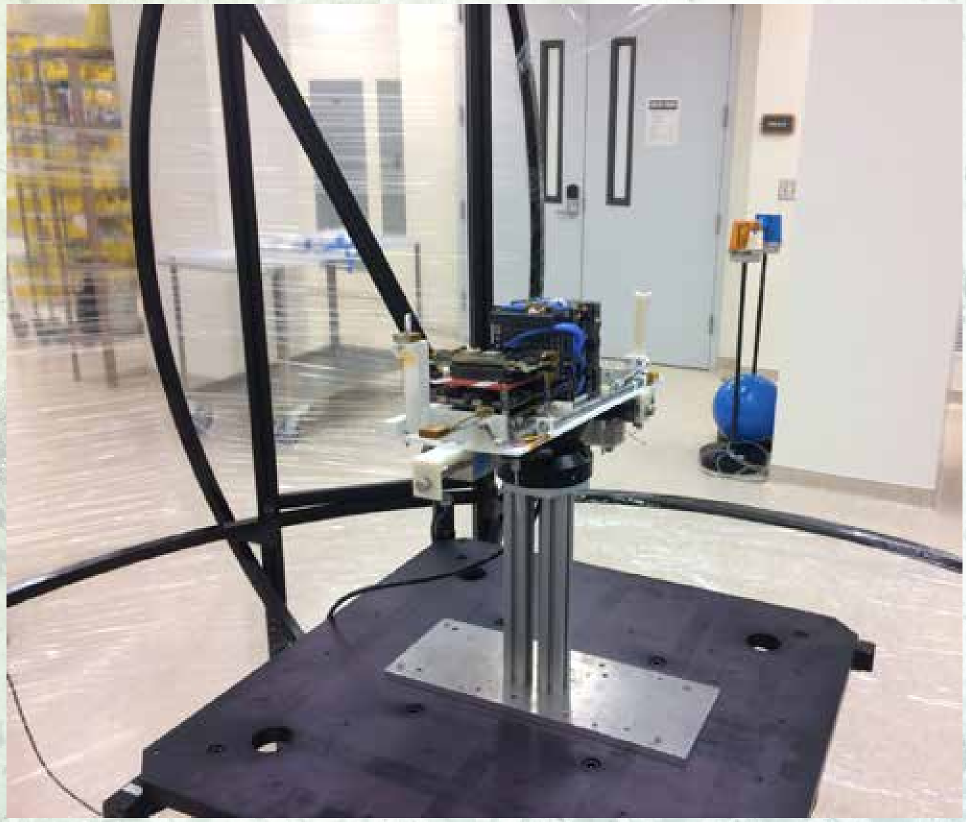
NASA Co-Technical Monitor
Dr. Michael A. Krainak
Glenn Space Flight Center

NASA Co-Technical Monitor
Dr. Anthony Yu
Glenn Space Flight Center



Prof. Renu Tripathi, Science PI, in research lab.

Hawai'i Research Infrastructure Development

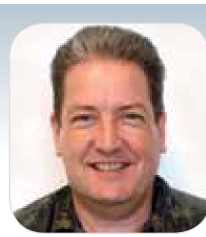


NASA EPSCoR RID funds were used to upgrade the Hawaii Space Flight Laboratory Attitude Determination and Control Test Facility to allow for testing of CubeSat ADCS components.

The Hawaii Space Flight Laboratory (HSFL) upgraded its Astrofein Attitude Determination and Control Test Bed with the help of NASA EPSCoR RID funding. The Astrofein ADCS unit in Hawaii is one of only three in the world and offers state-of-theart testing for satellites with masses up to 100 kg. The ADCS unit simulates the magnetic field and other phenomena experienced by small satellites orbiting the Earth. With ESPCoR RID funded modifications, the ADCS test bed now has the sensitivity to test smaller satellites down to CubeSat size. Situated on the test bed is one of HSFL's next satellites – Neutron-1, which will be flown next year as part of NASA's CubeSat Launch Initiative program. Under the direction of HSFL engineers, undergraduate research assistants designed and constructed modifications for the test bed.

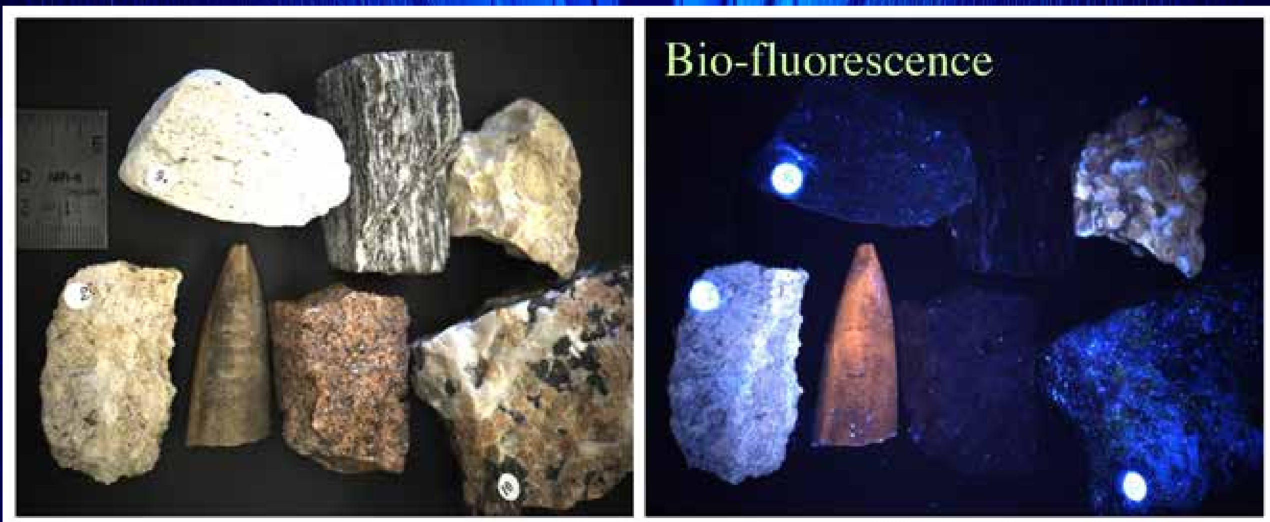
https://www.hsfl.hawaii.edu/
https://www.hawaii.edu/news/2017/03/07/project-imua-team-looking-forward-to-third-rocket-launch/

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



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

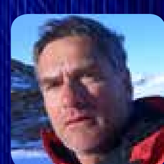
University of Hawai'i/NASA Goddard Space Flight Center, Ames Research Center, Jet Propulsion Laboratory, Science Mission Directorate, Space Technology Mission Directorate



Fast (0.1 second) remote detection of all biological materials in a collection of fossils and rocks using "color standoff biofinder" from 50 cm distance using one laser shot.

University of Hawaiʻi researchers have developed two laser based instruments for remote detection of present or past life on outer planets with funding from NASA. A new instrument knows as "Standoff Biofinder" can quickly detect the presence of biological materials in a large area using bio-fluorescence signals. The standoff biofinder can be operated at video speed to provide live images of biological materials in a large geological area. The standoff biofinder is expected to significantly accelerate NASA's "search of life" mission on outer planets and was featured in a NOVA next 2016 article. The second instrument developed is a compact remote chemical analyzer; a compact system capable of performing remote chemical analysis of a target from several meter distance using Raman, LIBS and fluorescence spectroscopies. This system will be suitable for future NASA planetary exploration missions for detection of biological materials, bio-markers, minerals, water-containing minerals, organics and water. The researchers have built systems which can perform chemical analysis of targets from a distance of few meters to hundreds of meters in daytime with fast detection time of few seconds using a green pulsed laser. The University of Hawaiʻi has collaborated with NASA AMES and NASA Langley Research Centers, and Los Alamos National Laboratory for this effort. Two of the researchers funded by this EPSCoR program were selected to be team members for the upcoming NASA's Mars 2020 mission for developing the "SuperCam" instrument in collaboration with LANL. The State of Hawaiʻi, typically known for its tourism industry, is systematically opening doors for space science and high tech industry. Under this EPSCoR project students were educated and trained to develop new laser based instruments for remote active sensing.

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



Dr. Chris McKay
NASA Technical Monitor
Ames Research Center

http://thinktechhawaii.com/

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

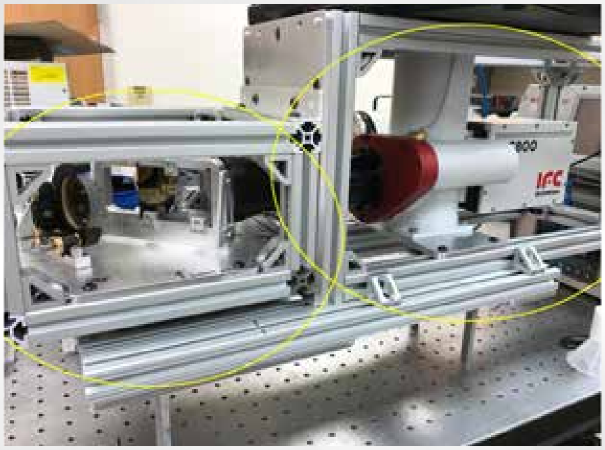
Hawai'i Institute of Geophysics and Planetology, University of Hawai'i at Manoa

The purpose of the project is to develop a miniaturized instrument for the detection of gases (primarily methane and carbon dioxide), using a Sagnac interferometer and a mid-wave infrared (i.e. 3-5 µm) detector array. An uncooled and a cooled MWIR detector will be compared to establish whether the extra sensitivity afforded by the cooled detector is necessary to detect and quantify atmospheric gas absorption/emission features. The instruments will be tested in i) the laboratory using gas cells filled with calibration gases of known concentrations, and ii) in the field over sites of known CH_4 emission.

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

Dr. Anthony Colaprete
NASA Technical Monitor
Ames Research Center

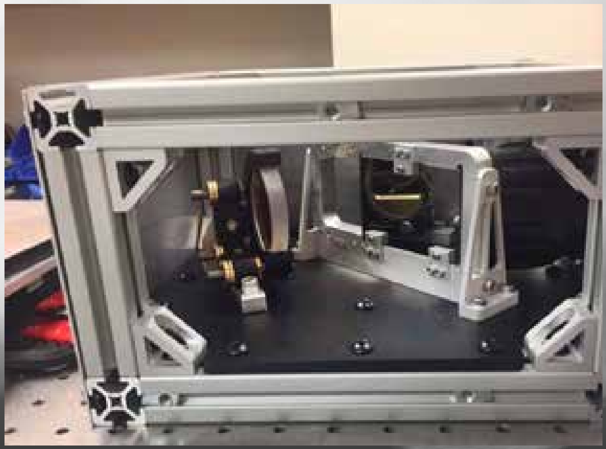
The first instrument (using the cooled InSb detector) is below:



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

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

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

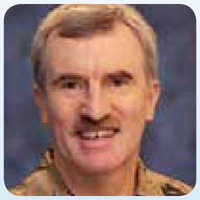


Side view. The aperture is on this side of the instrument.

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

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

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



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

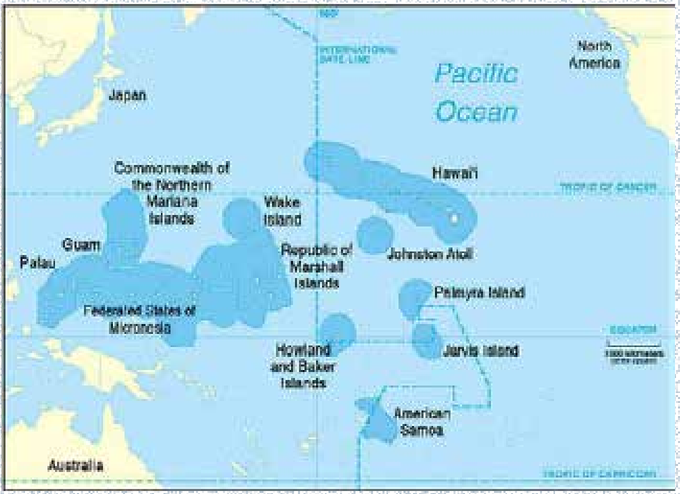
Dr. Matthew Fladeland
NASA Ames Research Center
Earth Science Division

Since 2008, an active lava lake at Halemaumau Crater within Kilauea caldera has been emitting ~1,500 – 2,000 tonnes of sulfur dioxide each day. These emissions have a significant impact on the area downwind, and have health implications for local residents. Plumes of volcanic gases ("vog") can extend all the way to Oahu. Our UAV studies focus on the development and flight of sensors to measure both the sulfur dioxide and the aerosols created by this eruption. Photo credit: Pete Mouginis-Mark, Univ. Hawai'i.

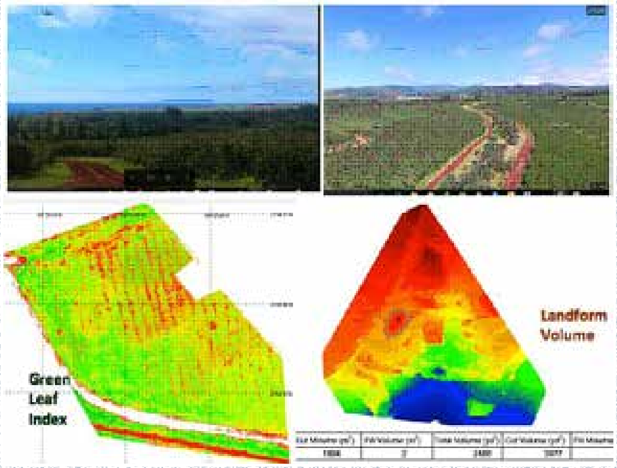
Autonomous Control Technology for Unmanned Aerial Systems with Agricultural and Environmental Applications in Central Pacific Islands

University of Hawai'i, Honolulu, Maui, Lanai and Kauai Islands of the State of Hawai'i, the College of Marshall Islands and the University of Guam/NASA Aeronautics Research Mission Directorate and Science Mission Directorate

The goal of this project is to create a real-time and autonomous control technology for unmanned aerial systems with agricultural and environmental applications in Central Pacific Islands. To achieve the proposed goal, the objectives are (1) to create and validate integrated targeting, guidance, navigation and control (TGNC) framework and software algorithms for an onboard implementation, and (2) to develop and disseminate educational courses and outreach activities in the design and development of unmanned aerial systems (UASs) with applications to Earth sciences in the Central Pacific Islands. These objectives are accomplished by the following research and educational tasks:

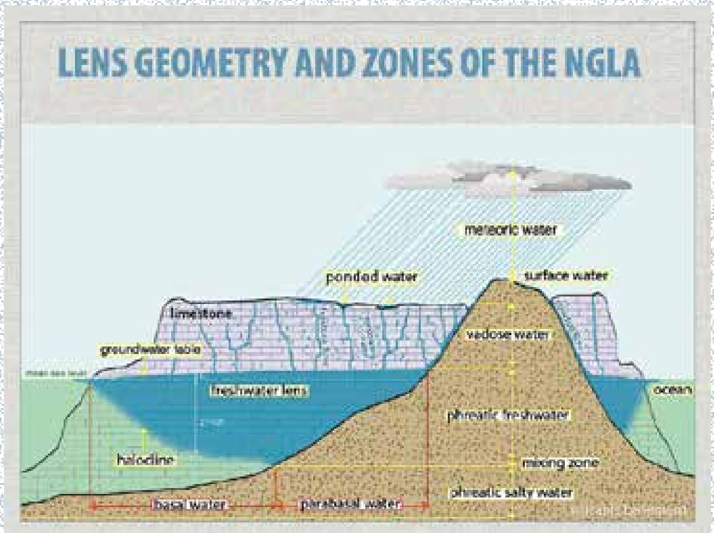


Map of Hawai'i and US Affiliated Pacific Islands.



Utility of UAS in "Kauai Coffee" field.

1) Demonstrate and simulate new analytical and/or numerical trajectory and attitude solutions, and an autonomous and target-relative guidance scheme utilizing the instantaneous screw motion (ISM) invariants to perform various maneuvers and tasks of interest; 2) Establish a new, high- fidelity computational framework of a hierarchical mixture of experts (HME) utilizing a new sensor data fusion technology to obtain real-time navigation solutions; 3) Integrate TGNC framework and software algorithms for agricultural and environmental applications in the Central Pacific Islands, namely the Hawai'ian Islands Oahu, Maui, Lanai and Kauai, and in Marshall Islands and Guam; and 4) Develop and disseminate educational curriculums for courses in flight dynamics and control, and in UAS design and development for the Earth sciences applications, including the proposed agricultural and environmental applications.



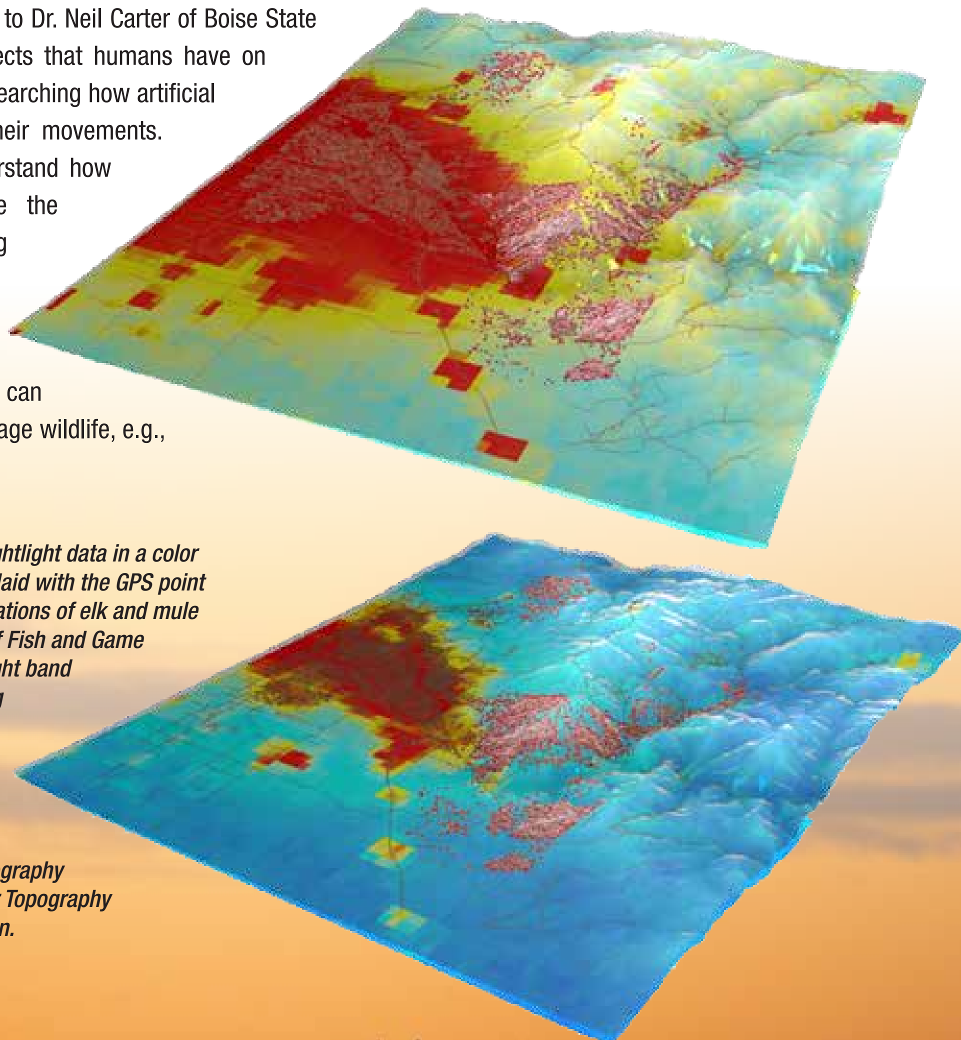
Schematic cross section of the NGLA. (http://north.hydroguam.net/illustr/).

Science PI
Dr. Dilmurat M. Azimov
University of Hawai'i, Honolulu

Dr. Corey A. Ippolito
NASA Technical Monitor
Ames Research Center

Idaho Research Infrastructure Development

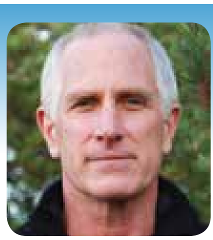
A new research initiation grant awarded to Dr. Neil Carter of Boise State University seeks to understand the effects that humans have on wildlife outside of cities. Dr. Carter is researching how artificial light from cities affects wildlife and their movements. Dr. Carter uses NASA imagery to understand how human and natural factors influence the habitat of wildlife species that live along a growing wildland-urban interface, such as in Boise. Together with state partners, Idaho Department of Fish and Game, Dr. Carter and team can investigate these effects and better manage wildlife, e.g., elk and mule deer.



This 3D image of eastern Boise showing nightlight data in a color palette from low (blue) to high (red), is overlaid with the GPS point locations of elk and mule deer. The GPS locations of elk and mule deer were collected by Idaho Department of Fish and Game from 2012 - 2015. Color images are day-night band (DNB) data from the Visible Infrared Imaging Radiometer Suite (VIIRS) aboard the Suomi National Polar-Orbiting Partnership. In the darker blue image, the VIIRS-DNB data is log transformed and in the other image the VIIRS-DNB data has not been log transformed. Also, 3D topography is based on data from NASA's Shuttle Radar Topography Mission. Road data from USGS is also shown.

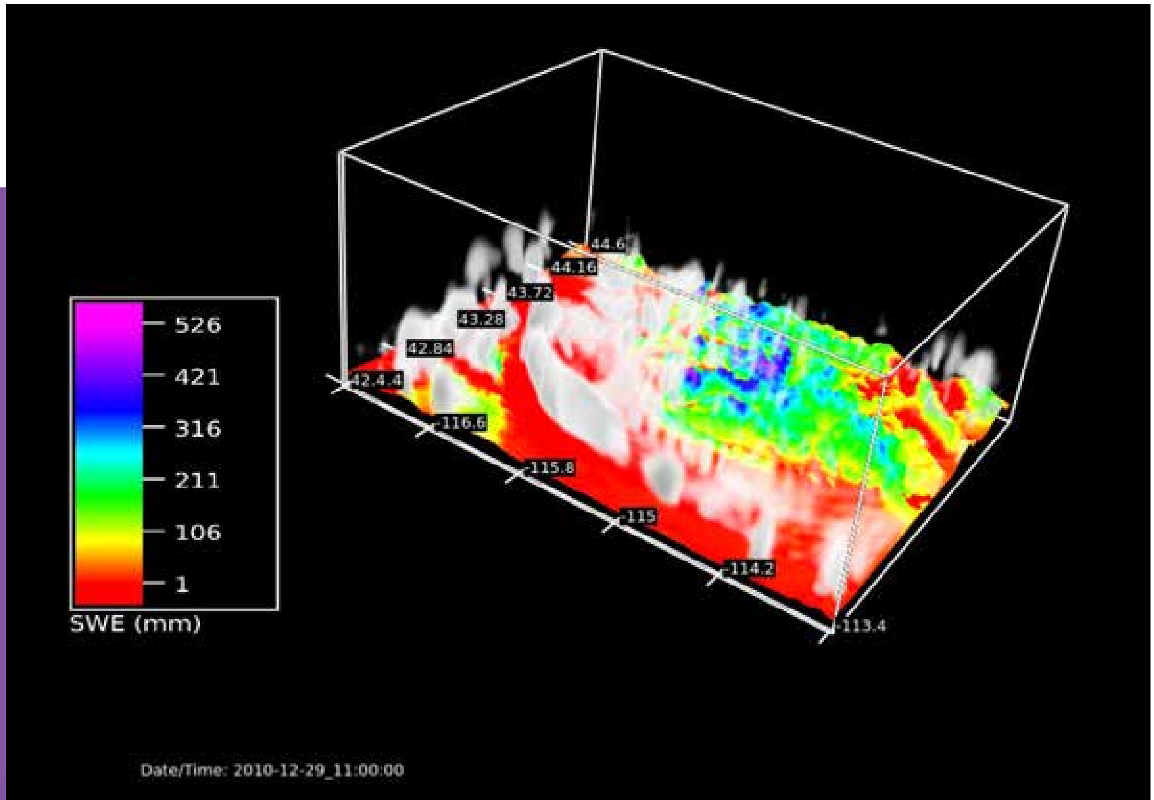
https://www.idahonasaepscor.org/

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



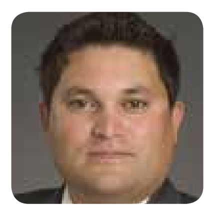
Monitoring Earth's Hydrosphere: Integrating Remote Sensing, Modeling, and Verification

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



A simulation of atmospheric water vapor content and simulated snow water equivalent on December 29, 2010 over southern Idaho from a high-resolution regional climate model.

Researchers at Boise State University are using NASA data and advanced models to make better predictions of weather, climate, and water resources in mountain landscapes of the world. Mountainous watersheds, where winter snowfall dominates yearly precipitation, are often referred to as the "water towers of the world" because they store water as snow that supplies cities and farms during hot, dry summers. These regions are often sparsely observed because they are rugged. Data from NASA satellites and advanced prediction models are critical to making better predictions of snowfall and snowpack volumes for water supply and documenting how they are changing as the climate warms. Using Idaho as a testbed, these researchers are applying regional climate and weather models to make predictions of precipitation, temperature, winds, and other climate variables at spatial scales that are significantly finer than available global products. They are simultaneously developing better algorithms to extract information about snowpack and vegetation characteristics from NASA remote sensing data and innovating less expensive sensor networks to measure these variables on the ground. This research will fundamentally advance in the modeling and remote sensing of the world's water towers and lead to more reliable predictions in the future.

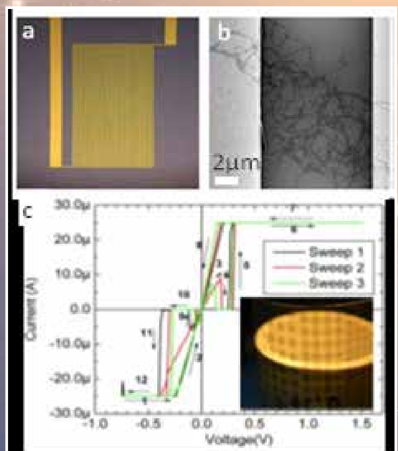


Dr. Alejandro N. Flores
Science PI
Boise State University

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

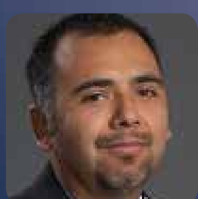
Space-Grade Flexible Hybrid Electronics

University Of Idaho, Moscow/NASA Space Technology Mission Directorate & Human Exploration & Operations Mission Directorate

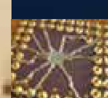


NASA Ames CNT and Boise State ChG sensors. a) Optical image and b) SEM image of CNTbased gas sensor with >100 ppm sensitivity to various trace gases. c) Optical image of ChG radiation sensors, d) I-V response of ChG radiation sensors vs. dose.

The intersection of additive manufacturing and nanotechnology stands to transform the way NASA approaches its mission of advancing science, technology, aeronautics, and space exploration. The ability to manipulate matter at the nanoscale enables the bottom-up design of innovative nanomaterial based sensors, which benefit from unique properties such as high surface area to volume ratio and tunable transport processes. The ability to print nanomaterials using additive manufacturing techniques highlights a path towards the digital design and in-space manufacturing of mission specific sensors. Our vision is to leverage the unique physical properties of nanomaterials to create a new design paradigm for space-grade flexible hybrid electronics (FHE) sensor systems, and build a light, flexible, and self-sustaining multifunctional sensor in accordance with performance goals outlined in NASA's Space Technology Roadmap. Printed carbon nanotubes, polymer brushes, chalcogenide glasses, and thermoelectric nanomaterials will be combined with flexible silicon integrated circuits and wireless communications hardware to create a flexible multifunctional sensor node capable of transmitting real-time sensing data for trace gas vapors and exposure to radiation. To ensure project success the PI and SI have composed a team of experts in nanomaterial design, synthesis, and characterization; as well as industry partner American Semiconductor, Inc., a global leader in the manufacture of flexible silicon integrated circuits. Additional partnerships with Ames Research Center, Johnson Space Center, Marshall Flight Space Center, Air Force Research Laboratories, and PakSense/Emerson will help guide project progress towards NASA's performance goals and translation of sensor technology into the defense and consumer electronics industries. Integrating our nanomaterials with advanced manufacturing techniques and flexible silicon integrated circuits extends impact, potentially serving the public by providing a low-cost path towards large-scale manufacturing of nanomaterial-based sensors for agricultural technologies, human health monitoring systems, and aerospace sensors, all connected through the internet of things. Positioned in the Pacific Northwest near global and regional industry leaders, the proposed work will establish the foundation required to build a nationally and internationally recognized center for flexible hybrid electronics technologies, thus significantly enhancing research capacity and competitiveness in the Idaho EPSCoR jurisdiction.



David Estrada
Science PI
Boise State University



Jessica Koehne
NASA Technical Monitor
NASA Ames Research Center

Kansas Research Infrastructure Development

The NASA EPSCoR SRI projects have resulted in two (2) new proposals, with one (1) being funded. Five (5) faculty members and nineteen (19) students worked on these projects. Six (6) collaborations were made with NASA centers, and one (1) was established with a local high school. Dr. Cluff had great success with his NASA EPSCoR SRI titled “Bone Health Sensor for Monitoring Early Onset of Osteoporosis Due to Spaceflight” which led to one new funded proposal, one patent awarded, and numerous publications. Through the collaborations established during the project, Dr. Cluff identified several new possible project topics which could lead to new work in the future.

The NASA EPSCoR PDG awards resulted in seven (7) faculty members and eight (8) students working on these projects. Five (5) collaborations have been established. The work led to two (2) new proposals, one (1) of which was rejected and one (1) for which the decision is still pending. In addition, one NASA EPSCoR PDG resulted in the PI and Co-PI’s preparing to submit an application to be an early adopter of NASA’s upcoming SWOT and GRACE-FO missions.

The Kansas Board of Regents (KBOR) has continued to support the NASA EPSCoR RID program. The expectations are that the NASA EPSCoR RID program will have a positive economic impact leading to self-sustaining research infrastructure, in addition to workforce development.

L. Scott Miller
KS EPSCoR Director
Wichita State University

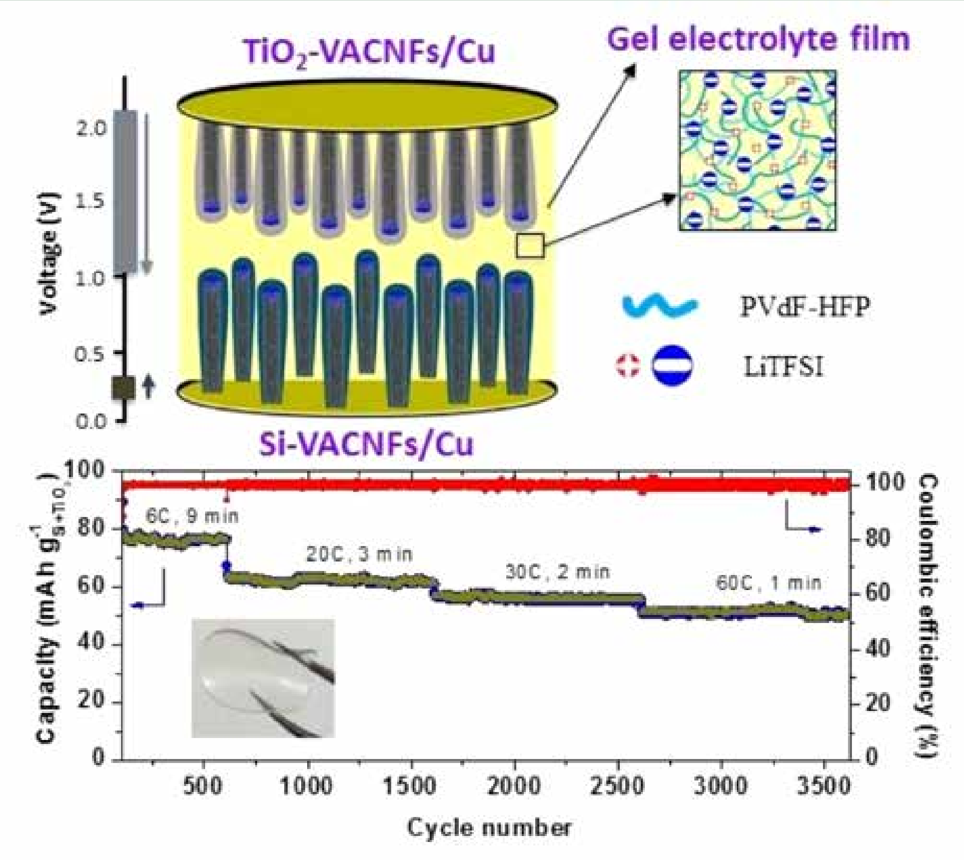
Nanostructured Solid-State Energy Storage Devices for Wide-Temperature Applications in Space Exploration

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

A novel solid-state battery-supercapacitor hybrid device is fabricated for high-performance electrical energy storage using nanostructured core-shell electrodes fabricated on vertically aligned carbon nanofibers (VACNFs) which serve as the current collector and structural template. The cell consists of a Si-coated VACNFs anode and a TiO2-coated VACNFs cathode, interfaced with a gel polymer electrolyte film. The nanostructured core-shell electrodes enable short Li-ion diffusion path and large pseudocapacitive contribution by fast surface reactions, leading to the hybrid features combining the merits of Li-ion batteries and supercapacitors, which provide high specific energy over a wide range of power rates. Due to the improved mechanical stability of the infiltrated composite structure, the hybrid cell shows excellent cycling stability and is able to retain more than 95% of the original capacity after 3500 cycles. More importantly, this solid-state device can stably operate in a temperature range from -20 to 60 oC with a very low self-discharge rate and an excellent shelf life. This solid-state architecture is promising for development of highly stable thin-film energy storage devices for unconventional applications requiring largely varied power, wider operation temperature range, long shelf-life and high safety standards (J. Power Sources 2017, 342, 1006-1016).

Dr. Jun Li
Science PI
Kansas State University

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



Schematic illustration of a thin-film solid-state full cell consisting of two nanostructured array electrodes, i.e. a Si-coated VACNFs anode and a TiO2-coated VACNFs cathode, interfaced with a gel polymer electrolyte and its remarkably high stability and power density over long charge-discharge cycles, showing the hybrid features of Li-ion batteries and supercapacitors.

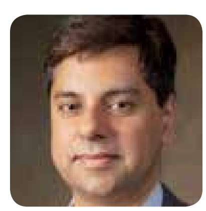
http://cusl.res.ku.edu/Research
http://www.ittc.ku.edu/cviu/tracking2.html

Active Wing Shaping Control for Morphing Aircraft

Wichita State University/Ames Research Center, Aerospace Research Mission Directorate

A prototype morphing UAV in the WSU Wind Tunnel.

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



Dr. Animesh Chakravarthy
Science PI
Wichita State University

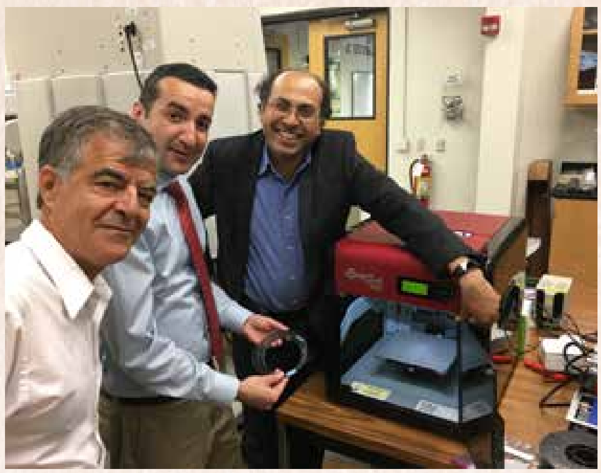
Dr. Nhan T. Nguyen
NASA Technical Monitor
NASA Ames Research Center

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

Wichita State University, Human Exploration & Operations Mission Directorate, Johnson Space Center, Langley Research Center, International Space Station

Subash Bhandari, an undergraduate research assistant in this work, created an RF skin patch sensor and is placing it on an arm.

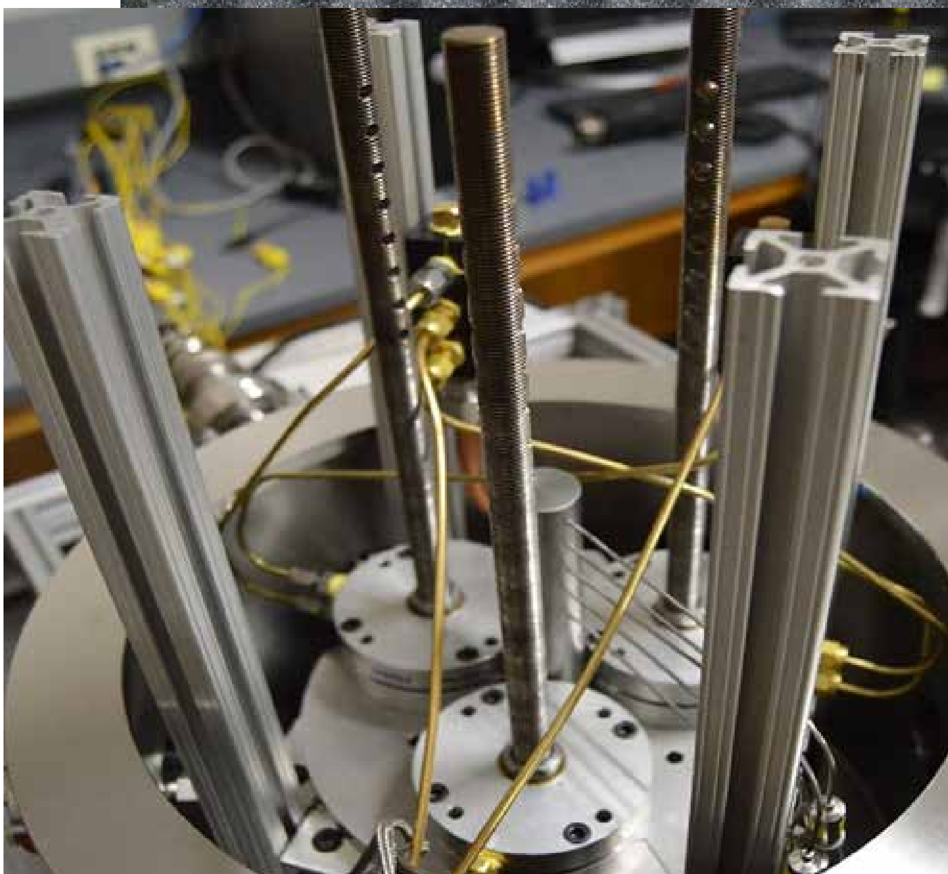
The long-term impact of this funding support is significant for the undergraduate research assistants, graduate students, and faculty here in Kansas. The student involvement in this work is inspiring them about science and biomedical engineering and motivating them to pursue STEM fields and graduate school. This research is providing a foundation for our students and faculty researchers to excel in scholarship, contribute to solving real world problems. Publications with the undergraduate student researchers and graduate students will have long-term effects in helping them to be competitive for graduate school and obtain scholarships. Our work addresses NASA research interests in wearable health monitoring systems to address the gaps and risks that are critical to crew health and performance during long duration space missions. Specifically, our research fits well with the directives of the National Space Biomedical Research Institute to develop Smart Medical Systems and Technology. We are developing a wearable skin patch to measure multiple physiological parameters in a single sensor which may provide a foundation for a novel strategy for monitoring mission critical crew health parameters in point-of-care fashion. Funding for this research has helped bring visibility to the high quality research being done in the Midwest at our University in Kansas.



NASA TM: Ali Shaykhian, KSC (foreground) Science-PI: Dr. Kim Cluff, Biomedical Engineering Department, Wichita State University, KS; Co-I: Dr. Anil Mahapatro, Dept. of Biomedical Engineering, Wichita State University, Wichita, KS (background)

Kentucky Research Infrastructure Development

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



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

Dr. Suzanne Weaver Smith
KY EPSCoR Director
University of Kentucky

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

As humans inhabit space for longer periods of time and prepare to explore Mars, critical safety challenges must be addressed. Important among these are effects of space radiation on the human body. Researchers at the University of Louisville are examining techniques for mitigating damage from exposure to space radiation through medical therapies that deliver radio-protective agents via precise methods of drug delivery utilizing nanotechnology. These drug delivery systems were tested at the NASA Space Radiation Laboratory against radiation in amounts experienced during space travel. Ensuring the safety of astronauts exposed to ionizing radiation beyond Earth's magnetosphere is a major technical challenge for NASA, with potential application to Earth-based situations such as nuclear power plant disasters.

Dr. Patricia Soucy
Science PI
Assistant Professor
University of Louisville

Research conducted under this grant has provided educational and research opportunities for Kentucky students at undergraduate, graduate, and post-doctoral levels in multiple disciplines at the University of Louisville. Due to the interdisciplinary nature of this research subject, students in bioengineering, pharmacology and toxicology, and chemistry have all participated. This advanced training has provided a stepping stone for students to receive internships at NASA Johnson Space Center, one of whom was selected for a National Space Biomedical Research Institute internship where he studied the effects of radiation on chromosomes.

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

Betty Nunn, Research Manager for the University of Louisville Biomimetics and Tissue Engineering Lab, spray dries particles loaded with radio-protective agents to minimize radiation induced cell and tissue damage.

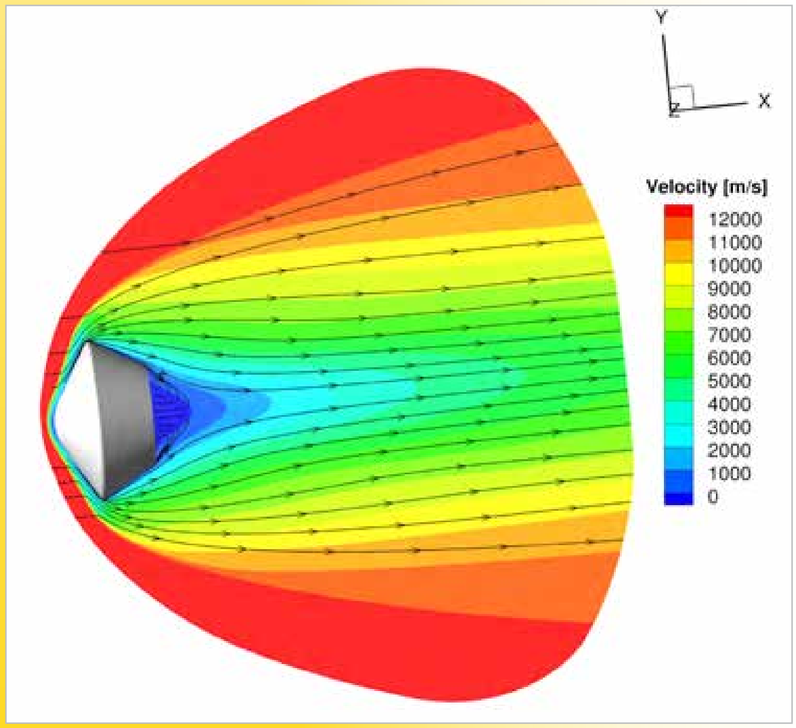
Improving Heat Shields for Atmospheric Entry: Numerical and Experimental Investigations for Modeling Ablative Thermal Protection System Surface Degradation Effects on Near-Wall Flow

Human Exploration & Operations Mission Directorate, Science Mission Directorate, Space Technology Mission Directorate/Langley Research Center, Goddard Space Flight Center, Marshall Space Flight Center, Ames Research Center, Johnson Space Center, University of Kentucky and Kentucky State University

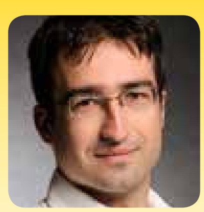
Two Kentucky universities recently conducted a study designed to improve performance of spacecraft heat shield materials. Heat shields, also known as thermal protection systems (TPS), enable spacecraft to survive the extreme temperatures of atmospheric entry. The project, titled "Improving Heat Shields for Atmospheric Entry: Numerical and Experimental Investigations for Modeling Ablative Thermal Protection System Surface Degradation Effects on Near-Wall Flow," helped to advance the technology of thermal protection systems 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 used numerical modeling combined with experimentation to develop computer simulation capability. The developed simulation code was optimized and validated with heat shield performance measurements conducted under simulated atmospheric entry conditions in a hightemperature arc-jet facility. Researchers at the University of Kentucky and Kentucky State University collaborating with multiple NASA Centers (Ames, Langley, and Johnson) 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 as well as follow-on research projects have resulted.

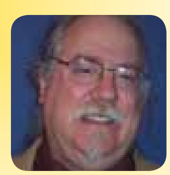
The material response (MR) code developed as part of this project is being used to investigate NASA test articles and performance of full-scale thermal protection systems, including for NASA's new crew vehicle Orion. GPU-processing techniques developed to run the code are advancing computer science programs at both participating Kentucky universities. Kentucky students who have completed or are on track to complete bachelor and graduate degrees have benetted 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.



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 Stardus 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



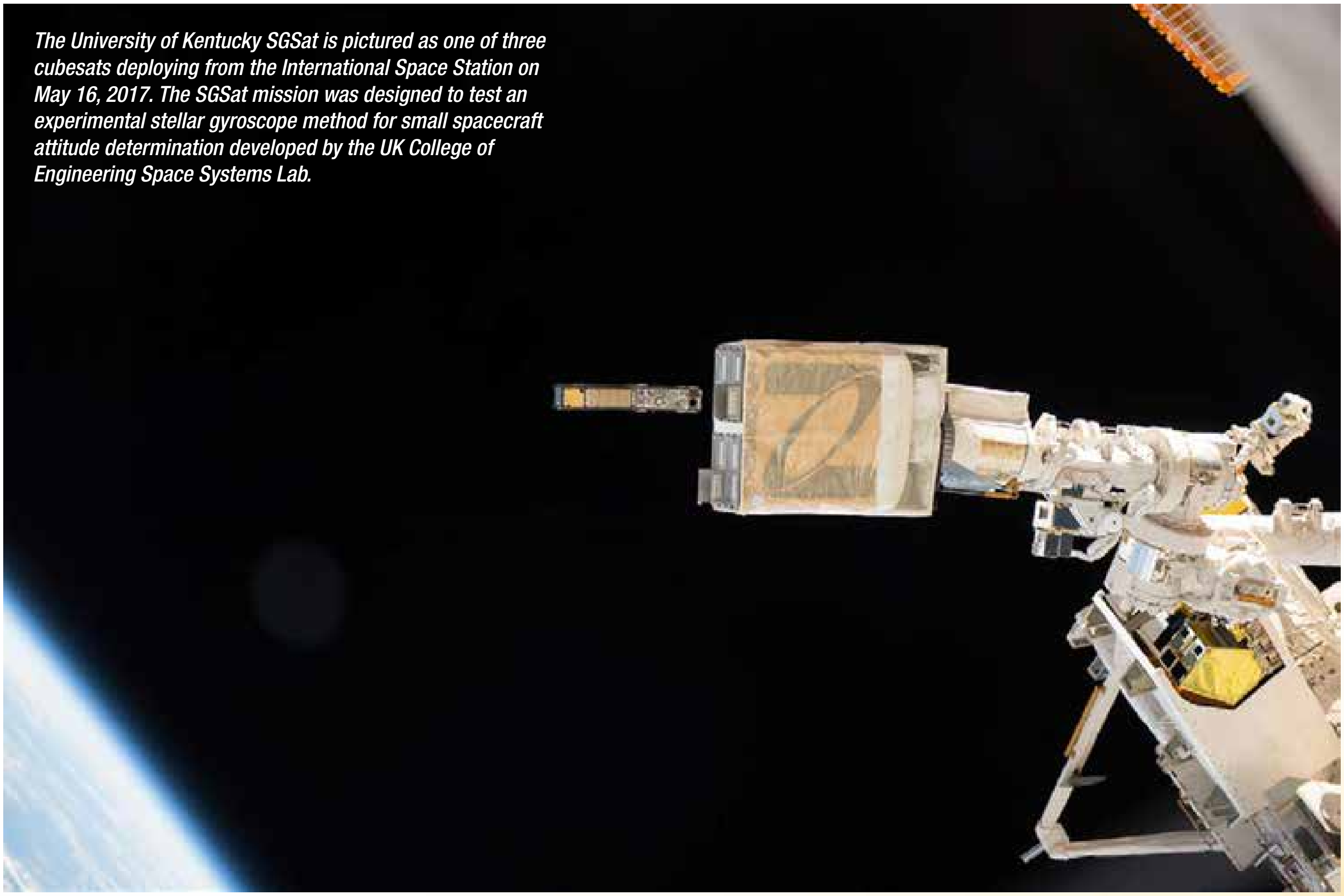
Dr. Alexandre Martin
Science PI



Dr. David J. Chato
NASA Technical Monitor

Validation of a Cubesat Stellar Gyroscope System

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

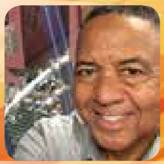


The University of Kentucky SGSat is pictured as one of three cubesats deploying from the International Space Station on May 16, 2017. The SGSat mission was designed to test an experimental stellar gyroscope method for small spacecraft attitude determination developed by the UK College of Engineering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

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

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

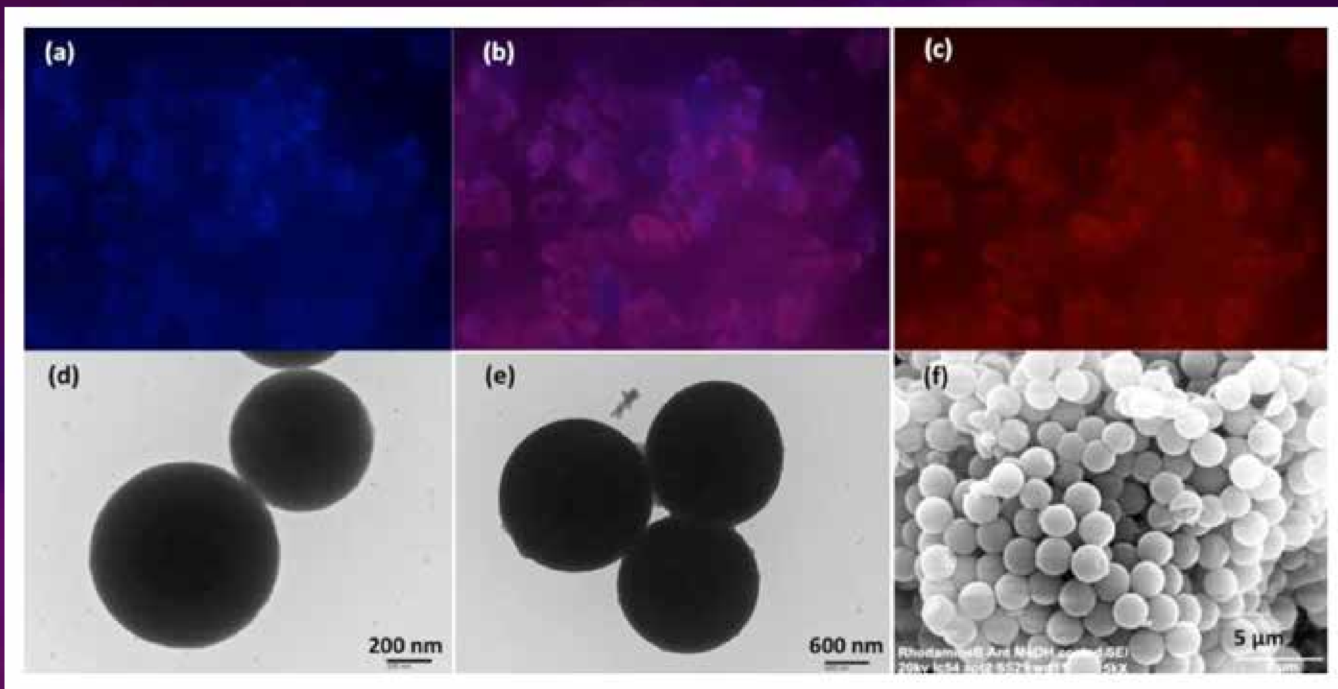
Dr. James E. Lumpp, Jr.
Science PI, Professor
University of Kentucky



Willie Williams
NASA Technical Monitor
Johnson Space Center

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

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



Dual-florescent Silsesquioxane particles (shown above) are the primary type of colloid synthesized for this project. Electron microscopy revealed the average size and shape of the particles. (Credit: H. Rathnayake; published in Sci. Adv. Today 3 (2017) 25266)

University of Louisville (UofL) and Western Kentucky University (WKU) faculty are working with researchers at NASA Glenn Research Center to examine colloid synthesis, nanoparticle haloing, and electrokinetics of colloidal samples in terrestrial and microgravity experiments.

The project, Influence of Gravity on Electrokinetic and Electrochemical Colloidal Self-Assembly for Future Materials, investigates how to precisely control colloids and develop the potential for new materials with enhanced energy, thermal, optical, chemical, and mechanical properties. Colloids are liquids, like milk, that contain suspended particles.

This NASA EPSCoR research project utilizes the national laboratory onboard the International Space Station (ISS) to perform experiments under microgravity and gain fundamental understanding of colloidal interactions where gravity would otherwise compromise such investigations, enabling insight into interactions that govern colloidal stability and assembly.

On the ground, extensive experimentation and sample characterization are currently being conducted to properly compare on-earth observations with results acquired from the ISS.

UofL professors are incorporating this experience with space-based research into their classes and student research programs. New equipment acquired for this project enhances existing infrastructure at the UofL Micro/Nano Technology Center, providing specialized multidisciplinary laboratory tools for Kentucky researchers and regional industrial partners.

Science PI:
Dr. Stuart Joseph Williams
University of Louisville

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

https://www.youtube.com/user/ULmicrofluidics

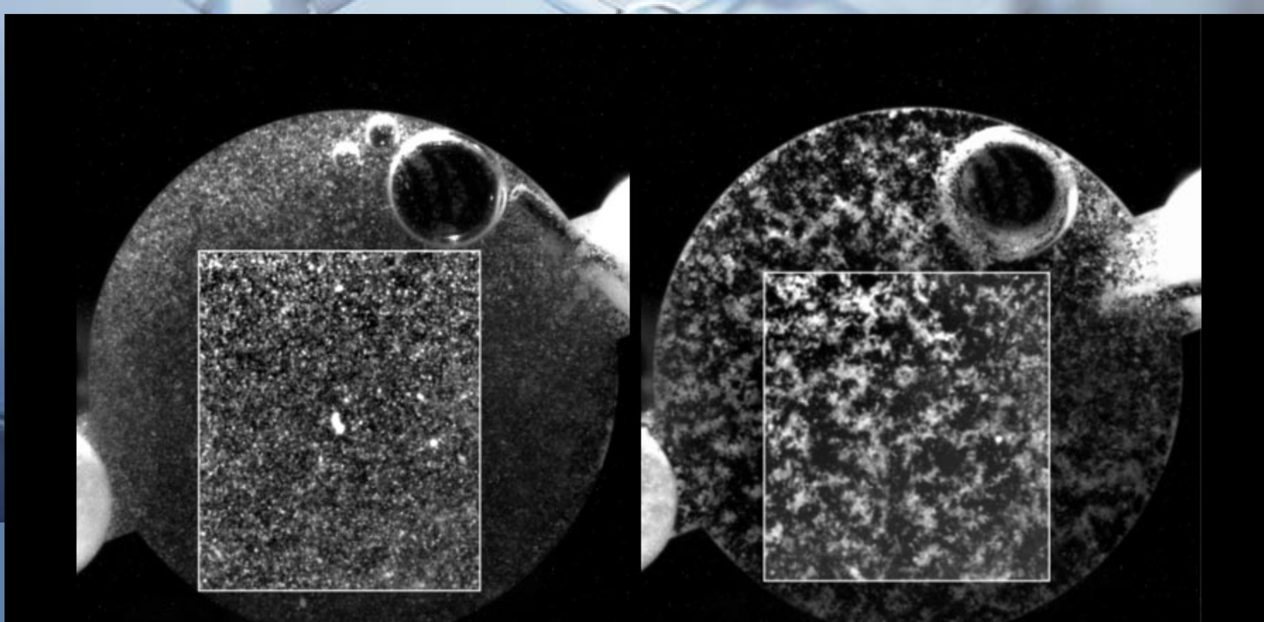
Enhanced Science on the ISS: Influence of Gravity on Electrokinetic and Electrochemical Assembly in Colloids

University of Kentucky, Lexington; NASA Human Exploration & Operations Mission Directorate, Science Mission Directorate, International Space Station/Johnson Space Center

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

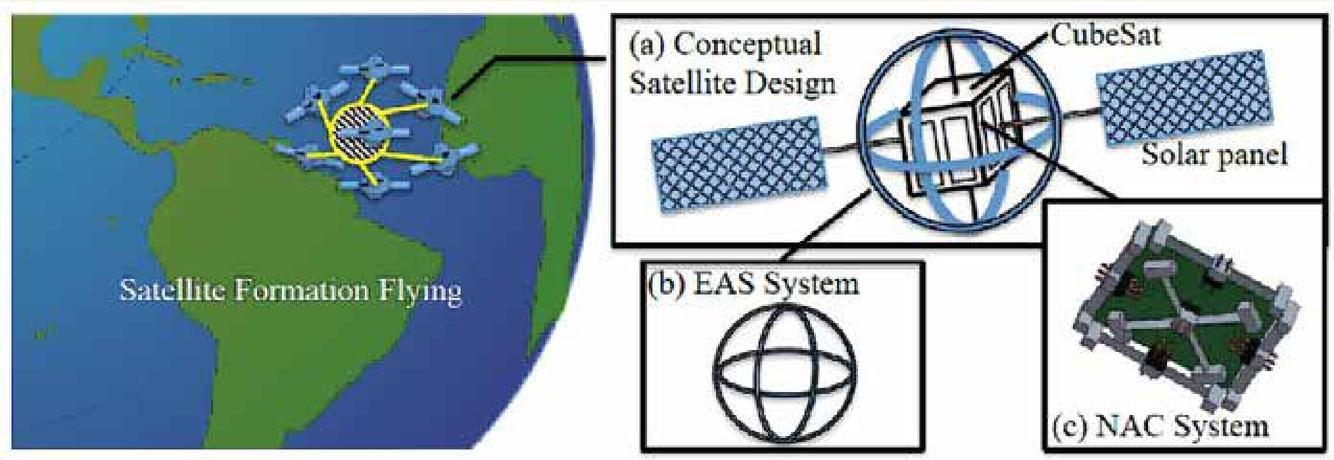
Dr. William V. Meyer
NASA Technical Monitor
Glenn Research Center

The proposed work complements ongoing work conducted by the research team on the International Space Station (ISS). In January 2016 the research team conducted a study on the ISS utilizing the Light Microscopy Module (LMM) in order to study nanoparticle haloing under microgravity. This experiment (ACE-H2) was part of a series of colloidal experiments organized by the NASA Glenn Research Center Advanced Colloids Experiments (ACE) whose mission is to gain fundamental understanding of colloidal interactions where gravity would otherwise compromise such investigations. Through our current NASA EPSCoR support (NNX14AN28A), we are to run two ISS experiments (ACE-H2 in January 2016 and ACE-E4 in May 2019). We are tentatively scheduled a six-week timeframe to execute ACE-E4. The work proposed herein will enable additional science beyond the scope of the RA to be conducted during the same six-week period. This study, termed ACE-E4ES (short for ACE-E4 Enhanced Science), will take advantage of updates to the LMM platform since ACE-H2, specifically microscopic confocal imaging and temperature capabilities. This work will enable a greater understanding of nanoparticle haloing which can be used to investigate colloidal stability and controlled self-assembly. Ultimately, the ability to design colloidal particles with a variety of well-controlled three-dimensional bonding symmetries opens a wide spectrum of new structures including photonic crystals.



Coordinated Position and Attitude Control for Formations of Small Satellites

University of Kentucky, Lexington/NASA Space Technology Mission Directorate/Johnson Space Center, Kennedy Space Center, Ames Research Center, Marshall Space Flight Center and industry partner Space Tango Inc



Actuation and sensing concept for small-satellite formation ight. (a) Each satellite is composed of a main frame and systems for actuation and sensing. (b) The electromagnetic actuation-plus-sensing (EAS) system consists of electromagnetic coils that are used to control relative position and provide estimates of the relative position and attitude of nearby satellites. (c) The noncommutative-attitude-control (NAC) system is an internal component of the satellite that is used for attitude control.

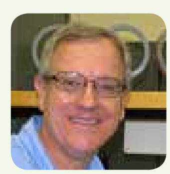
Small-satellite swarms are an integral part of future space missions, including exploration, atmospheric measurements, comet detection, cosmological and biological studies, and space-weather monitoring. Small-satellite formations are candidates for nextgeneration interferometers, large-aperture space telescopes, antennas, radiometers, and gravity-wave detectors.

The primary actuation-and-sensing challenge for small satellites is their strict size-and-weight limitations. Conventional large-satellite actuation systems (e.g., propellant thrusters and reaction wheels) are not well suited for small satellite swarms. This project will develop and integrate innovative actuation, sensor, and control technologies that are both small, efficient, and have renewable power sources. The objective of this project is to develop and integrate three key enabling technologies: 1) a noncommutative-attitude-control (NAC) system for orientation control, 2) an electromagnetic actuation-plus-sensing (EAS) system for relative-position control and sensing, and 3) discrete-time formation (DTF) control algorithms that address the unique features of the NAC and EAS systems. The research team is currently applying noncommutative-attitude-control for medical microrobots and discrete-time formation control algorithms for multi-vehicle aerial distributed sensing systems. The unique combination of technologies developed in this project will advance the state-of-the-art in small satellite swarms for NASA. These technologies will also have broader application for NASA challenges such as formations of large satellites and small terrestrial robots.

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

This project leverages results of prior NASA EPSCoR seed investments to build a unique experimental infrastructure that expands Kentucky's research capability in a new dimension, develops specialized knowledge and expertise for faculty and students, increases collaborations between Kentucky's researchers, start-up companies and NASA, and supports future research funding success. The work aligns with the Kentucky Science and Innovation Strategy priority for High-Value Research and Development. The proposed research directly supports NASA Space Technology Mission Directorate (STMD), specifically, the Small Spacecraft Technology Program (SSTP), which is tasked with identifying and developing new technologies to enhance or expand the capabilities of small spacecraft and support flight demonstrations of new technologies. This project has a high potential to impact future NASA missions and produce technologies for the growing U.S. small-satellite sector.

Dr. Thomas Seigler
Science PI
University of Kentucky, Lexington



Dr. Robert C. Youngquist
NASA Technical Monitor
Kennedy Space Center

Maine Research Infrastructure Development

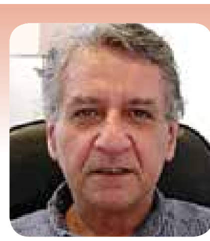
The Maine Cyber Security Cluster (MCSC) is an academic and research center that brings together government, businesses, and academia for workforce development and the enhancement of educational and undergraduate research opportunities, public service, training and educational programs in the field of cybersecurity exemplifying community engagement. MCSC proposes to organize and implement a "visioneering" process, which will include hosting a 3-day "visioneering" workshop, to bring together academic, government, and business leaders and practitioners to generate ideas and potential solutions for addressing the cybersecurity vision and applied research growth opportunities in Maine and the greater New England Region.

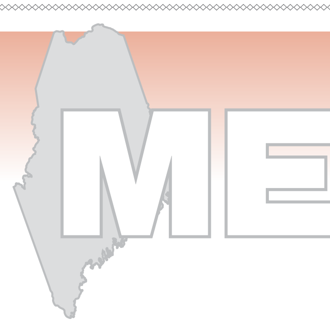
The workshop's primary goal is to generate two to three collaborative ventures that could be pursued as applied cybersecurity research projects, facilitated by MCSC, and that would simultaneously address the needs of both NASA and Maine. The workshop session will be held October 10-12, 2017, in conjunction with the statewide Cybersecurity Conference sponsored by United States Coast Guard (USCG), Maine Emergency Management Agency (MEMA), and MCSC. The primary deliverable of the workshop will be two to three cybersecurity research proposals written in 2017-2018 and a refined 3-5 year applied research vision for MCSC. This project would extend and strengthen MCSC's cybersecurity collaborative efforts as well as guide the prioritization and coordination of MCSC's applied research efforts most relevant to the state's economy. This "visioneering" process will also ensure that MCSC is well established as the center for cybersecurity education, training, professional development, research and public service for the citizens of Maine.

Photo above: Beta Port, loosely modeled on the city of Portland, is a cyber-security exercise environment. Students architected the Beta Port infrastructure used in the Collaboratory cyber security simulation.

http://mcsc.maine.edu/

Dr. Terry Shehata
ME EPSCoR Director
Maine Space Grant Consortium



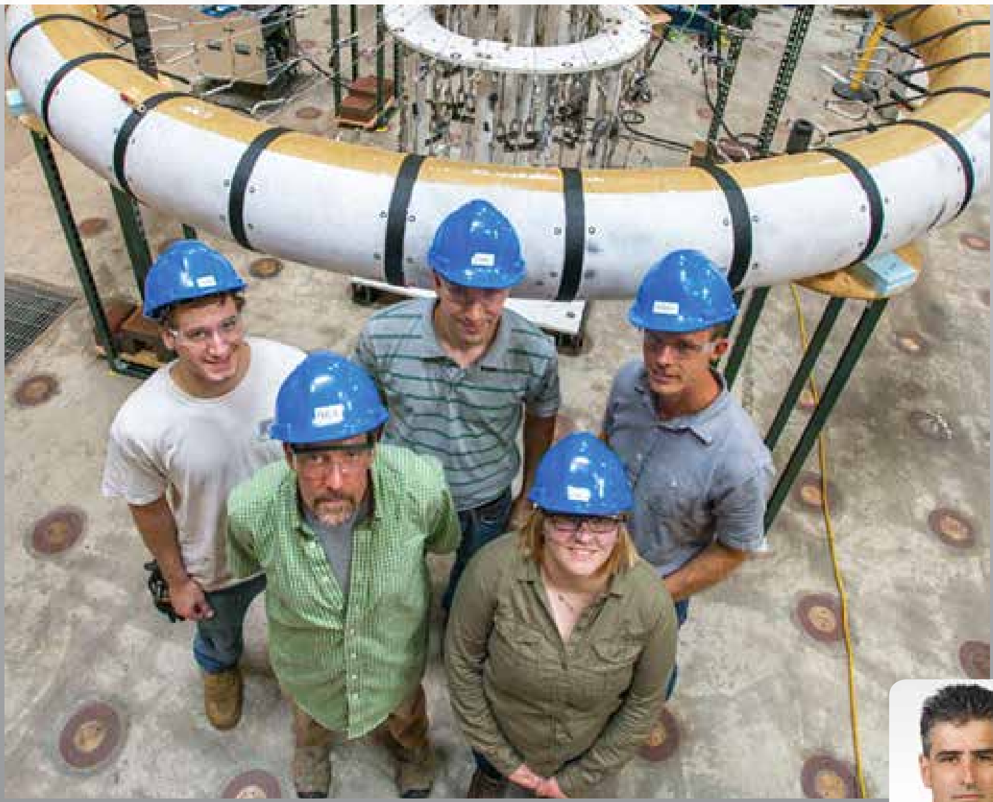


Behavior and Optimization of Hypersonic Inflatable Atmospheric Decelerator Devices for Spacecraft Re-Entry

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

The University of Maine (UMaine) worked closely with NASA Langley Research Center to help improve our understanding of the structural behavior of Hypersonic Inflatable Aerodynamic Decelerators (HIADs). HIADs are an enabling technology for new space exploration opportunities such as a manned mission to Mars. UMaine's role was to help fill knowledge gaps. This was achieved through a rigorous component-level experimental program, full-scale element level experiments, and the development of computationally efficient 3D beam-based finite element models to complement existing high fidelity 3D shell-based finite element models developed by NASA. The modeling methods were validated using experimental data from both straight beams and torus articles. The ability of the model to perform HIAD design optimization studies was demonstrated by showing similar predicted response compared to the NASA model with greatly reduced solution time. Significant infrastructure improvements occurred through this NASA EPSCoR grant that put UMaine in a position to continue supporting NASA's efforts in the future. This project supported 2 PhD students, 1 MS student, 23 undergraduates, and 9 high school students.

A tension-torsion machine was purchased for this project.



UMaine researchers with torus test article. Back row left-to-right: Cody Sheltra, Josh Clapp, and Andy Young. Front row left-to-right: Bill Davids and Dana Pride.

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

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

http://bangordailynews.com/2015/08/24/news/bangor/umaine-research-could-help-nasa-put-man-on-mars/

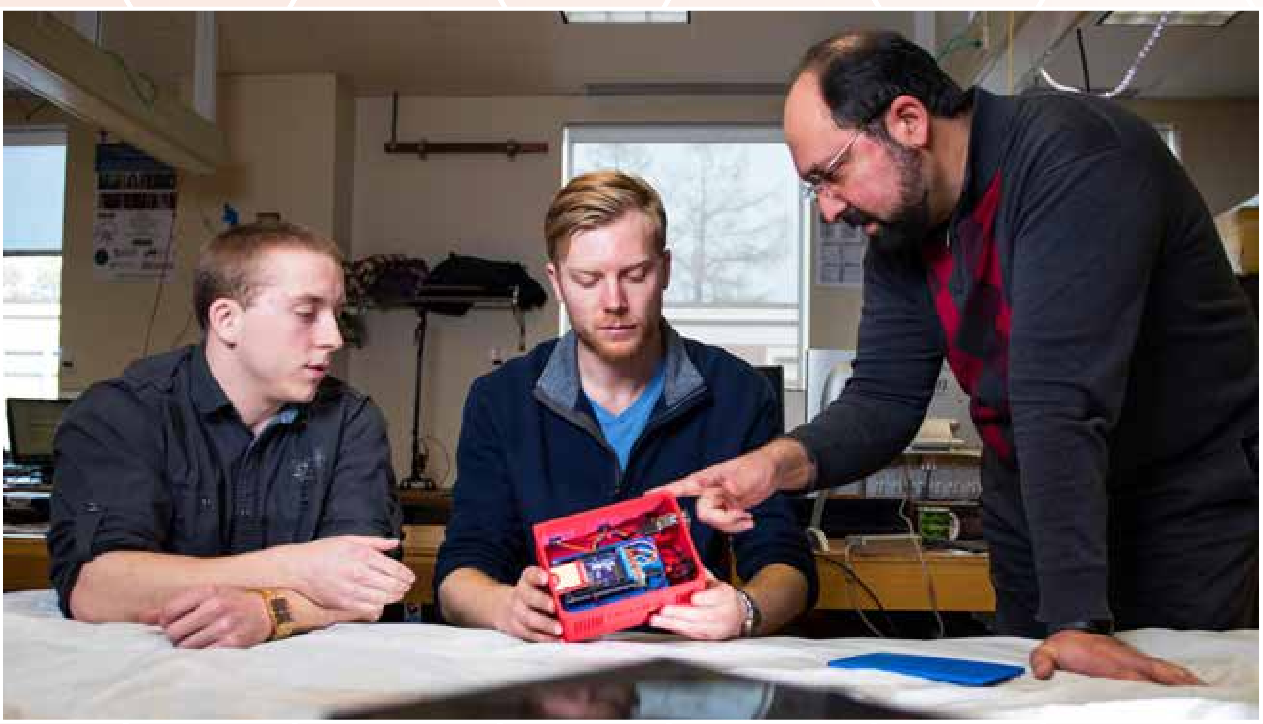
http://bangordailynews.com/bdn-maine/community/umaine-student-collaborates-with-nasa-at-langley-research-center/

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

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

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

Willie Williams
NASA Technical Monitor
Johnson Space Center



From Left: Lonnie Labonte of Rumford, ME (PhD Student, Payload Engineer), Casey Clark of Old Town, ME (MSEE Student, Project Manager), and Professor Ali Abedi (Science PI).

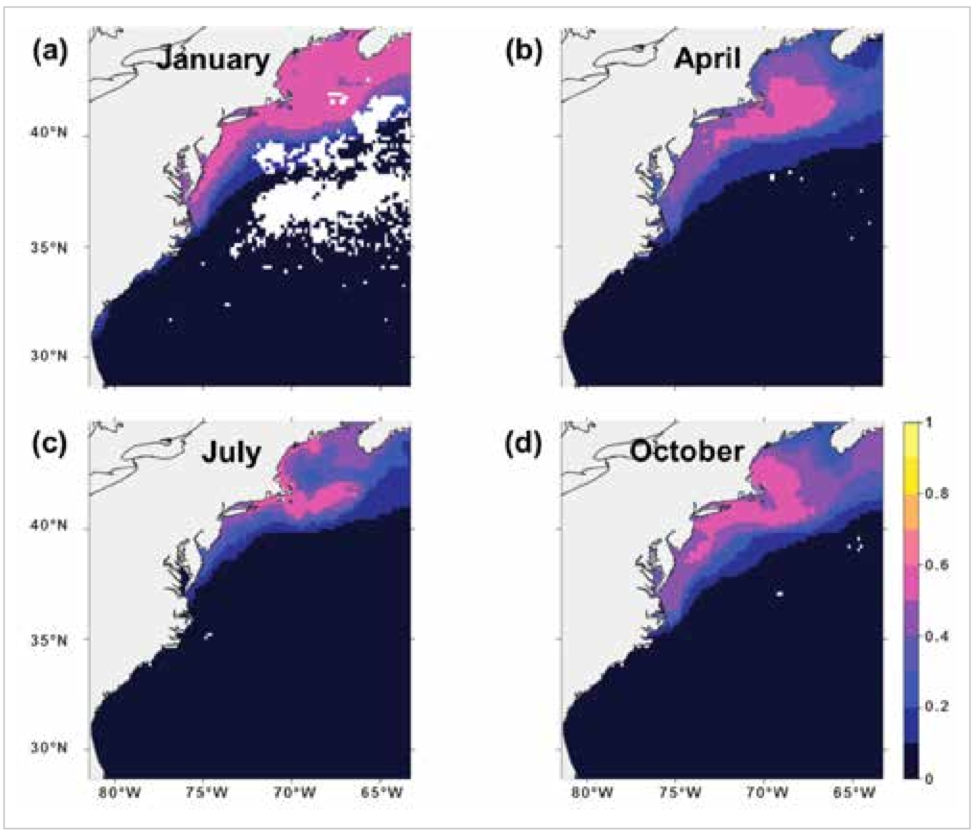
https://umaine.edu/wisenetlab/

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

Conditions in the ocean change from day to day and month to month. Fishermen rely on their experience to know where to find fish and managers use this experience to design policies like seasonal closures that ensure sustainability. Climate variability and increasingly climate change are altering these historical relationships, challenging both fishermen and managers. Our NASA EPSCoR project used a statistical approach called MaxEnt to build models relating the occurrence of fish to environmental conditions measured using NASA satellites. We applied this approach to several important fishery species including Atlantic herring, Atlantic mackerel, and butterfish. We produced monthly habitat maps (Fig. 1) and showed that these models do a good job explaining past changes in fish distributions. The models also provide insights into what processes drive the distribution of these fish. This project demonstrates the potential for using NASA's vast array of earth system observations to improve the management of the nation's valuable fishery resources. It also shows how bringing together experts from multiple fields, in this case, oceanography, ocean data processing, statistics, and fish ecology, can produce new insights into how our planet is changing.

Habitat suitability maps of Atlantic herring for January (a), April (b), July (c), and October (d) depict the shifting seasonal distributions related to spawning and feeding migrations. The MaxEnt models showed good predictive ability in hindcasts of fish distributions in recent years, therefore have the potential to provide forecasts of fish future distributions. The color of each ten-minute-square cell indicated the monthly habitat suitability value calculated by MaxEnt. For the scale bar, the color at the top (yellow) indicated highest habitat suitability, and the color at the bottom (dark blue) indicated lowest habitat suitability. Blank pixels occurred where there were missing values for chlorophyll-a estimates from satellite remote sensing because of cloud coverage.

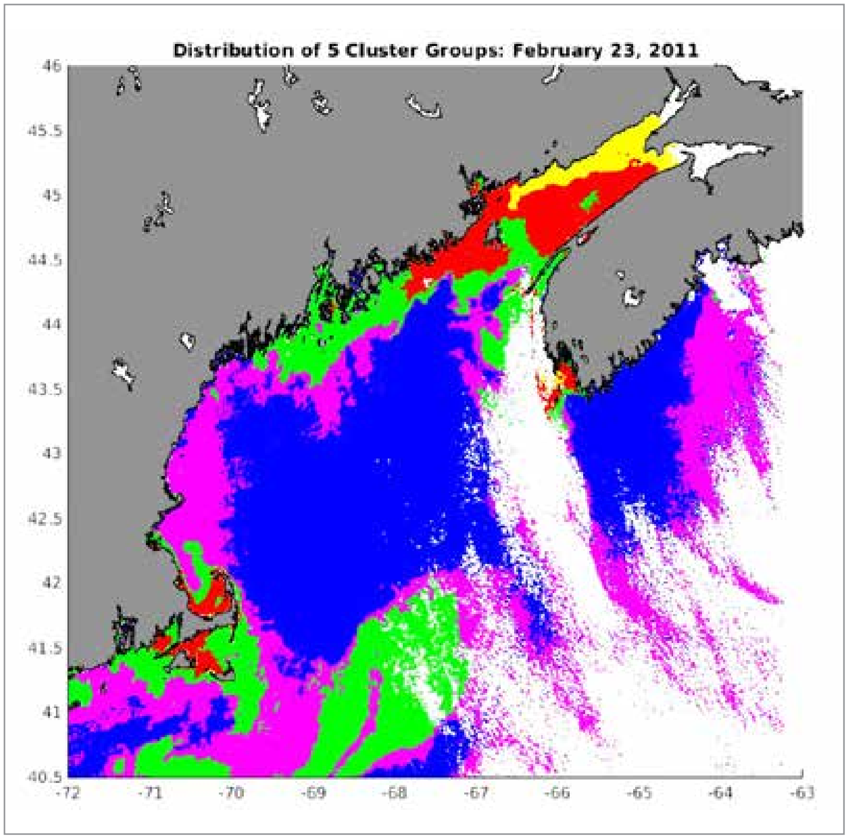


Dr. Andrew J. Pershing
Science PI
Gulf of Maine Research Institute

Edward M. Armstrong
NASA Technical Monitor
Jet Propulsion Laboratory

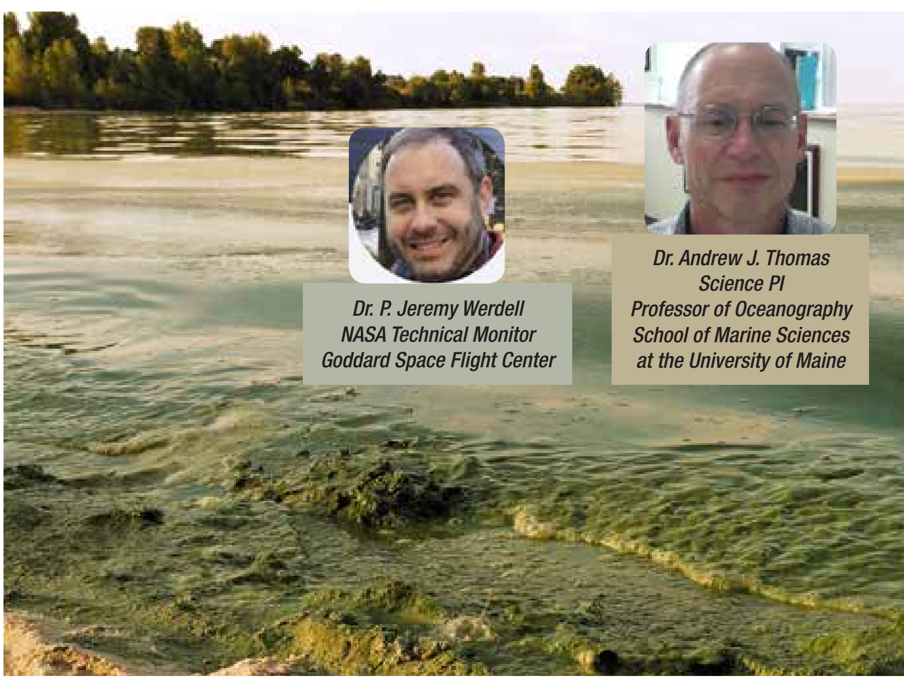
Multi- and Hyperspectral Bio-optical Identification and Tracking of Gulf of Maine Water Masses and Harmful Algal Bloom Habitat

University of Maine, Science Mission Directorate, Goddard Space Flight Center



Example winter map of Gulf of Maine water types, based on their satellite-measured multispectral properties.

The Gulf of Maine is one of the most rapidly changing ocean ecosystems on the globe. These changes will have a still poorly understood impact on its health, ecology, fisheries and our ability to manage these fisheries. This project brings a new approach to measuring and mapping these changes, based on over 18 years of archived, and still continuing, NASA ocean color satellite missions that make multispectral measurements of the ocean. These measurements allow a view of the "color" of the water that is controlled by the sediment type and concentration, dissolved organic content, and the plankton type and concentration, all of which are indicative of the physical and bio-geochemical processes occurring in the water. We are using multivariate statistical techniques to group the water into different temperature/ color "types" using the satellite data. We will then develop quantitative views of seasonal changes in the coverage and location of each water type, and track changes and trends over multiple years. These new views of Gulf of Maine change will be directed towards fisheries management issues such as changes in the position and distribution of the harmful algal blooms that annually shut down large portions of the coastal shellfish fishery.



Dr. P. Jeremy Werdell
NASA Technical Monitor
Goddard Space Flight Center

Dr. Andrew J. Thomas
Science PI
Professor of Oceanography
School of Marine Sciences
at the University of Maine

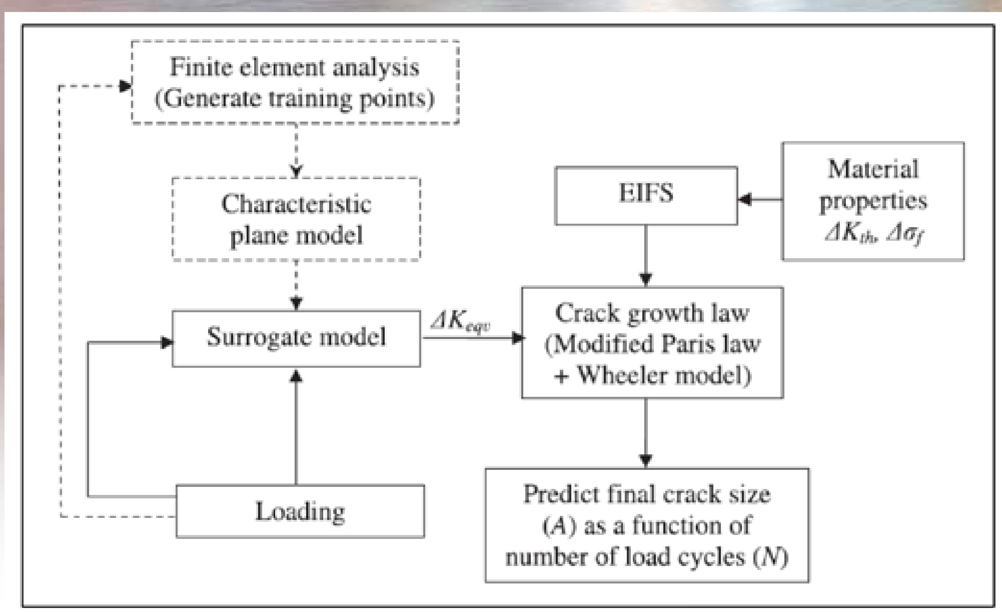
Louisiana Research Infrastructure Development

Prognostics of Crack Propagation and Damage

This Summer Assisted Research (SAR) project provided support for faculty at Southern University Baton Rouge (SUBR) to engage in a research project focused on failure prognostics of air and space vehicle structures in collaboration with the NASA AMES prognostics center of excellence (PCoE). The project team explored and assessed physics-of-failure approaches as well as data driven prognostics techniques applicable to high-strength aluminum and composite structural materials commonly used in aircraft and space vehicles. The project work was performed at SUBR campus and at NASA Ames PCoE. The project leveraged NASA expertise to significantly enhance research competencies at SUBR.

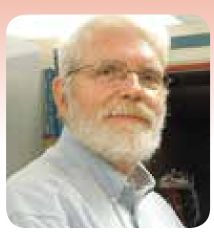
In this project the crack propagation analysis approach described in Figure 1 was adopted for application to rivet hole in high strength aluminum specimens when subjected to salt water conditions. Improved estimates of material properties $(\Delta K_{th,} \sigma_f)$ were obtained using experimental results collected at the Air Force Institute of Technology (AFIT), in the continuing follow up work. The crack growth law parameter estimates were enhanced using the Kitigawa- Takahishi (K-T) diagram approach to accurately identify propagating short crack transition. The prognostics modeling software algorithms developed at NASA PCoE were discussed with NASA Ames researchers. The technical discussions with NASA researchers lead to development of plan for future research projects for more experimental data and prognostics system development.

A proposal titled "Prognostics of Crack Propagation" was submitted to the Louisiana EPSCoR Research Awards Program (RAP), also funded under the NASA ESPCoR RID. The project was awarded and work began in January 2017.



Deterministic Crack Propagation Analysis Ref.

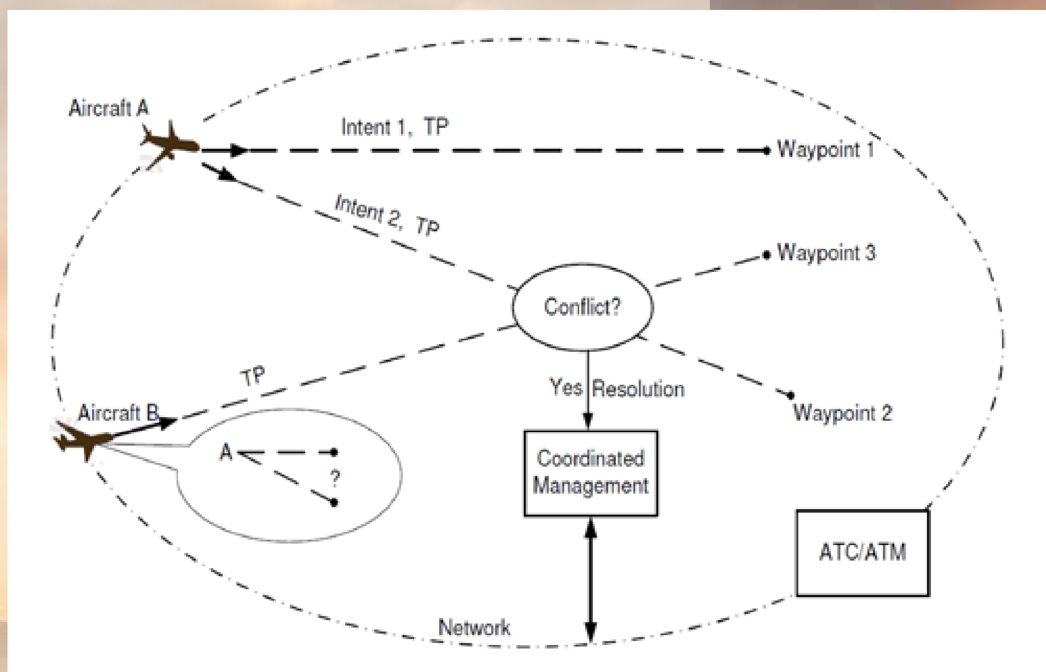
T. Gregory Guzik
LA EPSCoR Director
Dept. of Physics & Astronomy
Louisiana State University



Integrated Trajectory Information Processing and management for aircraft Safety (ITIPS)

University of New Orleans/Louisiana State University/Southern University/Ames Research Center, Aeronautics Research Mission Directorate

Air traffic demand has been forecast to double by the year 2025. Unfortunately, the present Air Traffic Control (ATC) system is already strained and cannot scale to meet this demand. The situation will deteriorate even more rapidly with the advent of unmanned aerial systems. To restructure the ATC system, NASA is working with FAA and other government agencies to develop the Next Generation Air Transportation System (NextGen). "Enabling heavier yet safer air traffic" is a simplistic description of project ITIPS ("Integrated Trajectory Information Processing and Management for Aircraft Safety"), yet it is the key goal for NextGen. To greatly improve the capacity, efficiency, safety, flexibility, and environmental protection, NextGen calls for a transformation from ATC to air traffic management. It is centered on trajectory-based operations, which rely critically on reliable and accurate information processing and judicious management. ITIPS brings together researchers at the University of New Orleans with expertise at Louisiana State University and Southern University into a highly qualified team to research information processing and network-centric management for trajectory prediction, intent inference, conflict detection and resolution, separation assurance, and conformance monitoring. ITIPS results provide significant technical solutions to related important problems in NextGen.



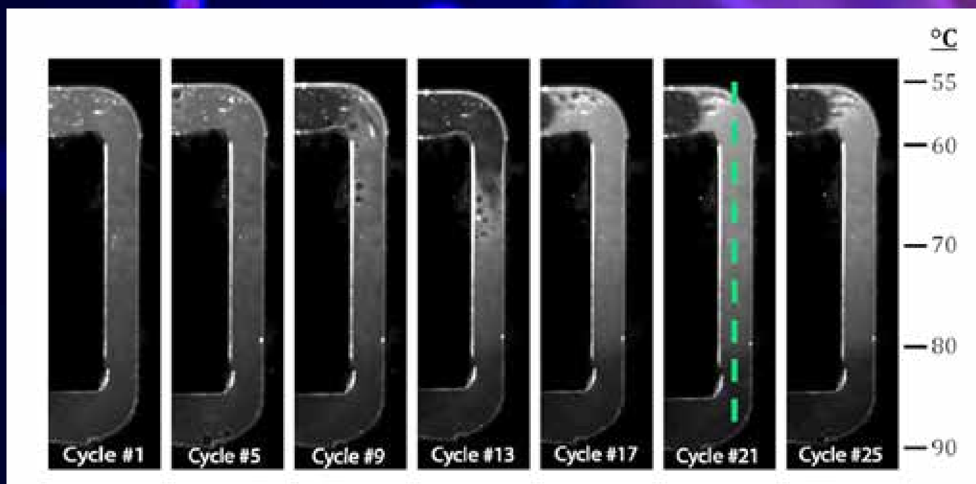
Trajectory prediction, intent inference, networked management, and conflict detection and resolution for air traffic control and management.

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

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

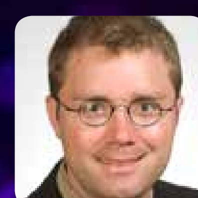
Genetic Assessment of the Space Environment Using MEMS Technologies

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



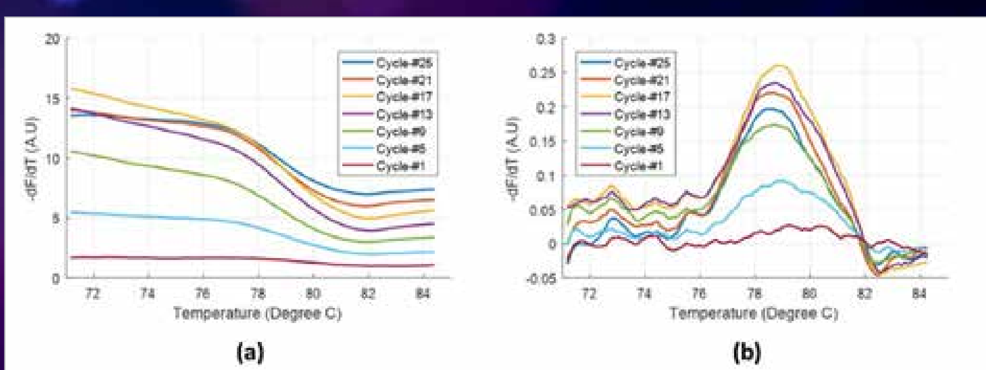
Fluorescence images of melts at various cycles in the PCR. By analyzing the fluorescence in the channel along the dotted green line provides a standard melt curves.

This project, “Genetic Assessment of the Space Environment using MEMS Technologies”, has developed a suite of technologies to support the fundamental study of radiation effects on humans. This has certain application for space travel, but also for many other areas of modern technology, such as power generation and disaster recovery. However, the several new technologies that are being developed for this instrument can have their own independent impact on much broader scale. These fields include cancer diagnostics, genetically modified plant research, and nuclear weapons tracking and disarmament verification. By integrating and developing these several cutting-edge components toward this NASA technical objective, diverse research teams across Louisiana are being synergized. Beyond the strength this brings to research, this is also promoting an upswing in NASA interest as well as general STEM awareness for communities that are historically underrepresented in the scientific fields most critical to our nation’s future.



Dr. Niel Crews
Science PI
Louisiana Tech University

NASA Technical Monitor:
Dr. Ralph F. Fritsche



(a) melt curves obtained from analyzing the fluorescence images. The melt curves are separated for better visualization. (b) melt peaks obtained by the first derivative of the standard melt curves.

https://www.nasa.gov/mission_pages/station/research/experiments/2388.html

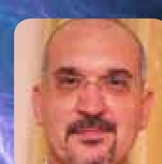
Investigating Terrestrial Gamma Flash Production from Energetic Particle Acceleration in Lightning using TETRA-II

Louisiana State University, Glenn Research Center, Science Mission Directorate

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

Lightning is of great interest to NASA, in part because of the potential damage due to strikes to space vehicles at launch. Terrestrial Gamma Flashes (TGFs) are intense millisecond-long bursts of gamma rays associated with lightning. TGFs are detected by satellite detectors, and a recent ground-based measurement has suggested that there may be a close connection between the particle acceleration that leads to the TGFs and the basic structure of the thunderstorm. The TETRA-II (TGF and Energetic Thunderstorm Rooftop Array) array of gamma ray detectors recently installed at ground level in Puerto Rico is designed to provide detailed and close-up information about nearby (< 5 km) thunderstorms producing TGFs.

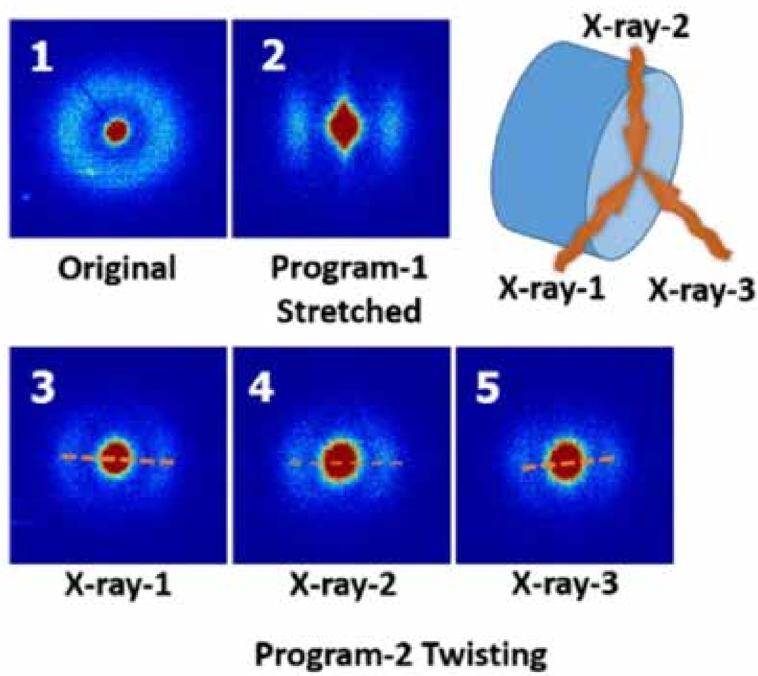
Dr. Michael L. Cherry
Science PI
Professor, Louisiana State University



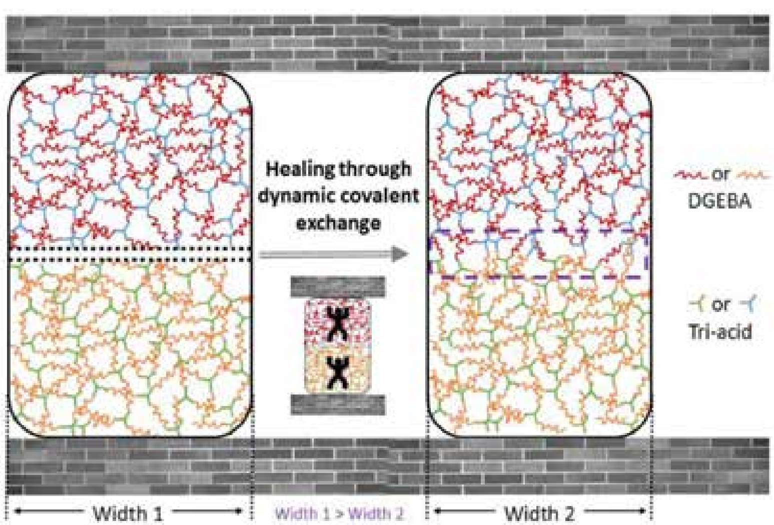
Nasser Barghouty
NASA Technical Monitor
Manager, Astrophysics Office at NASA-Marshall Space Flight Center

Damage Healing of Polymer Composite Structures Under Service Conditions

Louisiana State University, Langley Research Center, Aeronautics Research Mission Directorate, Human Exploration & Operations Mission Directorate, International Space Station



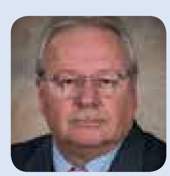
Effect of programming on the crystallization of two-way shape memory polymer (2W-SMP). The 2D SAXS patterns for 2W-SMP fiber (1), stretched fiber (2), and twisted fiber (3), (4), and (5).



Schematic of the self-healing process through dynamic exchange of the ester bonds under shape recovery force. The shape memory effect helps in closing the crack space and pushes the fracture surfaces in contact; the dynamic exchange of the ester bonds helps in molecular healing.

This project targets several programs in the NASA Aeronautics Research Mission Directorate (ARMD) and Human Exploration & Operations Mission Directorate (HEOMD), and responds to State and Institution research priorities. The research objective of this project is to develop new polymer composite panels for in-service damage healing through (1) design, synthesis, characterization, and manufacturing of two-way shape memory polymers (2W-SMPs), which expand when temperature drops, even without external tensile load; (2) multiscale modeling of the smart composite structures; and (3) additive manufacturing using 3D printing and experimental evaluation of the smart composite panels for impact mitigation and in-service crack healing. We designed and synthesized a new chemically cross-linked two-way shape memory polymer, which expands upon cooling and contracts upon heating. We developed a solid solution approach and found the way to process the bulk polymer into fibers, and through twist insertion, we transformed the fiber into artificial muscle, which further amplified the actuation strain. We also developed a new self-healing polymer that utilizes its shape memory effect for crack closing and transesterification reaction for molecular healing. The combination of intrinsic self-healing and shape memory effect within one polymeric network ensures that wide-opened cracks can be healed repeatedly and molecularly, by simple heating.

Dr. Isiah Warner
Science PI
Louisiana State University



Dr. John H. Vickers
NASA Technical Monitor
NASA Center for Advanced Manufacturing

Missouri Research Infrastructure Development

Observatory 'Open House' on the 27th of August 2016. The occasion is the Jupiter-Venus transit. More than 200 students, children, and members of the general public attended the event.

Star Spots and the O'Connell Effect in Low Mass Stars

The most significant impact of this project has been on the undergraduate students participating in this research. Two of the students, Tyler Gardner and Gage Hahs, are first & second authors on a peer-reviewed journal article. One of the participating students, formerly a Biology-major, has successfully completed his BA in physics, and started graduate school in astronomy at the University of Michigan. The second most significant impact of this project has been on the content and quality of the new advanced 'Observational Astronomy' class offered at Truman State. This project has helped improve and refine our data collection and analysis techniques, strengthening the astronomy-research program at Truman. In particular, our research is leading to a better understanding of the O'Connell effect and of stellar activity. The continuing success of this project has encouraged administrators to support the strengthening of existing infrastructure via an upgrade of the Truman Observatory: from a 14-inch Meade LX200 telescope to a 17-inch planewave telescope mounted on a paramount ME-II mount. Outreach efforts supported by this grant have led to an increase in the number of outreach activities, and a significant increase in the number of members from the general public attending 'open house' star-parties at the Observatory.

https://missouriepscor.org/nasa-epscor

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

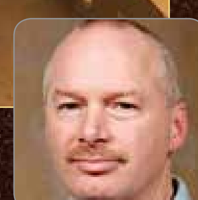
Understanding the Atmospheres of Hot Earths and the Impact on Solar System Formation

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

It has recently been determined that nearly every star in the sky has at least one planet in orbit around it. However, we know very little about conditions on these planets, including how they were made. We do know that quite a few are extremely close to their stars, and so heated the point where even some rocks can vaporize. As part of our grant, we have set up a high-temperature lab where we will be able to reproduce those conditions and understand what these places are like. By understanding their chemistry, we hope to understand how they were made, and by extension how solar systems form. This lab, in concert with one at NASA's Glenn Research Center, is on the cutting edge of what we can do technologically.

Graduate student Heath Gemar makes an adjustment in the high-temperature lab.

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



Dr. Mike Reed
Science PI
Missouri State University

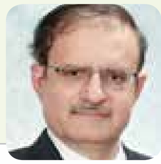
Development of Turbulence Models, Uncertainty Quantification and Optimization Tools for Aircraft and Turbomachinery Analysis and Design

Washington University in St. Louis/NASA Glenn Research Center, Langley Research Center, Ames Research Center, Aeronautics Research Mission Directorate

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

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

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



Dr. Mujeeb Malik
NASA Technical Monitor
Langley Research Center

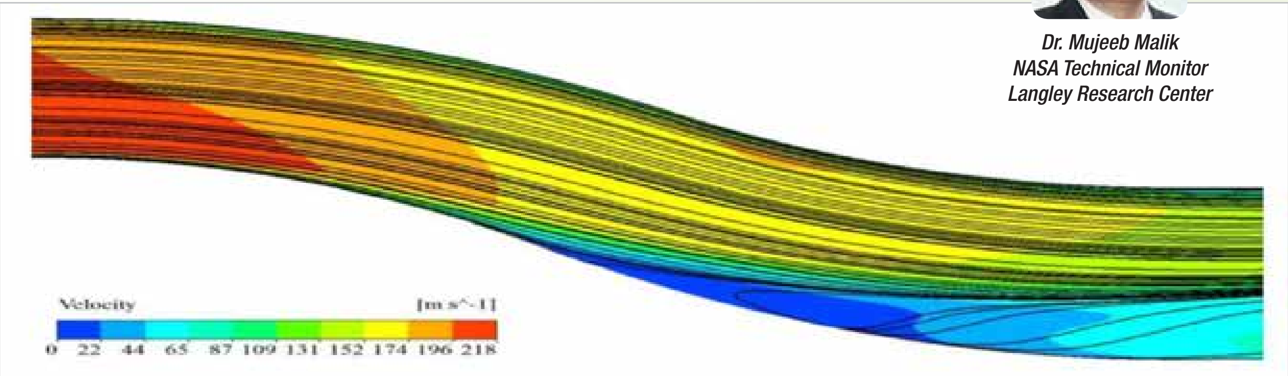


Fig. A: Computed velocity contours in S-Duct using the Wray-Agarwal turbulence modelt

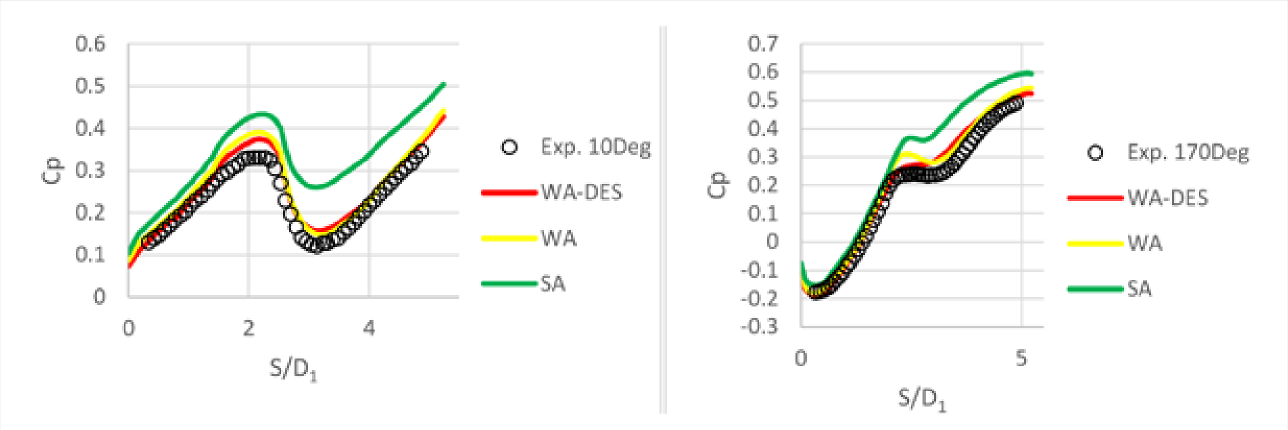


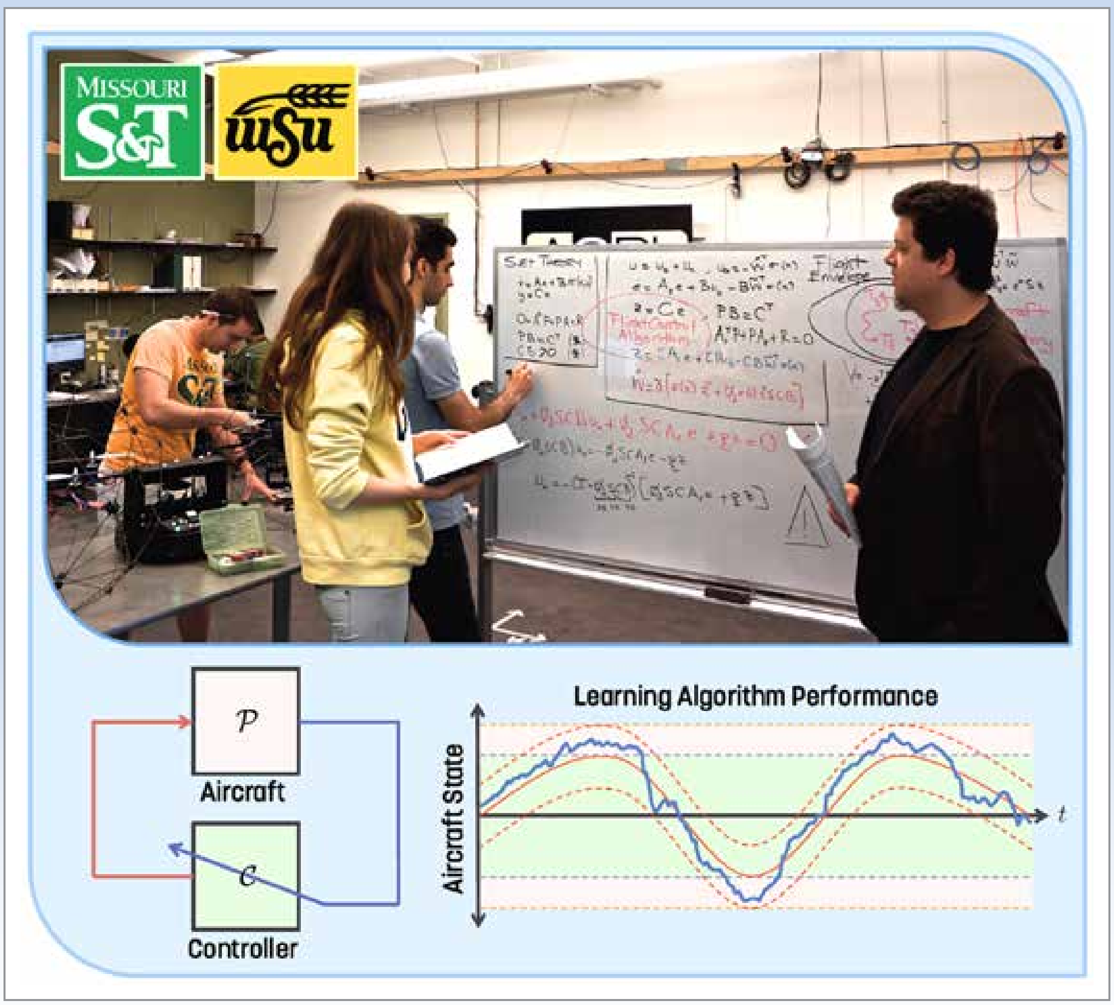
Fig. B: Comparison of pressure distribution along the NASA Glenn S-Duct at two angular locations of 10 and 170 degrees.

http://scholarsmine.mst.edu/masters_theses/7480/ **http://turbmodels.larc.nasa.gov/**

Learning Algorithms for Preserving Safe Flight Envelope Under Adverse Aircraft Conditions

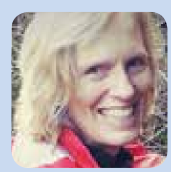
Missouri University of Science & Technology/NASA Langley Research Center, Aeronautics Research Mission Directorate

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



Dr. Tansel Yucelen and two graduate students, Merve Dogan and Ehsan Arabi, working on learning algorithms for safe flight control.

Dr. S.N. Balakrishan
Principal Investigator
Missouri University of Science & Technology

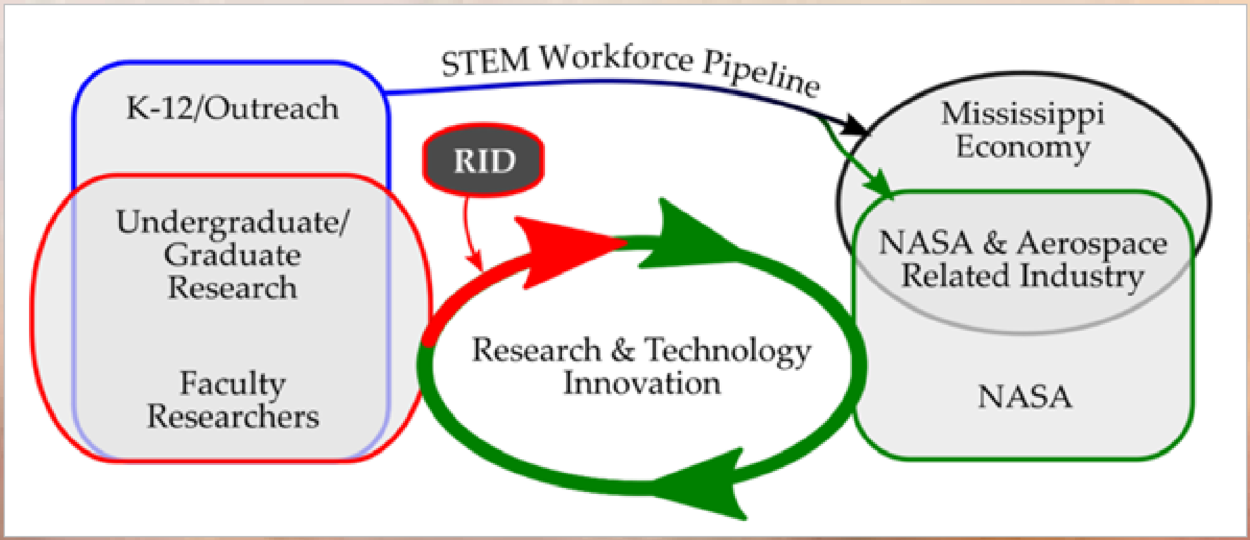


Dr. Susan Frost
NASA Technical Monitor
Intelligent Systems Division
NASA Ames Research Center

Mississippi Research Infrastructure Development

PhD candidate Vasileios Sassanis (foreground) and MS student Jeremy Sawaya discuss results of a computational simulation at Mississippi State University.

NASA EPSCoR in Mississippi is funding research infrastructure development (RID) grants to set in motion the maturation of innovative research and technology ventures that are relevant to NASA and NASA related Mississippi industry. This RID program is working to evolve Mississippi's academic research enterprise leading to long-term, self-sustaining, nationally-competitive capabilities in NASA and NASA-related fields and promote growth in the Mississippi economy. The success of the program comes largely due to the targeting of specific research activities that have a high potential for growth and are directly applicable to the statewide economic interests in Mississippi. Recent research projects have involved Big Data for Geoscience, Biology for Zero Gravity Life Support, and Aerospace for Hypersonic Vehicles. In the last two years, the project has produced a 245% return on the NASA investment, generated 21 journal publications and 18 conference papers, and supported a total of 7 graduate and 2 undergraduate students.



http://msnasaepscor.org/

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

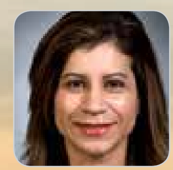
Hyper Velocity Impact - Environmental Resistant Nano Materials in Space Applications

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

Graduate Research Assistant Chris Douglas conducting oxidation experiment on graphene material.

The near-earth space environment is cluttered with man-made debris, naturally occurring meteoroids, and other highly energetic species such as photons from sunlight, particles from solar flares and galactic cosmic rays, originating from the sun and other stars. These particles and debris can travel at velocities in excess of 6 km/sec. Space activities in Near Earth Orbits (NEO) will encounter this environment and hardware must be designed to survive it. Orbiting spacecraft in NEO are critical to national interests. They serve essential roles as communications links, navigation beacons, scientific investigation platforms, and providers of remote sensing data for weather, climate, land use, and national security purposes. A Mississippi EPSCoR project focused on the develop and demonstration of a new and unique, state-of-the art, material system with exceptional hypervelocity impact resistance capabilities. This material system is a composite with Nacre-like material properties which could provide superior hypervelocity impact resistance. This new material system, additionally, was proven to be environmentally stable under atomic oxygen (AO) attack. This composite is made from exfoliated graphene nano composites, embedded in a host polymer that has been modified with Polyhedral Oligomeric Silsesquioxane (POSS) materials.

Dr. Ahmed Al-Ostaz
Science PI
University of Mississippi



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

An energetic research group, which includes faculty and graduate students from University of Mississippi (UM) and Jackson State University and collaboration with scientists in Jet Propulsion Laboratory, has been formed with this grant. As one consequence, we have successfully established a UM site of Broadband Wireless Access and Applications Center sponsored by NSF, and have collaborated with companies including Intel, Qualcomm, Raytheon, X2 Biosystems, and C-Spire in various projects in wireless communications. Specific to this NASA project, techniques to improve both the quantity and quality of information obtained through deep space exploration are being developed. Fountain codes and a new protocol are being designed that may result in substantial improvements in data transmission over space-to-earth channels. Efficient methods of fusing data to improve the quality of information derived from the collected data are also being developed. Interesting research outcomes have been documented in both journal and conference publications. This grant also actively involves citizen undergraduate students to gain hands-on research experience. Using USRP and GNU radio, the undergraduate students at UM have built up interesting projects, made an oral presentation in the 31st National Conference on Undergraduate Research and published a paper with University of Mississippi Undergraduate Research Journal.

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

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

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

GEANT4 Simulations for Astronaut Risk Calculations

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

One of the key safety considerations for long-term space travel is the effect of ionizing radiation on astronauts. Solar particle events (SPEs) and galactic cosmic rays (GCRs) pose significant risks due to their potential for causing damage at the microscopic level. In addition to breaking DNA strands via direct impact, radiation can indirectly damage DNA through generation of freeradicals in the cell nucleus. Simulations using newly developing DNA models in Geant4, an opensource radiation transport toolkit maintained by international collaboration, are being used to correlate such microdosimetric effects with known risks associated with radiation exposure. The goal of this work is to better understand the microscopic causes of astronaut risk and better inform future analysis of astronaut safety. In this project, simulations of radiation cascades have been implemented from the macroscopic level down to the cellular level and ultimately to the molecular scale of DNA. The figure below presents a Geant4-DNA visualization at the level of a nucleosome, one of the smallest structural units within a larger chromosome. Nucleosomes consist of the well-known DNA double helix (red, white) wound around a special protein called a histone (blue). The double helix winds around the histone twice, and short DNA segments link adjacent histones to each other.

Dr. Kerry Lee
NASA Technical Monitor
Johnson Space Center

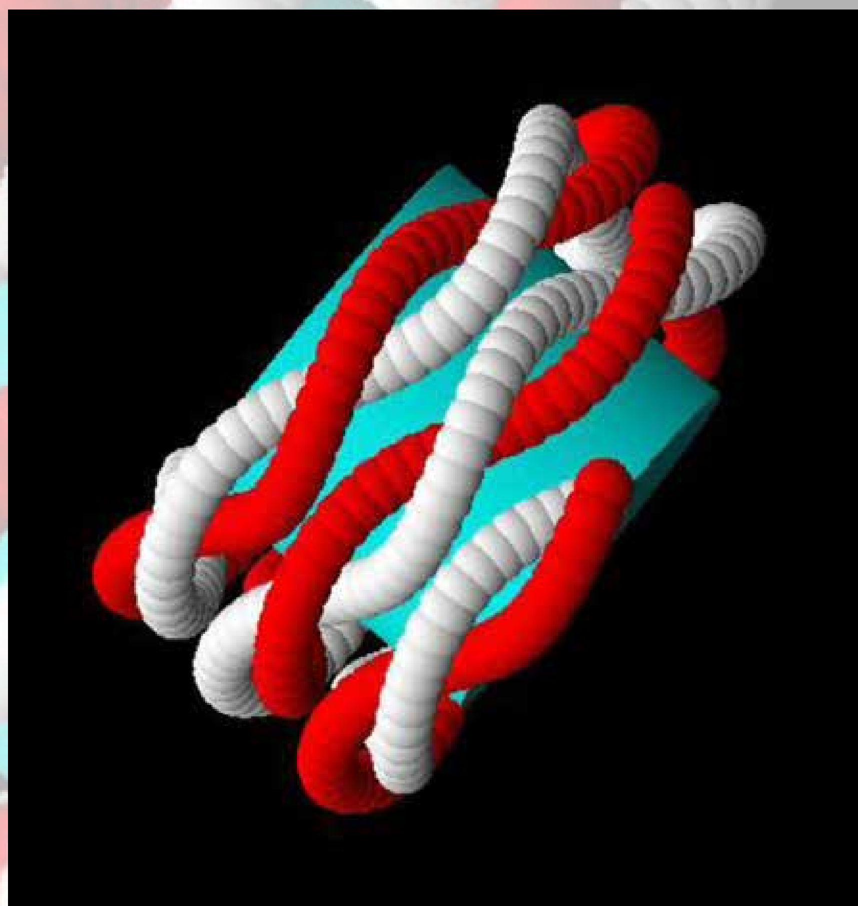
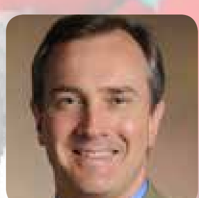


Figure: Geant4-DNA visualization of a nucleosome consisting of the DNA doublehelix wrapped around a protein known as a histone. Long chains of nucleosomes form chromatin fibers and ultimately chromosomes. The diameter of the depicted structure is approximately 11 nm.



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

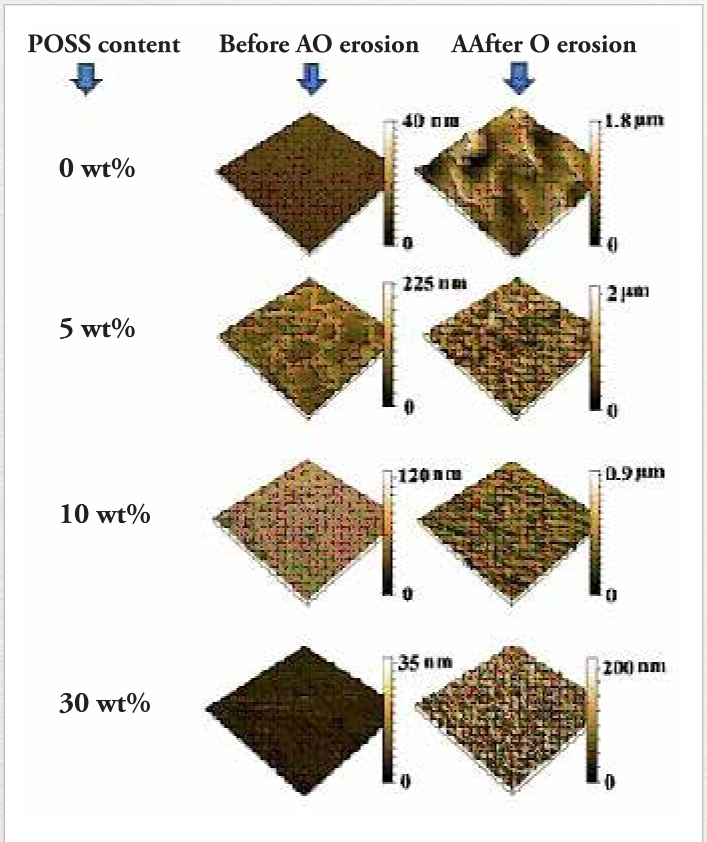
Utilizing ISS as a Test Bed to Validate the Performance of Nano-Enhanced Polymers Subjected to Atomic Oxygen and/or Hypervelocity Impact

University of Mississippi/NASA Human Exploration & Operations Mission Directorate, Space Technology Mission Directorate and Johnson Space Center

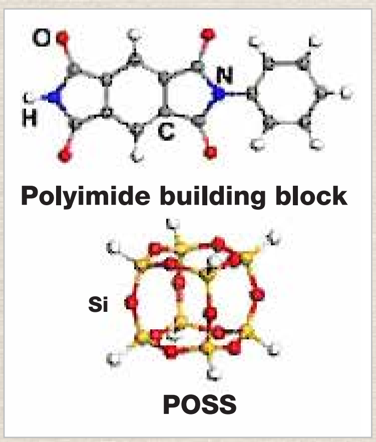
The PIs of this proposal investigated the efficiency of using nano materials to improve the performance of polymeric materials in space applications through a number of ground/ lab tests. The research was part of an EPSCoR research grant titled "Hypervelocity Impact – Environmental Resistant Nano Materials in Space Applications". The research attempted to improve the state of the art of hypervelocity impact-resistant materials and structures by designing and manufacturing a new family of composite materials for space applications. It focused on two debris-related threats to spacecraft survivability: hypervelocity impact and environmental degradation of transparent polymeric materials. The two threats were evaluated in the context of using graphene nanoparticles embedded in POSS modified polymers.

The objective of the proposed research is use ISS as a test bed for evaluating the performance of a new class of nanocomposites manufactured at University of Mississippi under a NASA EPSCoR program and perform relevant ground test experiments required, including flammability, off gassing, and toxicity, before deployment to ISS.

The proposed development and testing will determine the post space exposure performance of a specific type of ultra-lightweight nano-composite sheet that can prove to be a significant improvement in the shock absorption/attenuation and dispersion of modern debris shields. These new shields could be retrofitted on ISS and also used on spacecraft destined for planetary missions.



AFM 3-D images (9.6 x 9.6 μm) of films after AO radiation.



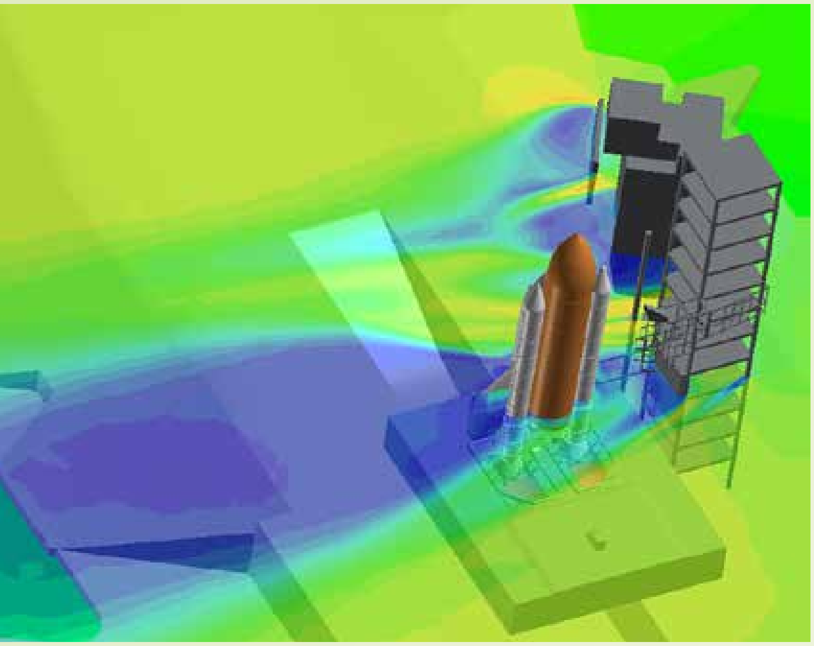
Models of the polyimide building block and POSS.

Dr. Ahmed Al-Ostaz
Science PI
University of Mississippi

Marisabel Kelly
NASA Technical Monitor
Glenn Research Center

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

Mississippi State University and University of Mississippi/ NASA Human Exploration & Operations Mission Directorate and Space Technology Mission Directorate/ Glenn Research Center and Marshall Space Flight Center



The objective of the proposed research is two-folds: (1) establish a multi-institutional aero-acoustics research program in Mississippi by bringing together computational expertise at Mississippi State University (MSU) and experimental expertise at University of Mississippi (UM), which have thus far been developed independently; and (2) develop and validate a high-fidelity fluid-structure acoustic interaction (FSAI) solver capability for the predictions of far-field acoustics and associated structural vibrations, including procurement of state-of-art experimental data for coupled fluid-structure response induced acoustics. The proposed research will build upon existing computational fluid dynamics (CFD) Loci-CHEM, computational aero-acoustics (CAA) Loci-THRUST (an extension of CHEM), and computational structural dynamics (CSD) solvers developed at MSU, and the experimental facilities at UM. The CFD and CAA solvers has been developed under NASA funding, and the former is used extensively at NASA Marshall for launch vehicle, propulsion, and missile systems analysis. The CSD solver has been developed under AFRL funding, and has been extensively validated for transonic flutter analysis and used for design of thermally stressed structures. The proposed research will focus on:

(a) enhancement of the hybrid Reynolds Averaged Navier Stokes (RANS)/Large Eddy Simulation (LES) turbulence modeling capability in Loci-CHEM by developing and implementing an adaptive LES turbulence model based on numerical dissipation; (b) enhancements to the capability and performance of the high-order accurate discontinuous Galerkin (DG) scheme to improve the accuracy and efficiency of Loci-THRUST; (c) development of coupling interface for CFD, CAA, and CSD solvers for time-accurate predictions of acoustics generation, propagation, and associated fluid-structure vibration response; (d) measurement of near- and far-field acoustics and surface loading for a novel test case involving jet interaction with flexible surfaces, which will serve as a state-of-art validation dataset for FSAI solvers; and (e) dissemination of the results to the scientific community via peer-reviewed conference and journal papers.

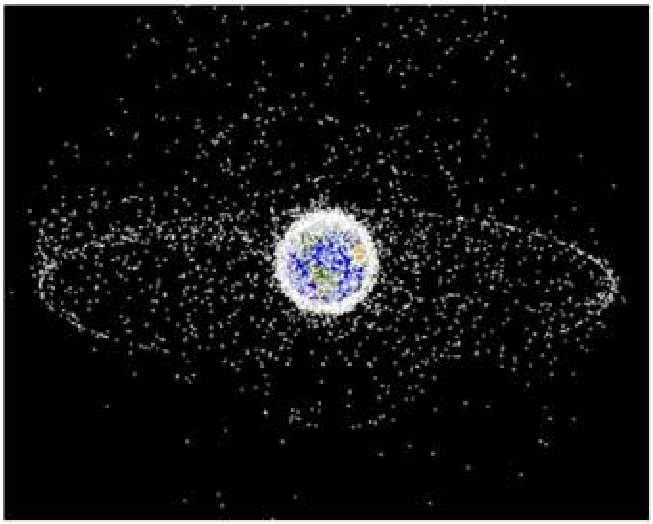
The research will contribute to the advancement of computational modeling via development of a new LES model; and advance fluid-structure interaction flow physics knowledge by improving the understanding of interaction between acoustics and structural-vibration. The advancements of Loci-CHEM will directly influence NASA Marshall Aerothermodynamics team research. The FSAI computational tool will likely have broad applicability, but it should be immediately useful to NASA's launch vehicle development program need of assessment of vehicle vibrations and resonance due to far-field acoustic loads. This computational tool also has the potential to influence the research needs of NASA's Aeronautics Research Mission Directorate (ARMD), who are currently focusing on high-fidelity simulations for the design and analysis of main landing gear noise reduction technologies. In addition, the availability of the new vibro-acoustics experimental data set will impact the broader CFD community by providing additional validation data for emerging FSAI solvers.

The proposed research will further strengthen the ties between researchers at MSU and UM as well as their external partners at NASA. Beyond that, the proposed research activities will bring together existing computational and experimental expertise in Mississippi to build the foundations of a strong aero-acoustics research program. These activities will enhance the competitiveness and sustainability of aerospace research in the state, and improve the Mississippi Space Grant portfolio through the publication of peer-reviewed conference and journal papers. In addition, the project will enhance educational infrastructure through funding of four (4) graduate students, and enhance diversity in STEM disciplines.

Shanti Bhushan
Science PI
Mississippi State University

NASA TMs:
Thomas B. Steva and
Christopher I. Morris, MSFC

Montana Research Infrastructure Development



Computer generated orbital debris graphics displaying currently tracked debris objects. Approximately 95% of the objects in this illustration are orbital debris, i.e., not functional satellites. The dots represent the current location of each item. (Left) Geosynchronous Earth Orbit (GEO) (Right) LEO.

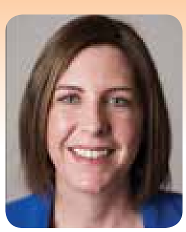
Nategh Award

Tracking and characterizing orbital debris– the "remains" of manmade objects orbiting the Earth– is critical to the safe and reliable operation of spacecraft in Earth orbit. The 2015 NASA Technology Roadmaps, which considers needed technologies and development pathways for the next 20 years, identifies needed technologies to measure and model orbital debris to maintain detailed knowledge of their characteristics in order to predict future collisions and potentially avoid them. As highlighted in the Technology Roadmaps, a critical gap is to track and characterize debris 10 to 100 times smaller than what is currently being tracked; and reduce tracking time to accommodate the larger number of targets being tracked. This research project develops a robust, real-time computational model and algorithm to detect, segment and track moving objects in the presence of observer motion under difficult tasks in space motion tracking. This 1-year seed project will result in optimizing and validating the tracking algorithm recently developed in the PI's lab for the performance goal of 2015 NASA Technology Area (TA) 5.7.1. This preliminary data will be used as a proof of concept to guide the system level design of a novel Orbital Debris Tracking Technology.

This understanding will lay the foundation for subsequent research into vision based autonomous navigation, target recognition and tracking that are targeted at the needs of NASA applications, and will result in a research infrastructure enabling future research into space hardware implementation of the developed algorithms in collaboration with Space Science & Engineering Laboratory at MSU.

https://mus.edu/research/MUS_STPlan_2015.pdf

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



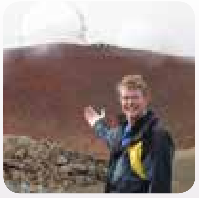
Minerva: A Dedicated Observatory for Exoplanet Science

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

The MINERVA telescopes at Whipple Observatory outside Tucson, Arizona. The University of Montana telescope is second from the right. The MINERVA telescopes can work together by pooling their collected light together or work independently. They are remotely controlled.

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 ScI McCrady.



Dr. Nate McCrady
Science PI
University of Montana, Missoula

Dr. Charles Beichman
Technical Monitor
Jet Propulsion Laboratory

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

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

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

Willie Williams
NASA Technical Monitor
Johnson Space Center

The Artemis Prototype currently being tested on the ISS.

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

Two recent Electrical Engineering graduates working with the short-wave infrared polarimeter they helped build as their senior project at Montana State University.

Dr. Wataru Nakagawa
Science PI
Montana State Untiversity

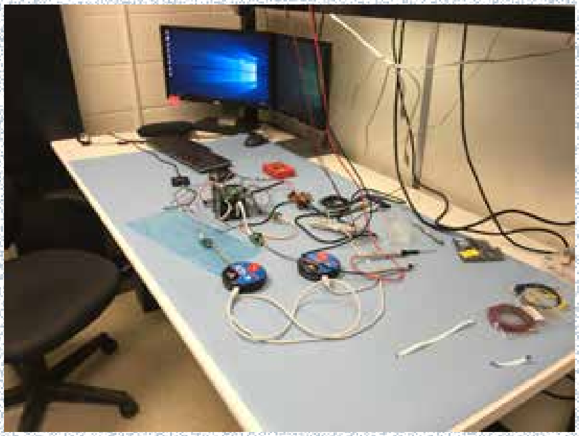
Dr. David J. Diner
NASA Technical Monitor
Jet Propulsion Laboratory

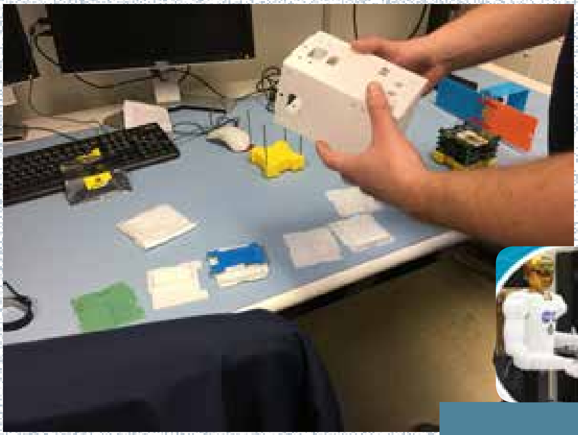
In this project, we are developing new optical devices and instruments to remotely determine the properties of clouds in the atmosphere. These properties influence climate, weather, and military surveillance. The project is providing students with new skills that prepare them for both employment and further education. As an example, this photograph shows two recent graduates who worked on this project as seniors before graduating and moving on to new professional opportunities made possible in part by their research experience. Both students received electrical engineering bachelor's degrees in May 2017 from Montana State University (MSU). Benjamin Moon (left) will start a new job in June at a local laser manufacturer (Quantel USA) and Carol Baumbauer (right) is next going to pursue a Ph.D. at the University of California – Berkeley. Even though Bozeman, Montana is a fairly small town (population approximately 40,000), it is home to more than 30 companies working with lasers and optical systems. Most of these companies were started as technology spin-offs from MSU, often by MSU graduates interested in remaining in Montana. At Montana State University, research is helping create new companies, new jobs, and new knowledge.

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

Montana State University, Bozeman/International Space Station/Human Exploration & Operations Mission Directorate, Space Technology Mission Directorate/Johnson Space Center

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

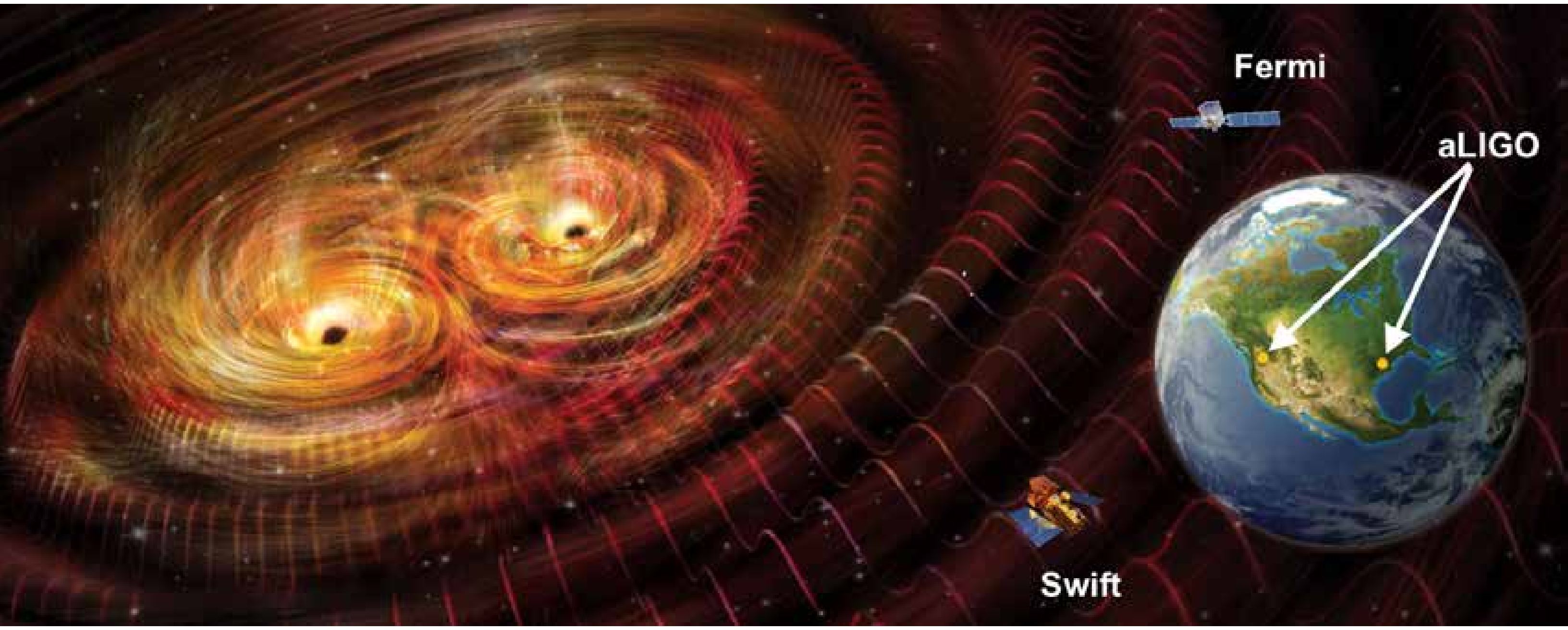




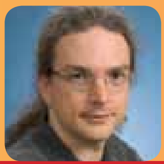
Dr. Broc
Sc
Associate Professor
Montana State University

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

Science Mission Directorate/Goddard Space Flight Center, Marshall Space Flight Center, Jet Propulsion Laboratory



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



Dr. John G. Baker
NASA Technical Monitor
Goddard Space Flight Center

North Dakota Research Infrastructure Development

Assessing the Effects of Zero Gravity on the Mechanical Properties of Recombinant Spider Silk Fibers

By Amanda Brooks

The variety of potential applications spawned from spider silk is exciting and almost endless, garnering the interest of scientists and popular culture. Unfortunately, since spiders cannot be farmed, we must rely on biotechnology to realize its promise. Here, my team developed an artificial spinning device that mimics the spider's natural spinning system for the commercial production of tunable silk fibers. Using a combination of computer simulations and advanced 3D printing has allowed us to not only advance the field but also to have a broader economic impact in the state of North Dakota, as we were recently awarded a Phase 1 venture grant to start a business to commercialize spider silk spinning technology. Furthermore, I have created an interdisciplinary team of students to engage in an authentic, mentored research experience for which they are able to receive academic credit. This student-led team recently established a business, Spinthesis, to commercialize synthetic spider silk. They have also placed in several business pitch competitions and received one business development grant. The value of this exposure to the modern research ecosystem is distinguishing our program at NDSU and in the region, earning us popular media coverage and facilitating K-12 STEM outreach efforts.

North Dakota State University assistant professor in pharmaceutical sciences, Amanda Brooks, presents the golden orb-weaver silk, which is at the center of the Brooks lab research program.

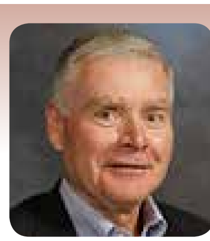
Above: Pre-pharmacy student Briana Breemeersch works in Dr. Brooks' lab to forcibly silk spiders and produce the raw materials necessary for spinning.

Left: Mechanical engineering Master's student Brad Hoffmann mounting a silk fiber on the new Instron microtester. The purchase significantly expands the capabilities of the Brooks lab.

https://www.ndsu.edu/pubweb/~yochoi/

https://sites.google.com/a/ndsu.edu/dongcao/home

Dr. James Casler
ND EPSCoR Director
University of North Dakota
Grand Forks



ND

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

Beginning manufacturing of structure for Plant Production Module.

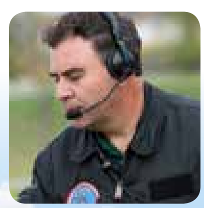
Stringers and aluminum skin installed in Plant Production Module.

Thermal Insulation of modules.

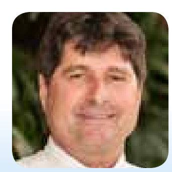
The University of North Dakota (UND) Human Spaceflight Laboratory is working to develop a Multi-Purpose Research Station in North Dakota designed to expand NASA-relevant research opportunities for students and faculty within the state, as well as project collaborators. Four modules are currently being constructed and added to the existing habitat. These modules include geological studies, extra-vehicular activity (EVA) research and operations, plant production studies, and human factors research (both physiological and psychological studies).

The research includes a collaborative effort among numerous departments throughout UND campus and several NASA centers. Three crewed analog missions have been conducted (one 30-day and two 10-day missions), with additional missions planned following the integration of the new modules.

North Dakota offers a unique environment for this type of research. The climate extremes are ideal for testing performance of equipment designed for similar conditions on other planetary surfaces, and there is no NASA center or related industry in the area. These factors make North Dakota an optimal location for these simulation studies, 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
Department of Space Studies
University of North Dakota

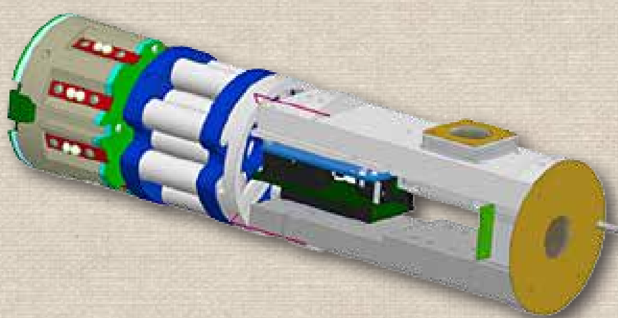


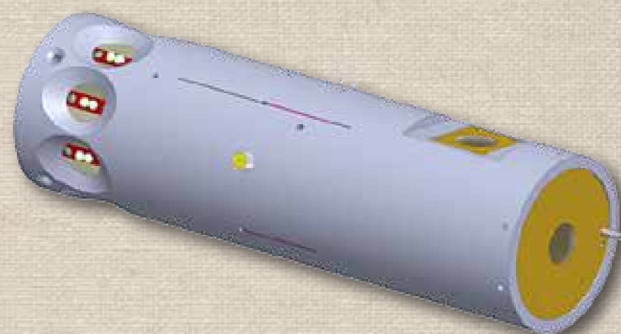
Mr. Douglas Gruendel
NASA Technical Monitor
Kennedy Space Center

Four new modules already at the site.

New Hampshire Research Infrastructure Development

The models shown in the figure were developed by postdoctoral researcher T Max Roberts at Dartmouth College. They illustrate the final design of the small payloads used on the Isinglass mission. The design combines, at close quarters, thermal plasma sensors, an inertial measurement unit, battery systems, a local communications system, an Arduino-based spacecraft bus, and an LED beaconing system which is recorded by ground-based auroral cameras. The photograph shows the full array of payloads and instrumentation before delivery to the NASA Wallops Flight Facility for integration and test.

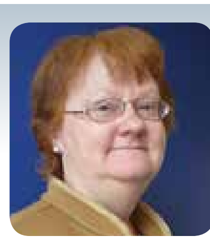




http://www.nasaepscor.unh.edu/

https://www.nasa.gov/feature/Wallops/2017/1-down-3-to-go-sounding-rocket-flies-in-alaska-to-study-aurora

Antoinette B. Galvin
NH EPSCoR Director
University of New Hampshire



Responsive Autonomous Rovers to Enable Polar Science

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

Dartmouth College Ph.D. student Austin Lines examining ground penetrating radar data acquired from automated survey with the solar-powered Cool Robot, Summit Greenland July 2017.

Dartmouth College Ph.D. student Joshua Elliot (left) and Austin Lines (right) watching the Cool Robot perform a radar survey, Summit Greenland July 2017.

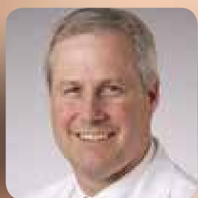
Dr. Laura Ray
Science PI
Professor, Dartmouth College

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

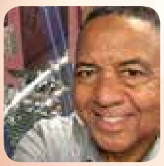
Scientists study climate change by observing the Earth from remote satellites and from permanent ground stations sparsely distributed through the Earth's ice sheets. These observations provide data from which scientists develop models to predict the effect of climate change on sea level. This project fills in the gap between point observations from ground stations and remote sensing satellites by using a solar-powered robot to measure important characteristics of snow and ice. In this way, measurements made by the robot can ground truth measurements made remotely. We develop instruments for measuring the amount of the sun's radiation that is reflected by the surface; and accumulation and compaction of snow and ice, which relate directly to the mass balance or net mass accumulated in the Earth's largest ice sheets. These instruments are deployed on Dartmouth's solar-powered Cool Robot. The project involves researchers at Dartmouth College, NASA, the University of New Hampshire, and the U.S. Army Cold Regions Research and Engineering Laboratory, and Dartmouth College graduate and undergraduate students. During our second year of the project, we completed the development of two instruments. The first instrument measures snow specific surface area, a snow property that is directly related to metamorphosis of snow and thus to mass balance. The second instrument is a ground penetrating radar system that images the upper layers of snow to determine accumulation rates and compaction rates. Each of these measurements impacts our ability to accurately predict the mass accumulating or lost from ice sheets.

ISS-Time Course of Microgravity-Induced Visual Changes

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



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



Willie Williams
NASA Technical Monitor
Johnson Space Center

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

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

Nebraska Research Infrastructure Development

NASA Nebraska EPSCoR continues to build a record of exemplary success, demonstrating its commitment to sustaining long-term, nationally competitive research capabilities. The Nebraska Research Infrastructure Development (RID) program supports and maintains unique research activities addressing both NASA and Nebraska priorities. The statewide competitive mini-grant program leverages resources to develop strong collaborative relationships with NASA and industry partners and to produce research outcomes that positively impact Nebraska's competitiveness. Research collaborations this year include NASA scientists, industry, and academia. A Ph.D. student was hosted at NASA for an internship.

Last year, Creighton faculty member Jack Gabel was funded for a faculty fellowship at NASA Jet Propulsion Laboratory (JPL). This year, Gabel received a seed grant to build on that research. His project resulted in collaborations with JPL and Caltech studying fundamental questions about quasars and their observed mass outflows.

Five seed grants of up to $20,000 were awarded to faculty members at the University of Nebraska-Lincoln, University of Nebraska Medical Center, University of Nebraska at Omaha, and Creighton University. Additionally, four researchers funded in Year 1 completed their efforts. Results of these activities will continue to inform decisions about human exploration and the development of future technologies for scientific research.

Artist's rendering of the accretion disk in ULAS J1120+0641, a very distant quasar powered by a black hole with a mass two billion times that of the Sun.[1] Credit: ESO/M. Kornmesser

Dr. Scott Tarry
NE EPSCoR Director
University of Nebraska at Omaha

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

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

Detecting neutron radiation: The Adventures of Solar Neutrons

by Peter Dowben, Nicole Benker

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

Now that the DANSON experiment has returned from the ISS, we are looking for radiation damage to the structure of the crystals and comparing the electronic characteristics of the diodes from before and after their journey. We hope that what we learn with this experiment will help to advance the development of small, effective neutron detectors for use on Earth and in space. By examining the distribution of neutron captures in our moderator, we also hope to catch a glimpse into the nuclear fusion processes that fuel our sun!

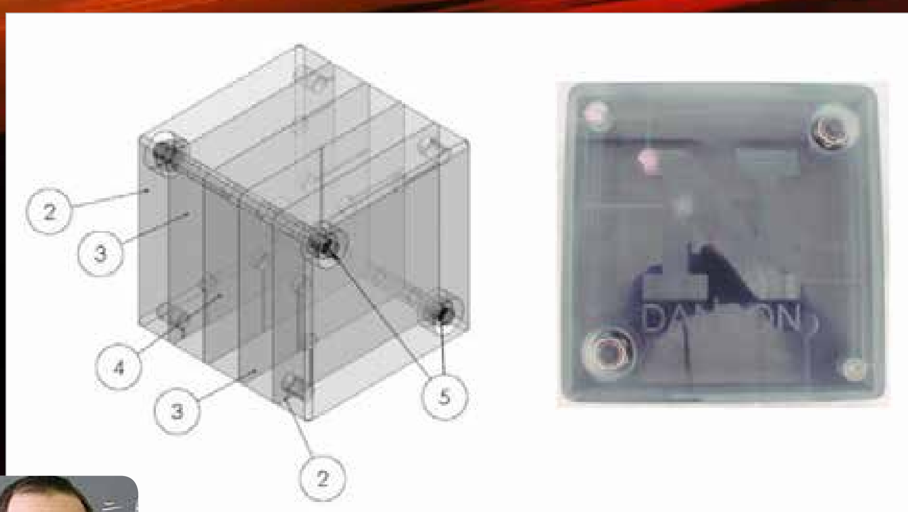
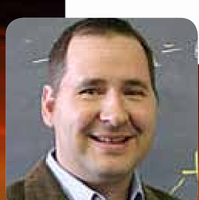


Fig. 1 The DANSON moderator cube diagram and photo. By encasing the detector elements in a neutron-moderating plastic, we can "slow down" the neutrons enough for the detectors to capture them.



Prof. Axel Enders
Science PI
University of Nebraska, Lincoln

Willie Williams
NASA Technical Monitor
Johnson Space Center

For the full article, see the Post:

https://funsizephysics.com/adventures-of-solar-neutrons

In addition there are two videos of the project to be linked.
A short version and a long version.

Long/Detailed Video: https://youtu.be/vc7omzvlXQ8

Short/General Public Video: https://youtu.be/KSAhojGglVo

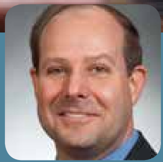
Highly Permanent Biomimetic Micro/Nanostructured Surfaces by Femtosecond Laser Surface Processing for Thermal Management Systems

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

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

Sarah Wallis (left) and Anton Hassebrook (right) working on an experiment to study the heat transfer characteristics of a metal surface functionalized using femtosecond laser surface processing.

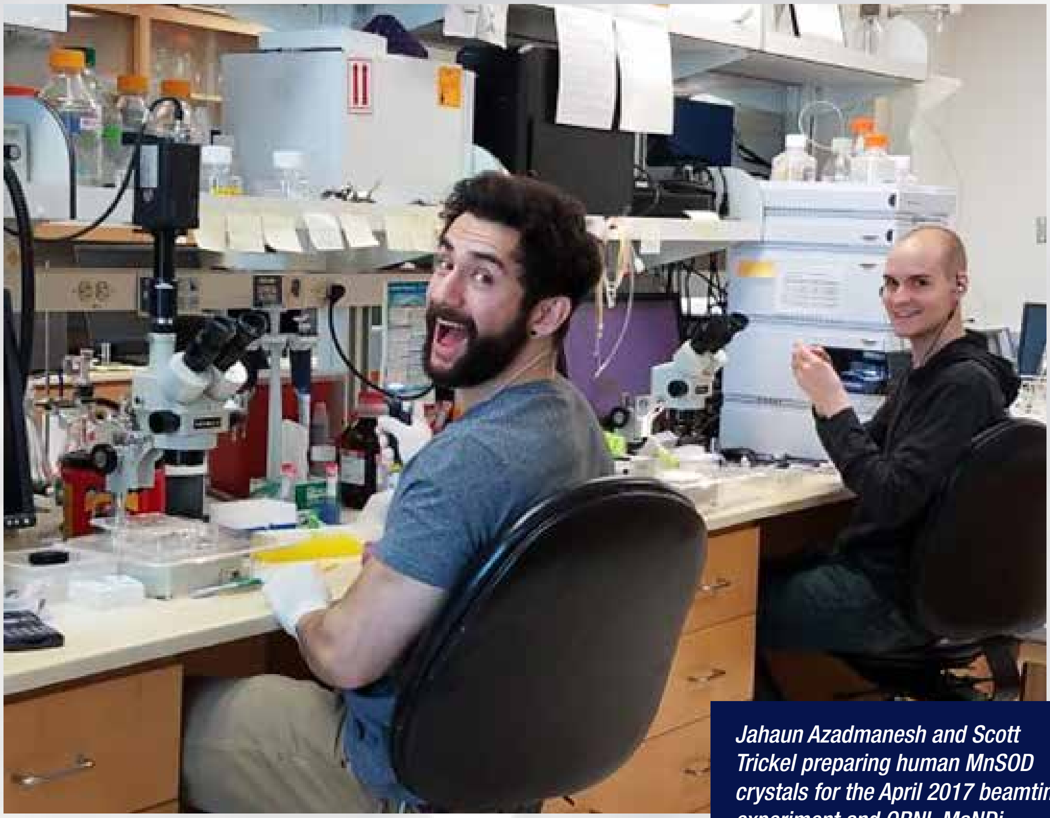
Prof. George Gogos
Science PI
University of Nebraska Lincoln



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

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



Jahaun Azadmanesh and Scott Trickel preparing human MnSOD crystals for the April 2017 beamtime experiment and ORNL MaNDi.

Radiation on earth and that encountered by astronauts and natural cellular metabolism produce reactive oxygen species (ROS) that damage the macromolecules of life and deteriorate human health. This research studies how the macromolecular defenders, or enzymes, within our bodies protect us against ROS and protect us from disease. This research will reveal the atomic basis for the enzymatic mechanisms of protection. This basis will be provided with neutron crystal structures. Outstanding progress has been made towards neutron data collection on perdeuterated crystals, that are essential for our overall goal, have been achieved. Our team of technical staff and students achieved two publications this year and wrote a proposal to NASA EPSCoR for microgravity environments on ISS that will allow us to grow large volume crystals for this project that will be of superior quality to crystals grown on Earth.

Dr. Gloria Borgstahl
Science PI
Professor, Eppley Cancer Research Institute
University of Nebraska Medical Center

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

Growth of Large, Perfect Protein Crystals for Neutron Crystallography

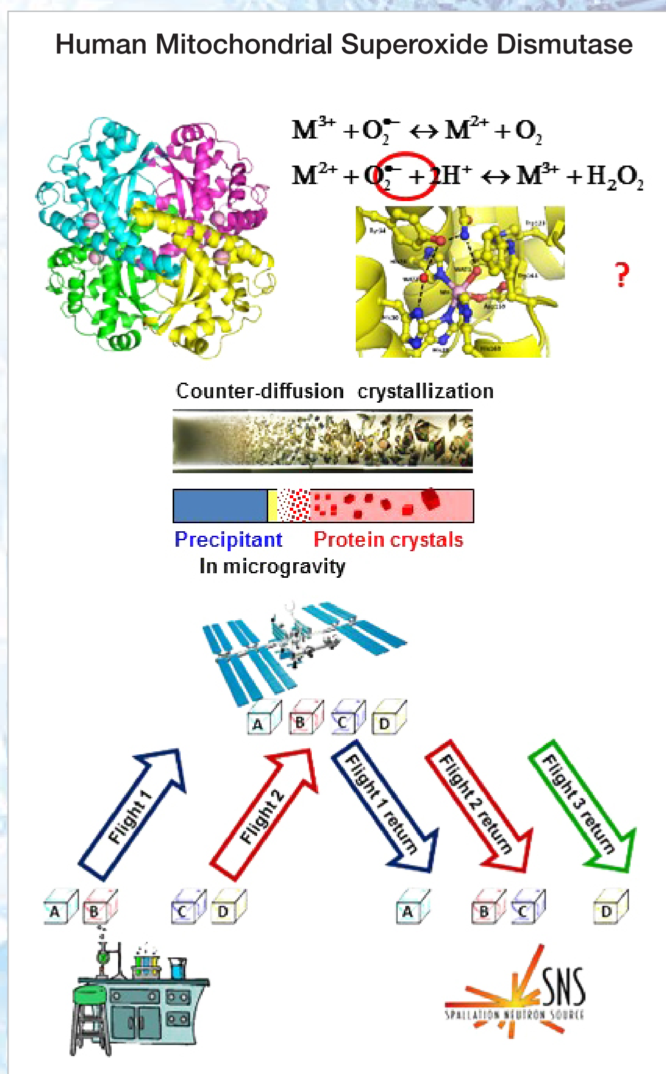
University of Nebraska, Omaha/Johnson Space Center, Science and Human Exploration Mission Directorate, International Space Station

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 defense against propagation of damaging oxidative reactions through elimination of superoxide. Superoxide is generated through normal metabolism and/or ionizing radiation. Each catalytic cycle dismutes two molecules of superoxide to oxygen and hydrogen peroxide via cyclic reduction and oxidation half reactions using the active site metal ion. Humans have Cu/ZnSOD in the cytosol and extracellular spaces and MnSOD in their mitochondria. Mutations in SOD lead to aging and degenerative diseases such as amyotrophic lateral sclerosis, diabetes, and cancer.

This flight proposal will provide the critical crystal samples needed for a detailed study of human SOD. Despite the biological and medical importance of SOD, the complete enzymatic mechanism is still unknown. Precise structural data are needed. 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 human MnSOD including structural intermediates and mutants will be the targets for large volume crystal (≥ 1mm3) growth for structure determination by neutron macromolecular crystallography (NMC). The quiescent environment afforded by microgravity is known to grow crystals large enough for neutron studies; not only are they large but their quality approaches perfection. In 2001, the Borgstahl laboratory successfully grew large crystals of SOD using microgravity conditions on the International Space Station (ISS). With NASA's renewed interest in implementing the microgravity environment on the ISS for protein crystal growth we would like to move forward with these exciting early microgravity crystallization results for SOD. Existing crystallization hardware that uses the Granada Crystallization Boxes (GCB) for capillary counterdiffusion protocols will be used to achieve these goals. A microgravity environment is essential to form a stable supersaturation gradient to obtain the large, high quality crystals required for NMC. Then NMC will be performed with collaborators at Oak Ridge National Laboratory (ORNL). The principal outcome will be to identify the role of hydrogen atoms in enzymatic activity, discern superoxide from peroxide, and water from hydroxide ion by their protonation state and decipher a structure-based mechanism for human MnSOD more precisely than from previous X-ray crystallographic models determined from Earth-grown crystals. These contributions will also provide criteria needed for the protein engineering of desirable properties into enzymatic metal centers for proton coupled electron transfer.

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

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



New Mexico Research Infrastructure Development

Modeling of Microcracking in 3D Woven Composites During Processing

The main goal of the project "Modeling of Microcracking in 3D Woven Composites during Processing" (10/01/2016 – 12/31/2017) is to identify the most important geometric parameters of 3D woven reinforcements contributing to microcracking of the material during manufacturing. To achieve the goal, a novel numerical approach is proposed. In the first months of the project, we developed the most realistic geometric representation of the complex "1x1 orthogonal" reinforcement architecture to date. The architecture was previously observed by the manufacturer to have the highest tendency to crack among all currently utilized configurations of 3D woven composites. We used an iterative refinement procedure based on digital fabric mechanics simulations and three-dimensional microtomography data. Our unique geometric model combined with non-linear finite element simulation of the composite processing has already provided us with an unprecedented insight into the factors contributing to microcracking. The project has provided the support for training of one PhD candidate in the area of high-performance composite geometric modeling and simulation. In addition, the research assistant is involved in preparation of the results for dissemination via professional journal papers and conferences. The project also provides an exciting opportunity for an undergraduate student to learn the basics of finite element analysis of composite materials via the individual course "ME 400: Undergraduate Research."

Borys Drach (Principal Investigator) and Dmytro Kuksenko (Research Assistant) discussing preliminary numerical simulations.

http://www.sciencedirect.com/science/article/pii/S1007570415004141

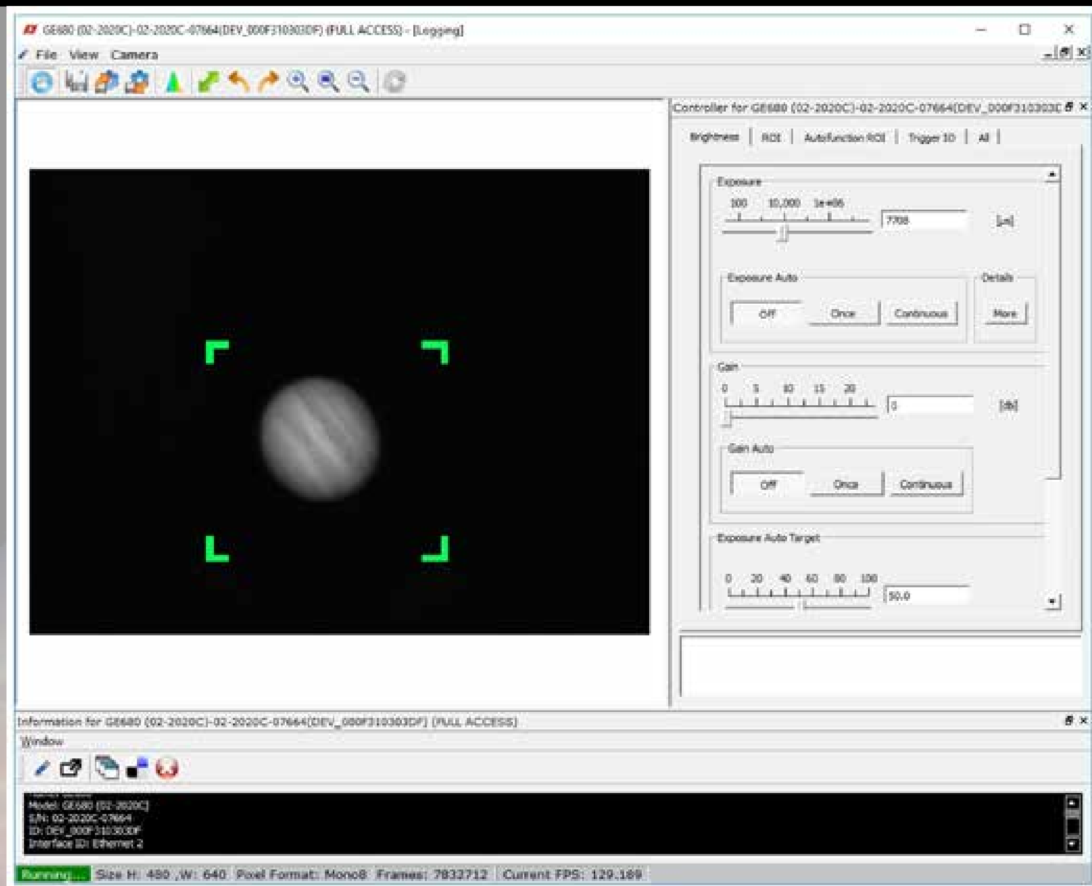
http://www.sciencedirect.com/science/article/pii/S0022460X15007002

Patricia Hynes
NM EPSCoR Director
New Mexico State University

NM

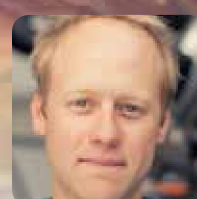
Jovian Interiors from Velocimetry Experiment in New Mexico (JIVE in NM)

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

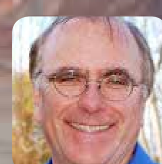


A unique snapshot of Jupiter captured by a solar telescope. A large collection of such images will be used in this project to measure Jupiter's pulsations for the first time.

Measurements of oscillations of Jupiter have eluded astronomers for over 40 years. While they are routinely observed on the Sun, this giant planet requires sensitive, optimized instrumentation. New Mexico State University is leading an international team of researchers in the Jovian Interiors from Velocimetry Experiment (JIVE) in New Mexico, a ground-based instrument and part of a global network that will decisively measure oscillations on Jupiter for the first time. Its results will allow for us to peer inside the planet understand its interior structure and composition. Initial instrument development and installation is complete at the Dunn Solar Telescope in Sunspot, NM, operated by the National Solar Observatory. The photo shows a real-time snapshot of Jupiter captured by a CCD camera connected to a novel optical interface at the solar telescope. One sees a centered, rather clear image of the planet, with atmospheric clouds and features very prominent. A large collection of images such as these will be obtained and analyzed in the coming year to nd those all-important oscillations.



Dr. Jason Jackiewicz
Science PI
New Mexico State University



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

Virtual Telescope for X-ray Observations

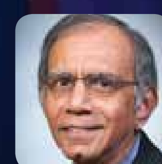
New Mexico State University/NASA Goddard Space Flight Center, Science Mission Directorate, International Space Station

Small Satellites Work Together for Big Science

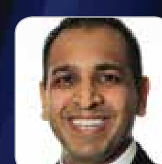
Dr. Steve Stochaj
Science PI
Klipsch School of Electrical and Computer Engineering
New Mexico State University

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

Kyle Rankin, presenting the paper entitled VTXO - VIRTUAL TELESCOPE FOR X-RAY OBSERVA- TIONS at the 9th International Workshop on Satellite Constellations and Formation Flying in Boulder, CO. Kyle is a PhD student in the Aerospace program at New Mexico State University. He is working as a NASA Intern at Goddard Space Flight Center during the Summer of 2017.



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

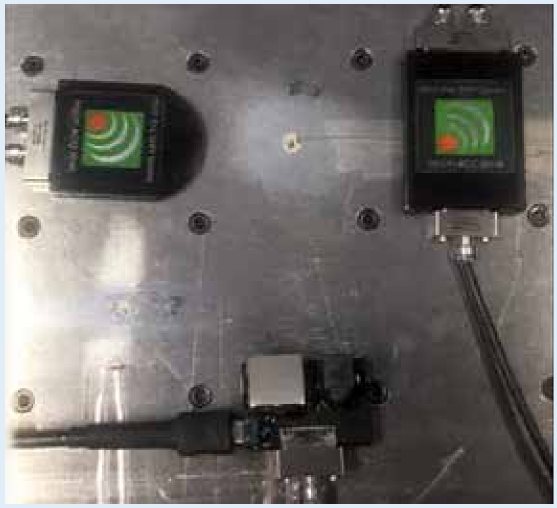


Neerav Shah
NASA Co-Technical Monitor
Associate Branch Head
Navigation and Mission Design Branch
NASA Goddard Space Flight Center

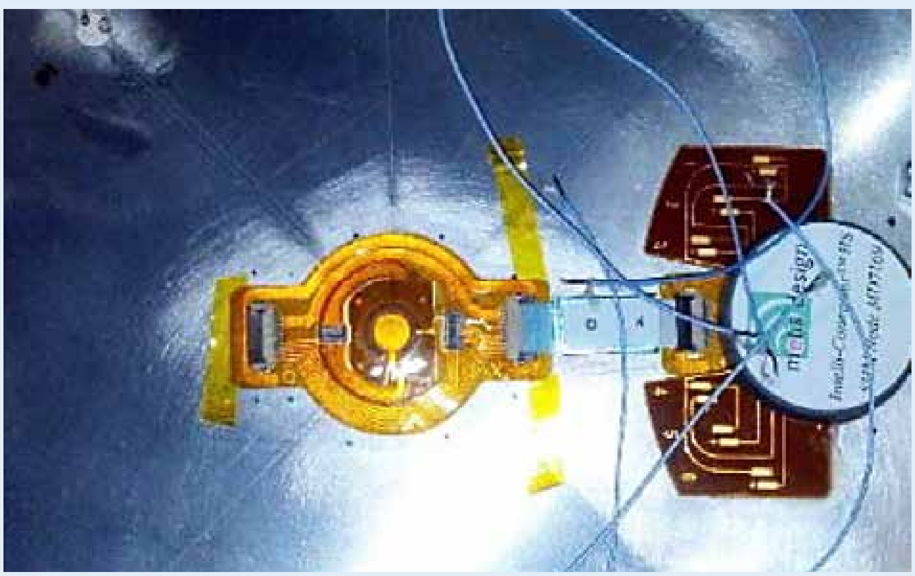
In Orbit Structural Health Monitoring of Space Vehicles

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

(a)



(b)



(c)

Metis Design hardware for elastic wave propagation and impedance tests: (a) top – Accumulation node and bottom with semicircular cap - signal generation/acquisition node, (b) both nodes are shown along with communication adapter on a realistic satellite panel, (c) older version of hardware flown on an SL8 sub-orbital mission (metisdesign.com).

A significant step in addressing the safety of space vehicles is development and testing of the flight information recorder, or "black box". It is envisioned, that a structural health monitoring system (SHM) would be an integral part of the "black box" and would record information on structural integrity during all stages of spaceflight. In this project, the team proposes to investigate the effects of the space environment on piezoelectric sensors – active elements of SHM, to explore structural vibrations in microgravity and to demonstrate the feasibility of SHM during long term space missions. To achieve this goal, 1U and 3U payloads (depending on space available) are proposed that will fit into a Nanoracks system outside of the ISS. Mission duration is expected to be less than 1 year (1 year maximum) with minimum of crew time. The power requirement is estimated to approach a few watts. The data collected in the proposed experiment would also benefit the FAA Center for Commercial Space Transportation. The principal investigator is a mechanical engineering professor that has previously participated in a NASA EPSCoR project and launched several suborbital payloads through the NASA Flight Opportunity Program.

Science PI: Andrei Zagrai • NASA Technical Monitor: John D. Lekki

Autonomous Structural Composites for Next Generation Unmanned Aircraft Systems

New Mexico Institute of Mining and Technology, University Of New Mexico, New Mexico State University/ Armstrong Flight Research Center, Aeronautics Research and Space Technology Mission Directorate

In this proposed study, PIs will devise autonomous structural composites capable of self-powered delamination detection in FRP composites and harvesting energy. The autonomous composites will be fabricated by embedding multifunctional thin films into structural FRP composites. The multifunctional thin films will be designed to perform self-powered strain sensing as well as energy conversion of ambient vibration to electrical energy. Research objective is three-fold. First, the copper-doped zinc sulfide (ZnS:Cu)/poly(3-hexylthionphene) (P3HT)-based multilayered thin films will be designed and optimized through theoretical and experimental studies. ML light emission of the ZnS:Cu-based layer and the photoactive P3HT-based layer will judiciously designed to exhibit multifunctional capability. The material and geometric design of the multilayered thin films will be optimized through in-depth studies for enhancing sensing capability, energy conversion efficiency, and micro-/nano-mechanical performance. Second, autonomous structural composites will be fabricated by embedding the designed ZnS:Cu/P3HT-based thin films into FRP composites. Multifunctional capabilities (i.e., self-powered delamination detection and energy harvesting) of the autonomous structural composites will be validated under space environmental effects (e.g., thermal gradients, space radiations, and blast, among some others). Last, Aerostructures Test Wing (ATW) will be fabricated using the developed autonomous structural composites to be tested at Flight Loads Lab (FLL) at NASA Armstrong Flight Research Center (AFRC) using Ground Vibration Test (GVT) setup. The autonomous delamination detection capability of the autonomous ATW will be validated through vibration-based SHM framework (e.g., natural frequency shift and mode shape changes) in mid-range vibrational loadings. Furthermore, energy harvesting capability of the autonomous ATW will be validated under ambient vibrations. Space environmental effects will be studied on the performance of the autonomous ATW in the state-of-the-art facilities at FLL at NASA AFRC.

Donghyeon Ryu, Ph.D.
Science PI
Assistant Professor in the Dept. of Mechanical Engineering
New Mexico Tech

Alexander Chin
NASA Technical Monitor
Aerostructures Branch
Armstrong Flight Research Center

Nevada Research Infrastructure Development

UGV-UAV Hybrid System for Unstructured Environment Exploration

The aim of this project is to develop a framework to enable cooperative control and learning of multiple UGVs+UAVs which can be applied for many applications such as civil infrastructure inspection, construction site management, etc. In order to develop this cooperative controllearning framework, we first focus on the development of an autonomous ground robot (see Figure 1). We have done some initial tests of this robot for UNR parking garage inspection (to find cracks, corroded steel rebars, and delamination inside concrete structures). The robot needs further development of localization and navigation algorithms to make it autonomous. In addition, the integration software of None-Destructive Evaluation (NDE) sensors need to be built to allow the robot to automatically collect data for inspection. Once the robot is fully completed we will work on the collaborative framework of UAVs+UGVs for multi-application purposes (e.g., construction site management, bridge inspections and similar infrastructure on Earth and for NASA's Mission to Mars). The significance of this project lies in its transformative research approach and potential broad economic and societal impacts.

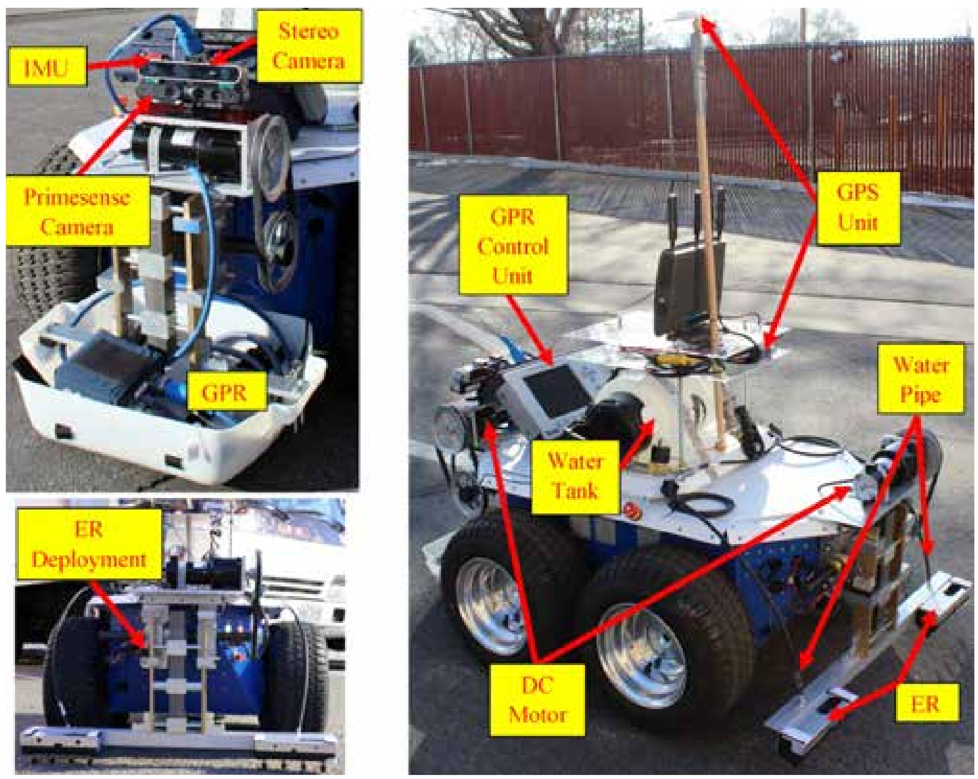
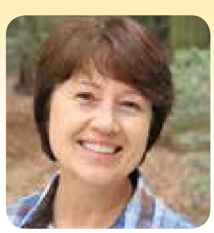


Figure 1. Multi-platform inspection robot (a) Front view with equipped sensors; (b) Side view with equipped Non-Destructive Evaluation (NDE) sensors.

(a) **(b)**



Lynn Fenstermaker, Ph.D.
NV EPSCoR Director
Nevada System of Higher Education

NV

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

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

Dr. Kumar Krishen
NASA Technical Monitor
Johnson Space Center

Ionomer precursor pellets drawn into filament.

The Universities of Nevada Las Vegas (UNLV) and Reno and the Truckee Meadows Community College are focused on development of ionomer materials with improved thermal properties and good ion-conductivity for space applications. We studied the material changes due to environmental effects, specifically thermal processes that can be useful for additive manufacturing (3D printing) of ionomer materials. The filament was successfully made out of Aquivion® precursor pellets with an effective extruder. This filament will be used in the future for 3D printing of various shapes, including those that will be of benefit to space exploration and development of habitats on the Moon and Mars.

The accomplishments in this project year are very significant and demonstrate a promising ionomer, Aquivion®, that can be used for IPMC robotic applications. Aquivion® presents researchers with possible significant performance improvements of this smart material. New teaching material was developed in parallel with this project and will help ensure that the next generation of students have access to the latest developments in ionomer materials. In Fall 2016, as part of ENGR 100 course, an updated demonstration laboratory was developed for Truckee Meadows Community College students to learn and understand the potential applications of IPMCs. The demonstration was accompanied with a presentation that explained IPMCs and showed some of the data results provided by UNLV/UNR.

Building Capacity in Interdisciplinary Snow Sciences for a Changing World

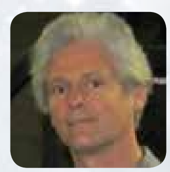
Desert Research Institute/NASA Goddard Space Flight Center, Ames Research Center, Science Mission Directorate

Improving Snow Cover Estimates in Forested Terrain

Seasonal snow cover is a key component of the hydrologic regime in many regions of the world, especially in the semi-arid Western USA, where large human populations depend on mountain snowpack for water. Quantifying snow cover accurately in these regions is important, yet challenging in mountainous forested terrain where trees and topography hamper accurate data acquisition. Currently, this work is accomplished using satellite data with global coverage in which snow cover algorithms assume that fractional snow-covered area under the canopy is the same as that in canopy openings. In-situ observations indicate otherwise, therefore there is a need to improve the under-canopy correction of snow cover (Figure 1). Thus, through strategic collaborations with NASA's Airborne Snow Observatory and the Airborne Visible/Infrared Imaging Spectrometer platforms, Dr. Adrian Harpold (Co-I from UNR) is leading the coordination of overflights with on-the-ground observations to compare snow cover both under and out of the forest canopy at Sagehen Experimental Forest in the Northern Sierra Nevada, California. Analyses and modeling of these multi-scale, high-density data sets are underway. Our long-term goal is to correct current overestimates of snow covered area in the western U.S. by accounting for the effect of forest canopy. This has far-reaching implications for hydrologic forecasting and improving scenario predictions especially during drought conditions such as was experienced recently across the Western USA.

Figure 1. Infrared radiometers were mounted in an isolated tree to measure the surface temperature of the tree and the snow during coincident thermal imagery overflights by a UAS and airplane.

Science PI Alison Murray, in a snow pit up on the Sierra Nevada crest (near Mt. Lincoln) where samples were collected on a monthly basis to determine snow physical characteristics, levels of dissolved nutrients, dust, and the diversity of life in the snowpack.



Dr. Brian Cairns
NASA Technical Monitor
Goddard Space Flight Center

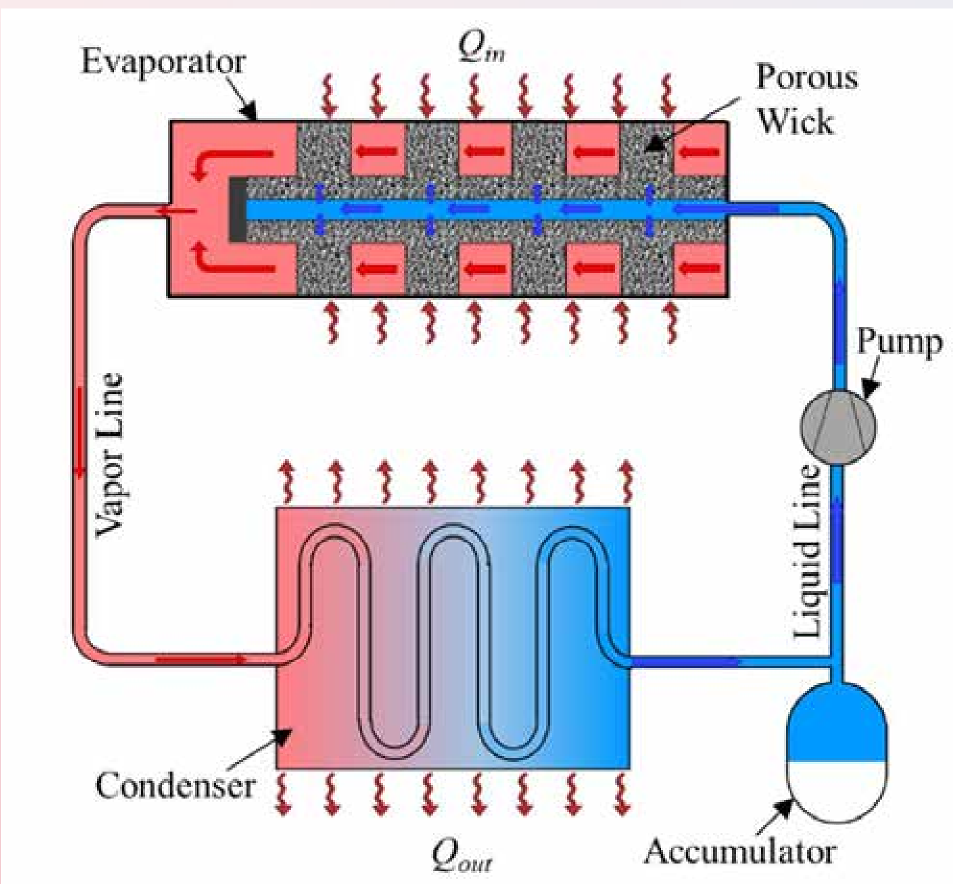
Advanced Transport Technologies for NASA Thermal Management/Control Systems

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

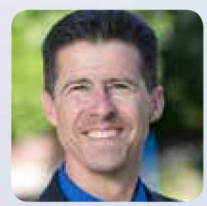
The goal of this research is to develop reliable, light-weight and low-power thermal management systems for precision temperature control of critical NASA electronic systems. This research develops high-performance, two-phase mechanically-pumped fluid loop (2φMPFL), which is illustrated in the figure below.

The 2φMPFL can maintain the temperature of several components to within precise limits even if their heat generation varies by a wide amounts. It can deliver that energy to fuels or other components that require it with minimal temperature difference between the source and sink, even when those components are separated by relatively large distances. The porous metallic wick used in the heatacquiring and isothermalizing evaporator is a key component of the 2φMPFL system, which influences the overall architecture. The porous metallic wick drives the liquid to the heated surfaces of the evaporator body for vaporization and keep the liquid and vapor phases separated.

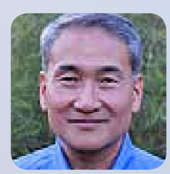
Ongoing research efforts includes development of an experiment to study two-phase fluid flow in porous media to benchmark computational fluid dynamic (CFD) simulation tools, and develop a scalable and performance-effective technique for enhancing steam condensation heat transfer rate and critical heat flux limit.



Two-phase mechanically-pumped fluid loop system under-development at UNR and UNLV.

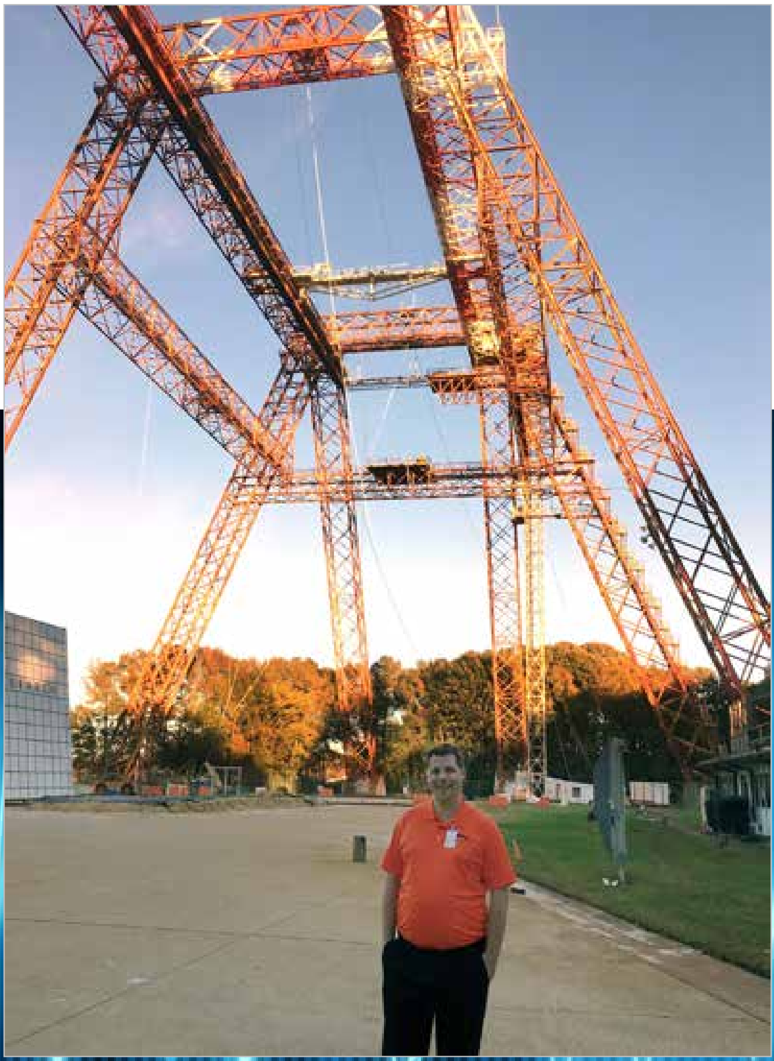


Miles Greiner, Ph.D.
Science PI, ASME Fellow
University Of Nevada, Reno



Dr. Eric Sunada
NASA Technical Monitor
NASA Jet Propulsion Lab

Oklahoma Research Infrastructure Development

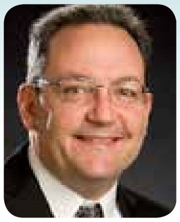


OSU student Anthony Hassett pictured in front of the Splash Impact Basin at NASA Langley Research Center.

Dr. Richard Gaeta, Research Professor at Oklahoma State University School of Mechanical and Aerospace Engineering collaborated with Dr. Douglas Nark, Senior Research Engineer and Dr. Nikolas Zawodny, Research aerospace Engineer from NASA Langley Research Center to investigate the possibility of partnership for investigative research into the topic of Unmanned Aerial Systems (UAS) low Reynolds number propeller aeroacoustics. OSU engineers are investigating methods for the rapid and accurate prediction of these noise sources and their control. It is expected these sources will become an important source of community noise in coming years, as UAS adoption increases. Research currently focuses on the prediction of broadband noise sources, as current methods for mitigating propeller noise can lead to broadband sources being commensurate with tonal noise. State of the art in prediction currently captures tonal noise sources well; however, for broadband current methods are computationally expensive, limited, or of uncertain accuracy. Development and improvement of improved methods is seen as highly important as it will assist in the inclusion of UAS platforms into the national airspace, provide further insight into influence and control of noise, and help to drive the Oklahoma and national economy.

http://epscor.oknasa.org/

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



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

Outdoor experiments on our lab's balcony confirm theoretical predictions, and these student-led hands-on tests are needed before fight testing.

Imagine the difference between a modern smart phone and a cell phone that existed five to ten years ago. The change is amazing, as consumers enjoy a variety of new functions from these newer phones. These include surfing the web, watching videos, etc. Similarly, as the demands of radar systems continue to increase, the need for more sophisticated radar architectures and transmitted waveforms is becoming more urgent. To elaborate, for phased array radar systems, high-power amplifiers are being placed at each element of the antenna array. For instance, there are 32 amplifiers in the radar of this NASA project. To maximize each amplifier's efficiency, the amplifier can be driven into compression where the efficiency is highest, but non-linearity in this region will cause distortion. By utilizing digital pre-distortion (DPD), the generated waveform is distorted by roughly the inverse of the amplifier response, so that the total system behaves as a linear system and the output of the amplifier is the ideal response. In summary, the technology here will allow scientists a bountiful number of new functions, such as estimating permafrost thickness to measuring the moisture in plant life, similar to the multitude of new functions today's smart phones.

Dr. Mark Yeary
Science PI
University of Oklahoma

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

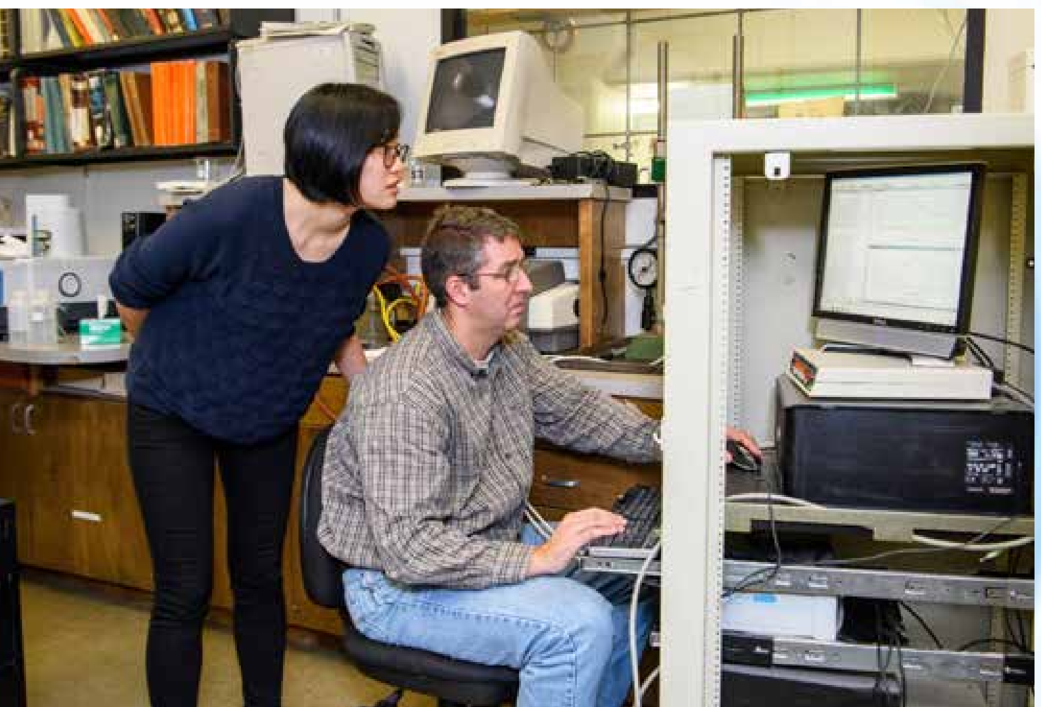
A Nanostructured Energy Harvesting and Storage System for Space and Terrestrial Applications

The University of Tulsa, Ames Research Center, Glenn Research Center, Human Exploration & Operations Mission Directorate, Space Technology Mission Directorate

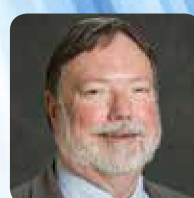
University Collaboration Project Creates Nanostructured Energy Harvesting and Storage System for Nasa

By John Ostrander, Chemistry Ph.D. Student, The University of Tulsa

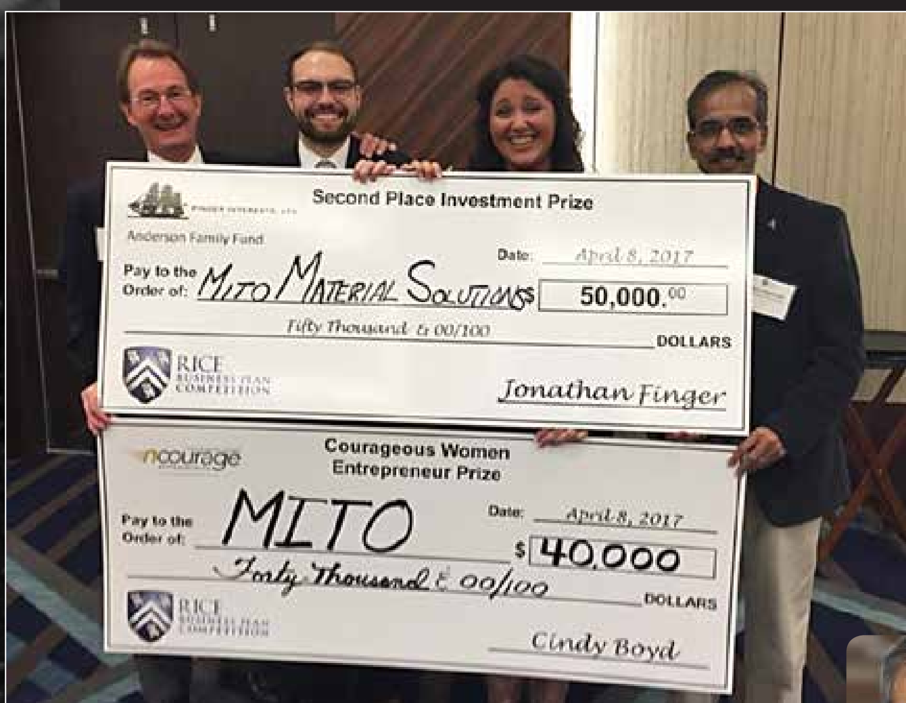
A NASA sponsored research team composed of faculty and students from The University of Tulsa, Oklahoma State University and The University of Oklahoma have used nanotechnology concepts to study, test, and fabricate an integrated photovoltaic (PV)/battery system. The system takes advantage of nanorods (200 nm in diameter) to efficiently collect the sun's energy, and the energy is then stored in nanoengineered batteries so small that more than two billion individual battery cells exist in an area the size of a dime. This battery configuration can be scaled up to the needed size for space applications. Nanostructuring the batteries greatly increases their ability to store energy and quickly release electric current. The integration of the PV and battery nanosystems for a combined energy harvesting and storage device will increase energy efficiency and capacity for NASA space and terrestrial applications.



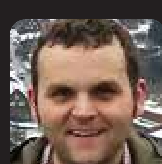
Oklahoma NASA EPSCoR researchers from The University of Tulsa Sha Xue, a Ph.D. Student in Chemical Engineering (left) and John Ostrander, a Ph.D. student in Chemistry (right), test a battery system with advanced properties due to a nanostructured design.

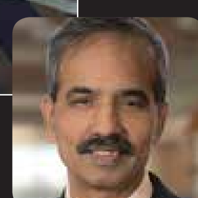


Jeremiah "Jay" McNatt
NASA Technical Monitor
NASA Glenn Research Center



Haley Kurtz and Kevin Keith of the MITO Material Solutions team receiving 2nd place investment prize at the Rice Business Plan competition along with Dr. Richard Gajan and Dr. Ranji Vaidyanathan.

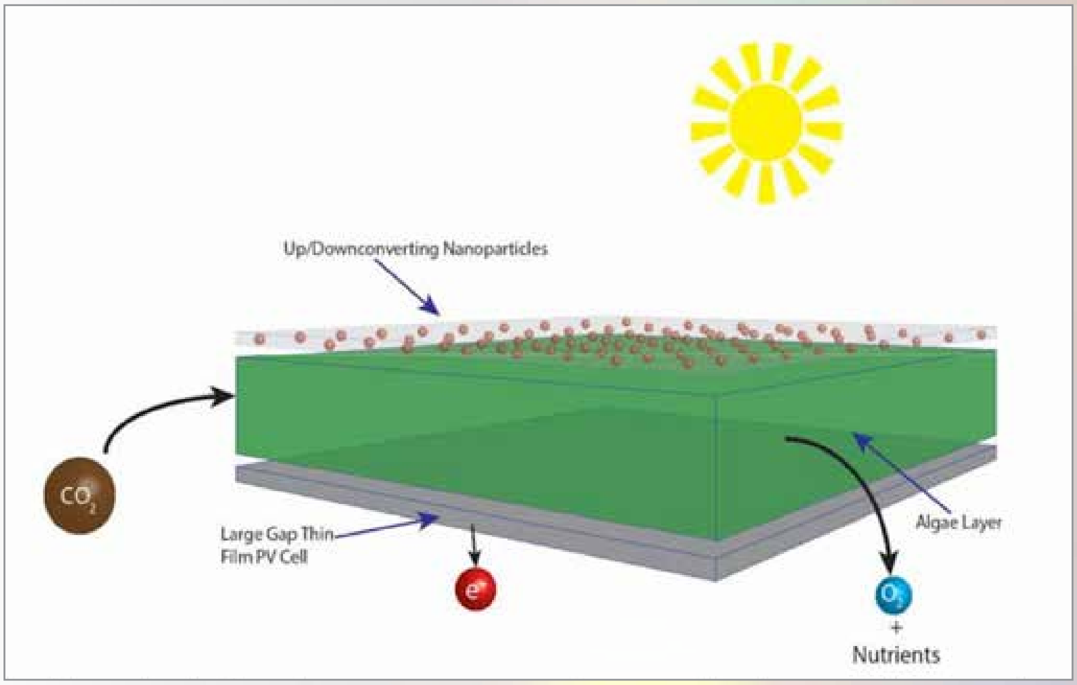




Ranji Vaidyanathan
Science PI
Oklahoma State University

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

University of Tulsa, Glenn Research Center, Human Exploration & Operations Mission Directorate



Prototype bio reactor with the bioreactor, nanoparticle layer and solar cells.

Dr. Parameswar Hari
Science PI
Associate Professor
Department of Physics and Engineering Physics
University of Tulsa

Jeremiah "Jay" McNatt
NASA Technical Monitor
NASA Glenn Research Center

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

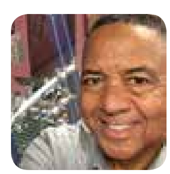
Demonstration of the OSU Tissue Equivalent Proportional Counter for Space Crew Dosimetry Aboard the International Space Station

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

Exposure of astronauts to elevated levels of ionizing radiation is one of the major hazards of spaceflight—especially long duration space missions such as the human exploration of Mars. Real time monitoring of the radiation levels that space crews are exposed to will be essential on human exploration missions. The Active Tissue Equivalent Dosimeter (ATED) currently being developed by the Radiation Physics Laboratory at Oklahoma State University and scheduled for flight on ISS in late 2017 measures the absorbed dose and biologically weighted dose equivalent during space flight due to ionizing radiation exposure in space. Because the detector used in ATED is made of a plastic that is similar to tissue, its sensitivity to radiation is nearly the same as that of the human body. We are developing ATED to be a low cost, low power, compact instrument for use on a variety of both manned and unmanned spacecraft, as well as on high altitude aircraft and balloons. Data from ATED will enable mission planners to better estimate the radiation exposure of astronauts of future missions, as well as providing data on radiation levels aboard the ISS.

Left: OSU Grad Student Oliver Causey working on the ATED power supply. Right: Detector head (cylindrical canister), spectrometer, computer and power supply with ATED enclosure.

Eric Benton
Science PI
The University of Oklahoma

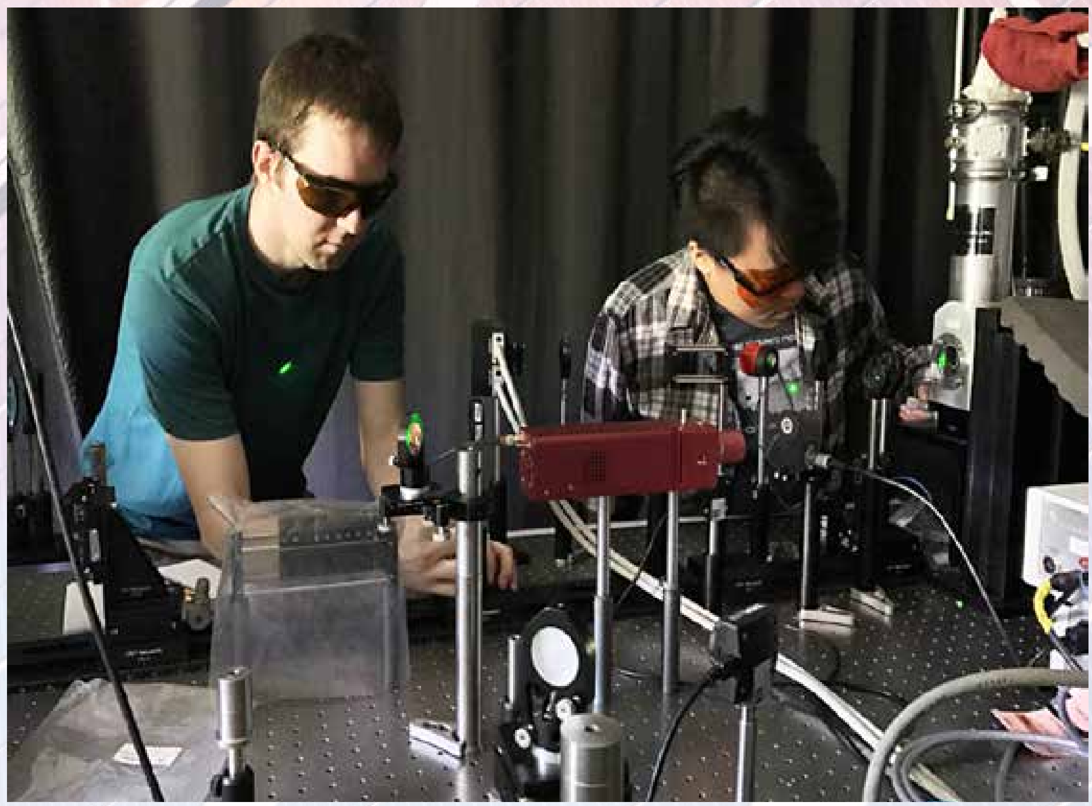


Willie Williams
NASA Technical Monitor
Johnson Space Center

OK

High Efficiency Dilute Nitrides Solar Cells for Space Applications

The University of Oklahoma, Glenn Research Center, Space Technology Mission Directorate, Human Exploration & Operations Mission Directorate



Collin Brown (GRA) and Hannah Harrell (REU) align the luminescence system in preparation of temperature dependent electroluminescence measurements of hydrogenation GaInNAs solar cells at the University of Oklahoma.

Dr. Ian R. Sellers
Science PI
The University of Oklahoma

Jeremiah "Jay" McNatt
NASA Technical Monitor
NASA Glenn Research Center

The most common form of power generation in space is through the use of solar cells. Although the cost of solar cells used in extraterrestrial applications is predominantly driven by performance, the weight (payload) of the systems is critical, and can significantly impact the cost of a mission if the cells are too cumbersome. High efficiency, lightweight solar cells are therefore promising for space applications, particularly as a cheaper power source for near orbit CubeSat systems, which are small satellites that are taken into space onboard other spacecraft and ejected once in orbit. These CubeSats are used to perform short term experiments in space and eventually "burn-up" in the earth's atmosphere. In this project, a statewide consortium of researchers led by OU is investigating the potential of using materials that contain small amounts of nitrogen as the fourth absorber in multi-junction solar cells (MJSCs). MJSCs divide the sun's energy into components so as to more effectively convert this energy to electrical power. The team in Oklahoma has developed techniques using hydrogen passivation to improve the quality of these nitrides and incorporate them on flexible substrates. Such advances have the potential to produce low payload systems operating with ultra-high efficiencies.

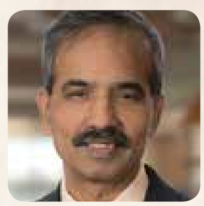
Assessment of Radiation Shielding Properties of Novel and Baseline Materials External to ISS

Oklahoma State University, Johnson Space Center, Human Exploration & Operations Mission Directorate, Space Technology Mission Directorate, International Space Station

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

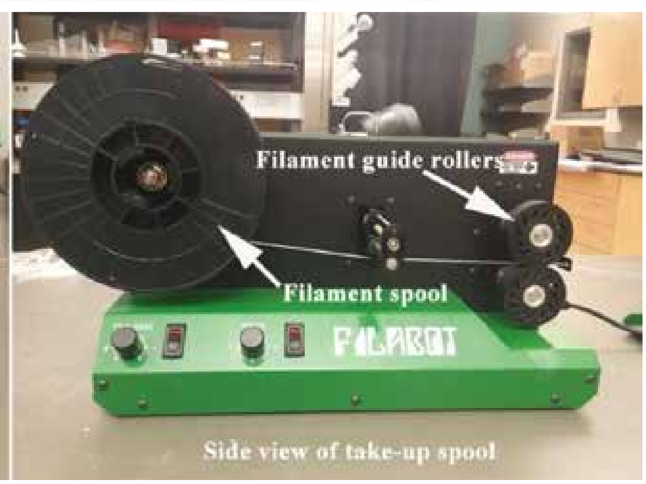
In response to the NASA EPSCoR ISS Flight Opportunity CAN of 12/5/2016, we propose an experiment to test and measure the radiation shielding and other properties of our multifunctional materials in the actual space environment external to the International Space Station (ISS). The proposed experiment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

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



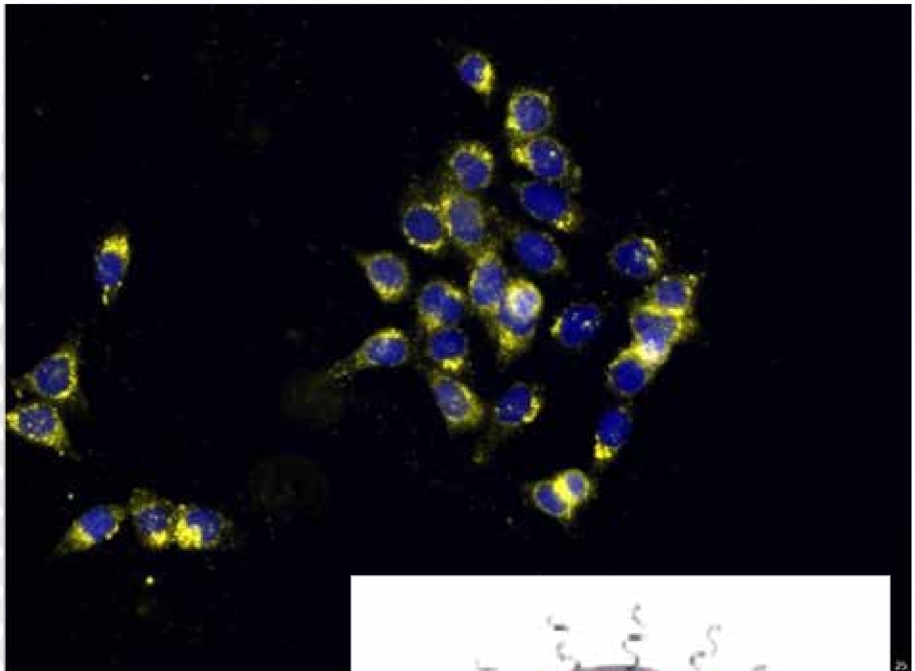
Ranji Vaidyanathan
Science PI
Oklahoma State University

NASA Technical Monitor
Laurence Thomsen:
Langley Research Center

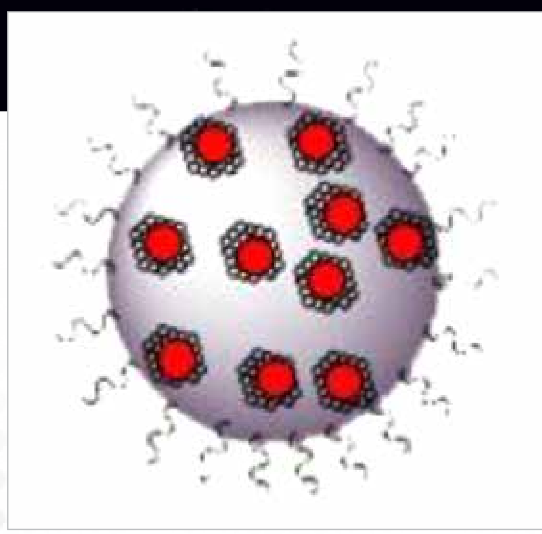


Filament extrusion set up (top and side views).

Puerto Rico Research Infrastructure Development



Microscopy image showing the Ag-GQDS:DOX nanocarriers internalized into cancer cells. The nanocarriers are able to transport the chemotherapy drug and release it into the cancer cell nuclei, avoiding the collateral effects of free chemotherapy drug in contact with non-cancer cells, and minimizing the dose needed to achieve therapeutic effects.



Representation of the drug nanocarrier. The chemotherapy drug is attached by the graphene quantum dots to the surface of the silver nanoparticle.

Silver nanoparticles coated with graphene quantum dots (Ag-GQDs) were developed as nanocarriers to deliver chemotherapy drugs against human cervical (HeLa) and prostate (DU145) cancer cells. The nanocarriers efficiently transport doxorubicin (DOX), a model chemotherapy drug, to both types of cancer cells in vitro. The cargo is delivered into the nucleus of cancer cells, where it induces apoptosis, without affecting the viability of non-cancer cells. The Ag-GQDs:DOX nanocarriers offer a general platform for targeted chemotherapy drug delivery. It is envisioned that chemotherapy drug nanocarriers can circumvent the adverse effects associated to standard chemotherapy drugs and eventually enable the implementation of cancer prevention protocols. This development helps to advance the fight against cancer on Earth and can be an important enabler of the long-term human exploration of Space.

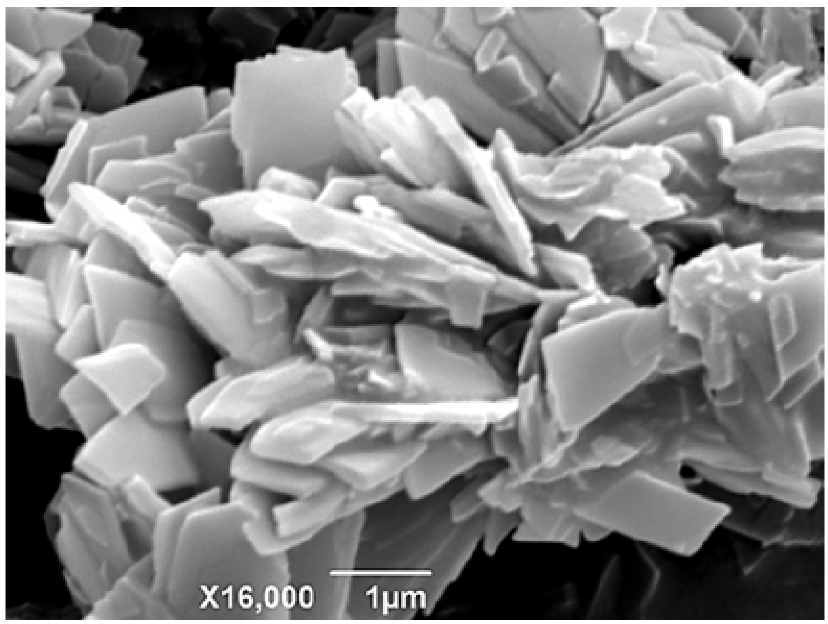
http://dx.doi.org/10.2147/IJN.S95440

Gerardo Morell, PhD
PR EPSCoR Director
University of Puerto Rico

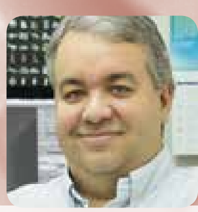
Carbon Dioxide Storage and Sustained Delivery by Porous Pillar-Layered Structure Coordination Polymers and Metal Organic Frameworks

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

Long-term space exploration by humans requires life support systems capable of providing the crew with the basic needs in a sustainable fashion. These systems must also consume little resources and should not increase payload costs. Yes, it is almost as challenging as fitting a square peg into a round hole! However, scientists from the University of Puerto Rico - Mayaguez (lead), Florida International University, NASA Ames Research Center and Marshall Space Flight Center are developing nanoporous materials that will address challenges related to life support systems. In particular, these materials could allow for vast storage of CO2 that is captured from space cabins and during outdoor space exploration activities. CO2 can then be converted by other of technology into an energy source and even used to produce oxygen, effectively closing the loop. Given that CO2 production is inherently and constantly produced by crew activity, its storage is essential to long-term missions. The aforementioned nanoporous materials will be at the core of storage technology that occupies minimum volume and will not require the use of heavy-duty gas compressors.



A scanning electron micrograph of a nanoporous material studied by UPRM scientists under a NASA grant. The material is capable of storing vast amounts of carbon dioxide at ambient conditions and delivering it on-demand. Source: Hernández-Maldonado and co-workers.



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

Jay Perry
NASA Technical Monitor
Marshall Space Flight Center

X16,000 1µm

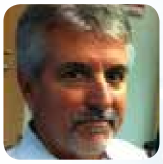
Enabling Technologies for Water Reclamation in Future Long-term Space Missions: Wastewater Resource Recovery for Energy Generation

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

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

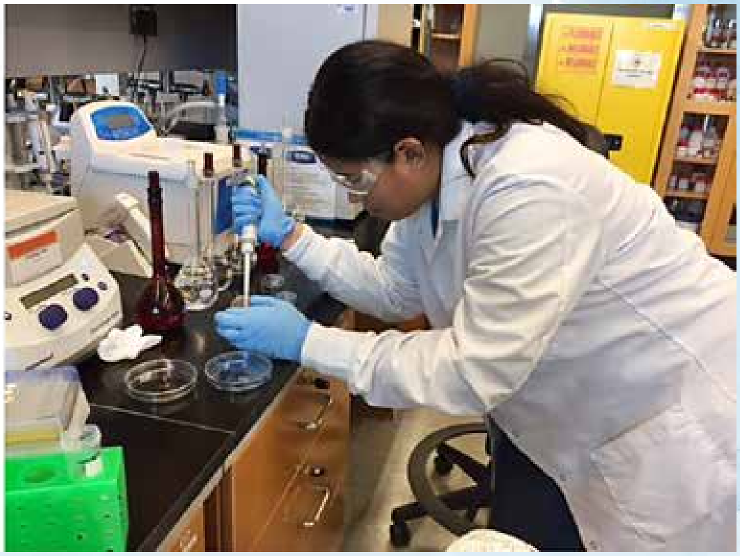
This project is performed in direct collaboration with the NASA Ames Research Center and is aligned to the Human Exploration and Operations Mission Directorate that states as a goal: to perform basic research proving new insights into problems affecting people on the Earth and understanding and developing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

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



Dr. Michael Flynn
NASA Technical Monitor
Ames Research Center

Dr. Nicolau, Science PI, explains strategies for the formulation of new methods to remove emerging contaminants and for the detection of arsenic in water.



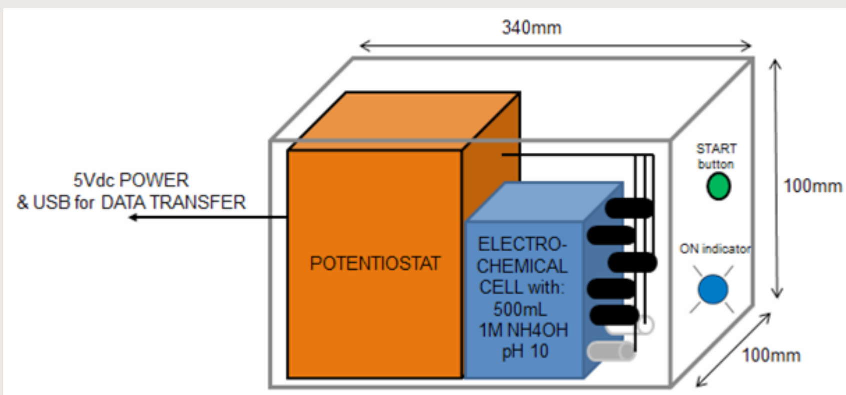
Research assistant Valerie Ortiz working to develop membranes with anti-microbial capacity for water purification purposes.

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

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

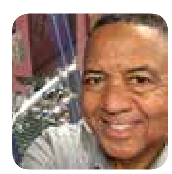
This project is a collaborative effort in conjunction with NASA Ames Research Center (ARC) to specifically address the Forward Osmosis Secondary Treatment (FOST) technology of urine reclamation. A key subsystem of the FOST is the so called Electrochemical Ammonia Removal (EAR) subsystem. The EAR is an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

UPR-ISS Logo



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

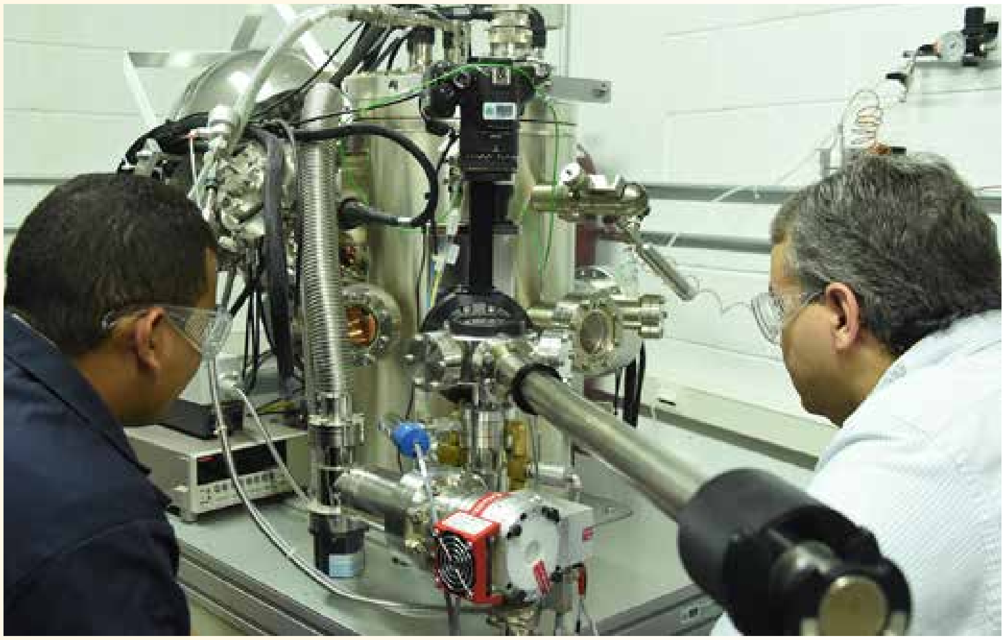
UPR-ISS Team: Prof. Eduardo Nicolau, Graduate Students Camila Morales- Navas, Juan Corchado, Jessika Pazol, and Luis Betancourt, and Prof. Carlos R. Cabrera, Science PI.

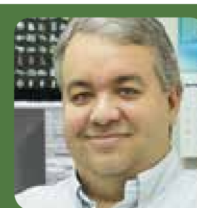


Willie Williams
NASA Technical Monitor
Johnson Space Center

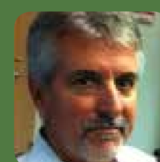
Development of Nanoporous Adsorbents for Aqueous Phase Separations in Life Support Systems

University of Puerto Rico/NASA Goddard Space Flight Center, Human Exploration & Operations Mission Directorate, Space Technology Mission Directorate





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



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

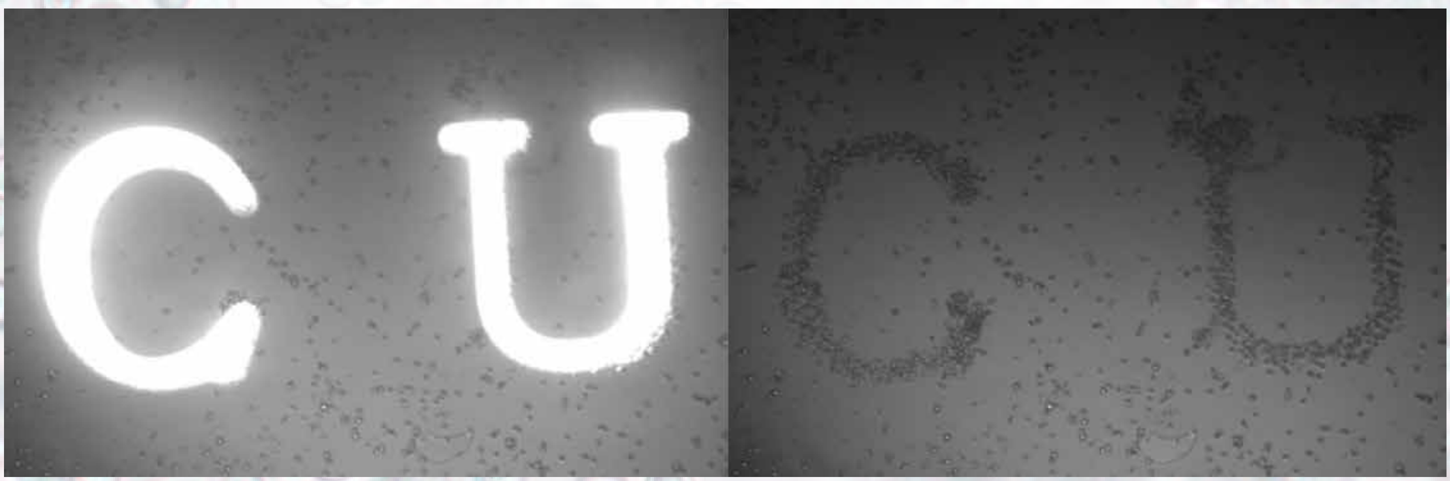
Co-NASA Technical Monitor:
Andrew J. Trunek
Glenn Research Center

The implementation of this research project will lead to innovative adsorbents for aqueous phase treatments that will be developed through a comprehensive, synergistic computational-experimental-engineering design strategy and will enable new technology for NASA Life Support systems. The new adsorbents will efficiently (i) remove PCs in the form of siloxanes that arise from crew hygiene products, adhesives, caulks, lubricants, various nonmetallic materials and reactions at Urine Processor Assembly (UPA) of the International Space Station (ISS), and (ii) recover medications (MCs), such as those based on N-acetyl-D-glucosamine, produced by NASA's Synthetic Drug Synthesis Systems (SDSS) prototypes. The overall goal is to produce novel adsorbent materials with superior selectivity toward PCs and MCs at ambient temperature with minimal physical volume requirements. Hence, the results of this research and development effort will enhance NASA's capabilities for long-term exploration missions, specifically those related to human life support and in situ resource utilization. The specific objectives include: (i) screening adsorption material surfaces based on anchored transition metals (Co, Ni, Cu or Zn) for weak complexation and enhanced, electrostatic interactions, and predictions of PC and MC adsorption loadings and energy via periodic boundary conditions calculations, and using quantum mechanics/molecular mechanics methods; (ii) synthesis and characterization of nanoporous adsorbents and composite adsorbents based on the theoretical/computational work output; (iii) performing single component batch and dynamic adsorption experimental tests to provide feedback to the computational component; (iv) developing testbeds in collaboration with NASA Marshall Space Flight Center (MSFC) and Ames Research Center (ARC) for adsorbent particle mechanical tests and small scale multicomponent adsorption tests, including processing of ISS Water Processor Assembly (WPA) and SDSS representative effluents containing PCs or MCs and other unavoidable background contaminants or competitive adsorbates (TRL 1-3). The siloxane-based contaminants targeted in this proposal are inherent to the ISS infrastructure and are not effectively removed by the ISS WPA and UPA. Moreover, the administration of medicines to space crew during space missions is essential for success. Although systems like the SDSS are still prototypes, the underlying principles are critical to elucidate the best possible way to provide space crew with the tools necessary to achieve feasible onboard production of medications, particularly those that would be deemed with short life spans. The deliverables anticipated from this project will also find important terrestrial applications. Efficient water treatment and reclamation methods are of utmost necessity to deal with potable water scarcity while the ever increasing number of epidemic diseases, particularly in remote areas with little or no resources, mandates the development portable synthesis systems for onsite medication production.

South Carolina Research Infrastructure Development

BioNanomanufacturing of Carbide Aerogels

This one-year seed project focused on manipulating the cellulose-synthesizing bacteria Gluconacetobacter xylinus (G. xylinus) for the fabrication of a designed cellulose pattern in the nanoscale. The functionalization and heat treatment of these cellulose fibers leads to carbide fibers. Besides obtaining carbide aerogels of random structure, this project led to the fabrication of an optoelectronic tweezer (OET) platform, the first of its kind at Clemson University. An OET platform uses patterns of light to create dynamic, controllable electric fields, and is now available infrastructure for the individual and parallel manipulation of cells using electrokinetics. The infrastructure developed for this project utilizes an image projector coupled to a microscope lens to create the patterns of light needed to invoke an electric field on the surface of a specialized chip. The image below shows how the OET platform was used to pattern yeast cells into the initials ‘C U’ (Clemson University). The application we target is bionanomanufacturing of aerogels with designed structure. Utilizing an OET platform to control biosynthesizing cells similar to G. xylinus offers a means of designing structures on the nanoscale with controllability and resolutions equal or greater than the current state of the art techniques used.



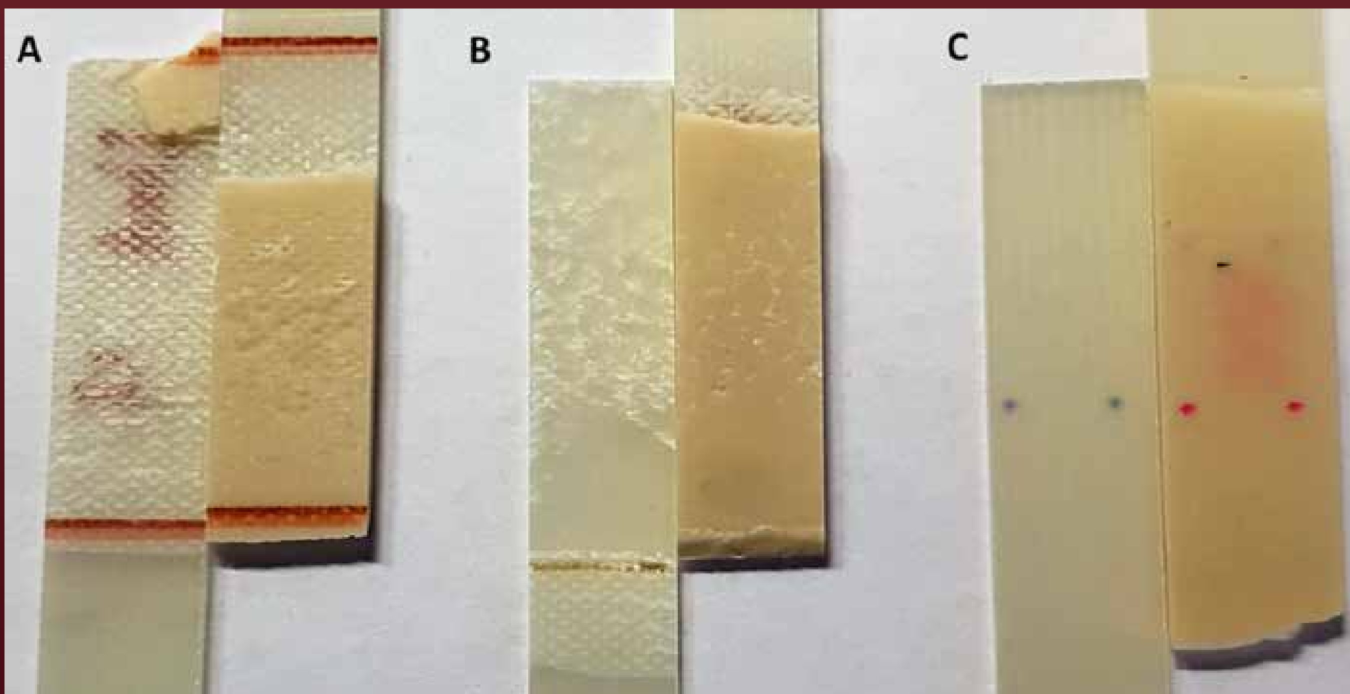
The patterning of yeast cells into the initials C U for Clemson University was demonstrated with the OET platform utilizing a positive dielectrophoretic force to manipulate the cells.

https://github.com/jpierel14/snsed

Dr. Casandra Runyon
SC EPSCoR Director
College of Charleston

Design, Manufacture, Evaluation, and Multi-physical Modeling of Aerospace Composite Materials for Enhanced Reliability

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



Adhesive joint specimens after failure A. with regula bond B. After release agent. C. After 3X release agent.

Dr. Prasun Majumdar
Science PI
Assistant Professor
University of South Carolina

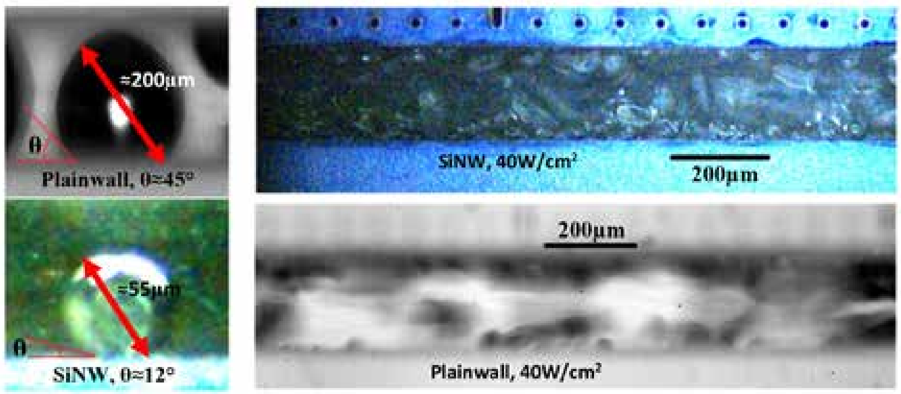
NASA Technical Monitor:
Dr. Cheryl A. Rose, PhD
Langley Research Center

Carbon fiber reinforced composite materials are used in a variety of applications such as aerospace, civil infrastructure, and bio-medical applications. During service, these materials undergo degradation which starts at the microstructure level. However, microstructural changes accumulates and lead to catastrophic failure. It is important to understand how local changes happen prior to global failure in real life structures. This NASA EPSCoR research have developed novel techniques to capture such changes due to manufacturing defect and other damage evolution during latent stage when no significant global property degradation occur. The outcome of the research will provide a better understanding of material state changes and may help develop more damage tolerant structures for enhanced life in the future.

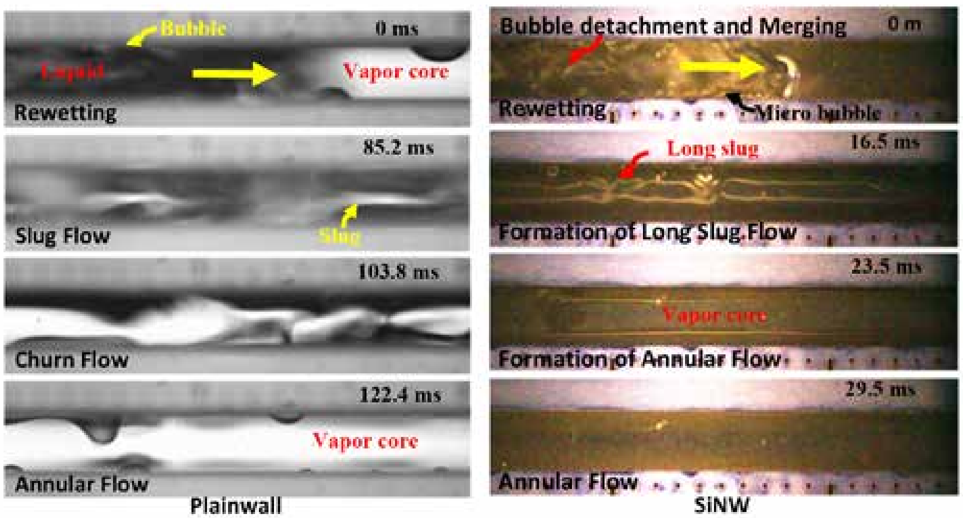
Explore a Unified, Ultra-efficient and Gravity-insensitive Flow Boiling Pattern for Space Missions

University of South Carolina/NASA Jet Propulsion Laboratory/Goddard Space Flight Center, Human Exploration & Operations Mission Directorate, Space Technology Mission Directorate, International Space Station

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



Reduced bubble departure diameter and increased bubble nucleation site density in SiNW microchannels



Flow regime development in Plainwall and SiNW microchannels

Dr. Chen Li
Science PI
University of South Carolina

Dr. Theodore Swanson
NASA Technical Monitor
Goddard Space Flight Center

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

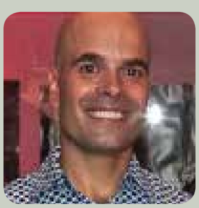
College of Charleston/NASA Goddard Space Flight Center, Science Mission Directorate

Installation of staff plates in the channel and on the floodplain.

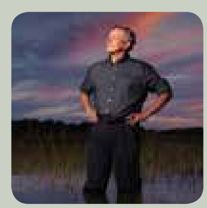
Development of the Virgin Islands Center for Space Science at Etelman Observatory: Research, Education, and Economic Development through Promotion of NASA's Vision

College of Charleston/University of the Virgin Islands, NASA/Goddard Space Flight Center, Science Mission Directorate

UVI physics faculty and first class of physics majors. Pictured (from left): Dr. David Morris, Dr. Antonino Cucchiara, Quianah Joyce (sophomore), Ulric Baptiste Junior (sophomore), Rodney Querrard (Junior), Alexander Fortenberry (Junior), Dr. Bruce Gendre, and Dr. David Smith.



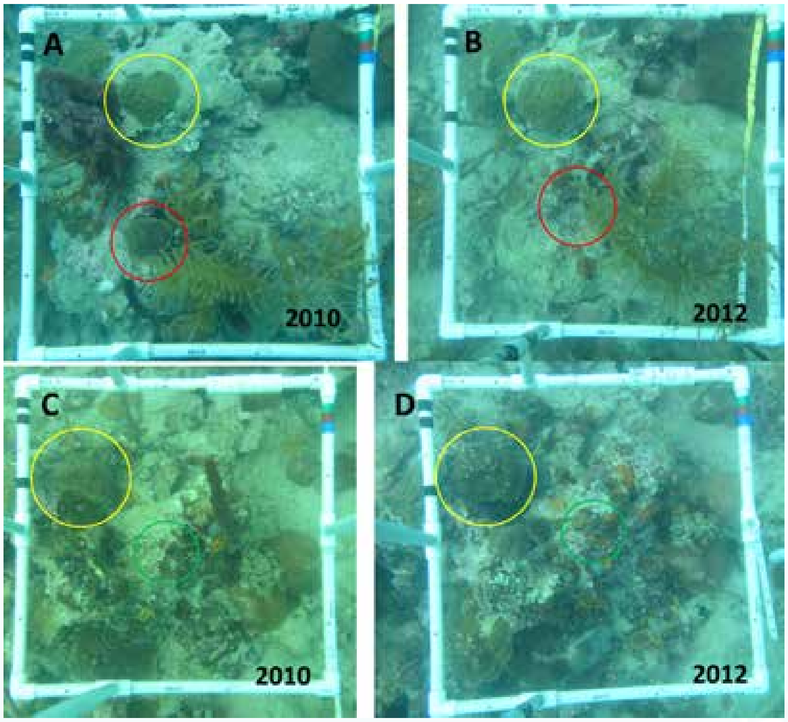
Dr. David Morris
Science PI
University of the Virgin Islands



Dr. J. Hakkila
Co-PI
College of Charleston

The University of the Virgin Islands first-ever NASA-EPSCoR grant has lead to far-reaching, and what we anticipate to be lasting, changes in the teaching of physical sciences in the US Virgin Islands. When our EPSCoR grant began in 2013, UVI faculty included 2 full-time physics faculty on the St. Thomas campus, and none on the St. Croix campus. When the grant began, UVI's Etelman Observatory was unused and its computers and instrumentation were neglected. When the grant began, UVI supported zero undergraduate students doing research in physics, either during the summer or academic year. Now, just 3 years later, UVI employs 7 full-time physics faculty and researchers spread across the 2 campuses and at Etelman Observatory, the Etelman Observatory is staffed around-the-clock by one UVI faculty and a research physicist, and this past summer UVI supported 11 summer research students doing projects in physics and astronomy. Perhaps most impressively of all, however, UVI has successfully established, in 2016, its first-ever bachelor of science degree program in physics, becoming one of only a handful of HBCUs of its size that is able to offer such a degree program. The future of physics education and research at UVI is bright, and it is due in great measure to the support received from NASA's EPSCoR program.

how reefs will respond to climate change. Yet collecting water quality data in the field requires significant human and financial resources, which many small island communities lack. The use of remote sensing tools can be a less resource-intensive way to collect this information. In this project, we are integrating data obtained from NASA satellites with field measurements to determine bio-optical properties and quantify water quality parameters in the coastal waters of the US Virgin Islands. Our goal is to analyze these data in relationship to long-term data on coral health and community structure in order to develop appropriate water quality assessment tools that can be used to predict coral reef response to global and local stressors.



Demographic monitoring plots at Coral Bay, St. John, a nearshore coral reef site with historically poor water quality. Plots were repeatedly photographed through time and individual corals have been identified for tracking using photoanalysis to determine changes in coral area, including growth, partial mortality, and death. Photographs A and B represent the same plot in 2010 and 2012; note the growth of Porites astreoides colony in yellow circle and loss of P. astreoides colony in red circle. Photographs C and D are the same plot in 2010 and 2012.

Dr. Marilyn Brandt
Science PI
College of Charleston

Liane S. Guild, PhD
NASA Technical Monitor
NASA Ames Research Center

Dr. Joseph Ortiz demonstrates to University of the Virgin Islands undergraduate Tia Rabsatt how to use a GER 1500 spectroradiometer to collect data on the optical properties of the water above a coral reef near St. Thomas, US Virgin Islands.

Rhode Island Research Infrastructure Development

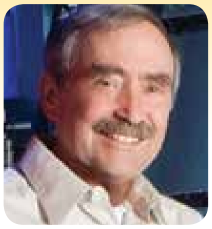
Remote Sensing of Sub-Surface Structure of Extraterrestrial Bodies using LaserDoppler Velocimetry Measurements of Rayleigh Waves

This project has brought together engineers and scientists from the geophysical world, signal processing, instrumentation, and laser research. The novelty of this study is the development and testing of a low-power, small-size and weight, chirp laser which can be used to estimate the range to a planetary body such as a comet, asteroid or moon and measure the motion of the surface due to impactors and other vibrations. The collaboration between the team members fostered the formation of an ocean engineering senior design project which enabled measurements of vibration in air and underwater of a variety of material types including soils, sediments, and ice. Two graduate student MS theses were supported by this project. We have effectively developed a laser "seismometer" that can measure vibration of surfaces of these bodies at a distance. The chirp laser development has been submitted for a patent by one of the P.I.s (Wei). This project has the potential to lead to a new laser altimeter for NASA missions that can also serve as seismometer.

Testing of the laser vibrometer sensing Rayleigh waves in a sand tank. From left to right are Prof. Chris Baxter, Prof. Gopu Potty, and graduate student Tyler Pickering.

http://semispheregroup.com/

Dr. Peter H. Schultz
RI EPSCoR Director
Brown University

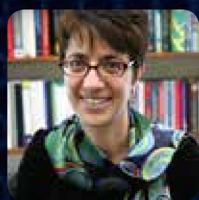


Web-Scale Assisted Robot Teleoperation

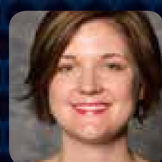
Brown University/NASA Glenn Research Center, Ames Research Center, Goddard Space Flight Center, Space Technology and Science Mission Directorates

Accelerating Feature Detection/Description Algorithms

Computer vision applications have gained significant popularity in mobile devices. Efficient feature extraction and description are crucial due to the real-time requirements of such applications. This effort compared different embedded platforms (CPU-based, GPU-accelerated, and FPGA-accelerated) and found that FPGA-accelerated implementation in particular offers attractive solutions for both performance and power, with a 98% power advantage over the CPU implementation and a 90% over a GPU implementation.



Dr. R. Iris Bahar
Science PI
Brown University



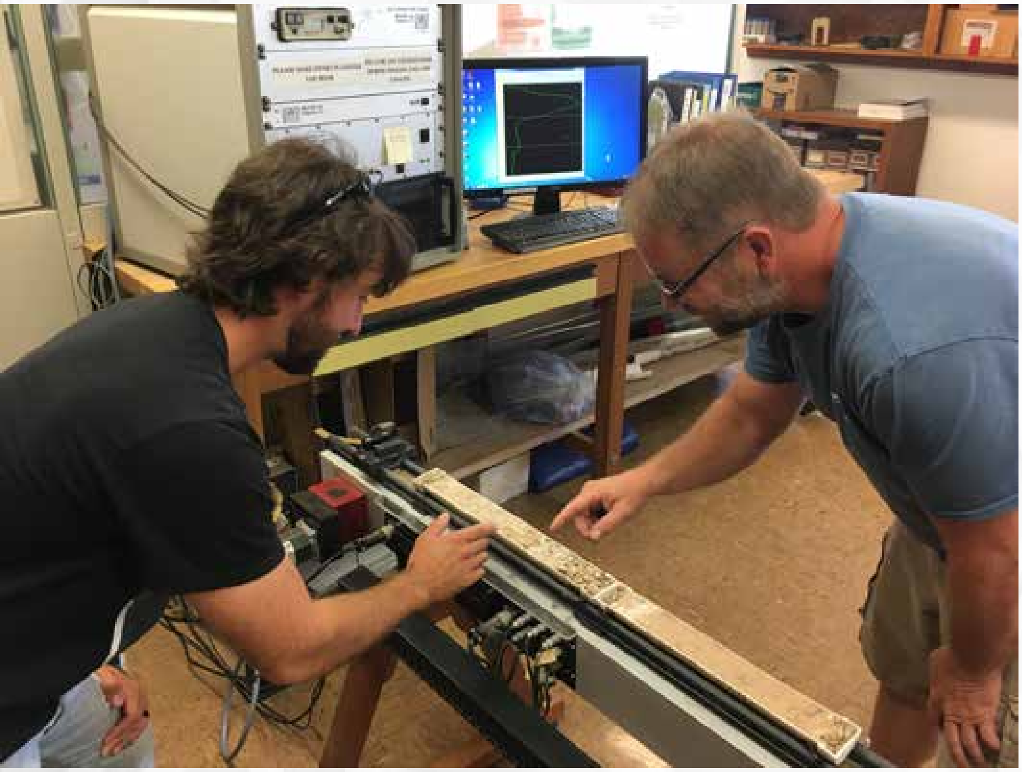
Dr. Kimberly A. Hambuchen
NASA Technical Monitor
Johnson Space Center

Improving Performance with Multiplier-Free Deep Neural Networks

Due to their performance, Deep Neural Networks (DNNs) are now used in many applications such as self-driving car, voice recognition and image search with drones, and voice recognition. However, DNNs are difficult to deploy on mobile/embedded systems, mainly because of limited computation and battery capacity, which means limited power and energy budgets. Thus, there is a need for low-power, low-latency DNN solutions with small model size for these types of application. In this effort, a power-of-two and dynamic fixed-point quantization scheme was adopted, with the introduction of three new contributions aimed at closing the accuracy gap and improving hardware metrics: improved quantization; multiplier-free hardware accelerator; and ensemble deployment of quantized models. Our approach achieved significant power and memory savings while increasing the classification accuracy.

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

Brown University/NASA Goddard Space Flight Center, Science Mission Directorate

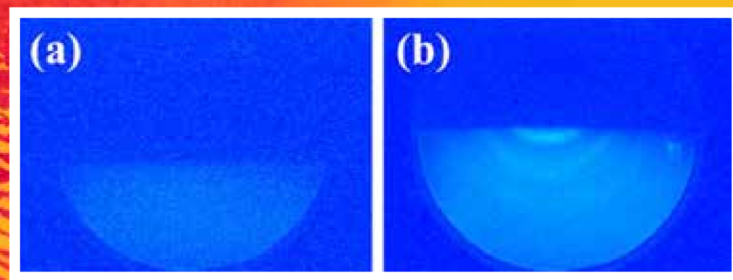


"Magnetic studies of the loess sequences of Argentina at the Graduate School of Oceanography at the University of Rhode Island help further our understanding of the effects of meteorite impact events on the ecosystems and the environment. Science PI Dr. Clifford Heil (right) and recent graduate, Brian Caccioppoli (left) examine loess cores from Buenos Aires province, Argentina in order to better understand changes in the concentration of magnetic minerals (displayed behind them). This will help guide their drilling efforts across an impact crater horizon this coming year."

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

Cynthia Evans, Division Chief of the Astromaterials Research and Exploration Science (ARES) Division, Exploration Integration and Science Division at the Johnson Space Center, NASA Technical Monitor, is a practicing field scientist, shown here as a member of the 2015-16 Antarctic Search for Meteorites field team.

South Dakota Research Infrastructure Development

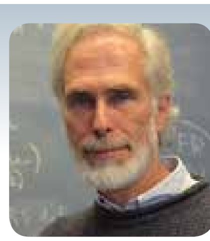


(Left) Tungsten filament heated to 2003.5 ˚C inside vacuum chamber.

(Above) Reflection high-energy electron diffraction patterns of surface of gallium antimonide (GaSb) wafers: (a) before hydrogen removal, (b) following laser-assisted hydrogen cleaning in the vacuum chamber shown at left. Concentric rings in (b) demonstrate that crystalline structure of the GaSb is more evident in sample following surface cleaning.

With funding provided by an FY 2016 South Dakota NASA EPSCoR Research Initiation Grant, Dr. Haeyeon Yang of South Dakota School of Mines and Technology is exploring methods to fabricate a next-generation thermal infrared sensor material. Dr. Yang uses a method known as Molecular Beam Epitaxy to deposit InAsSb epilayers on a substrate of gallium antimonide (GaSb). Thermal infrared sensors based on the InAsSb strained superlattice technology are considered to be critical advances for future NASA space missions, including the next imaging systems for the Landsat satellite series. Through this project Dr. Yang has developed collaborations with the Detector Development Laboratory at Goddard Space Flight Center as well as with Defense Department researchers and engineers at Lockheed Martin.

Dr. Edward Duke
SD EPSCoR Director
South Dakota School of
Mines and Technology



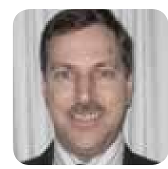
Flexible Electronics for Space Applications: Development of New Materials and Device Processing Technologies

South Dakota School of Mines and Technology/NASA Glenn Research Center, Jet Propulsion Laboratory, Langley Research Center, Space Technology Mission Directorate

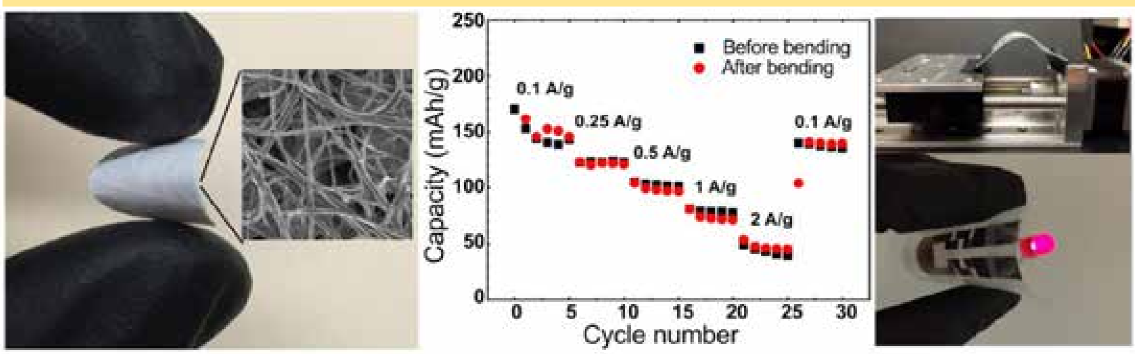
Flexible Lithium Ion Battery

Scientists from South Dakota School of Mines and Technology have developed a flexible anode material for lithium ion battery. Using an innovative dual-spinneret electrospinning technique, the team has prepared a flexible mat consisting of electrospun anatase TiO2 and amorphous SiO2 nanofibers together with anatase TiO2 nanoparticles. The composite mat is designed to process three unique properties simultaneously. The TiO2 nanoparticles with large specific surface area are essential for high battery performance, the SiO2 nanofibers render the mechanical flexibility, and the TiO2 nanofibers enhance electrochemical properties (through facilitating charge transport). The test results show that the binder-free composite mat maintains superior flexibility/robustness and good electrochemical performance after 5,000 continuous bending cycles. It is envisioned that the flexible/bendable mat consisting of three functional components are promising as advanced anode material for developing the next-generation of flexible lithium ion batteries. Lithium-ion battery of the flexible composite anode lights up a red light-emitting diode.

Dr. Zhengtao Zhu
Science PI
South Dakota School of Mines and Technology



Dr. William C. Wilson
NASA Technical Monitor
Langley Research Center

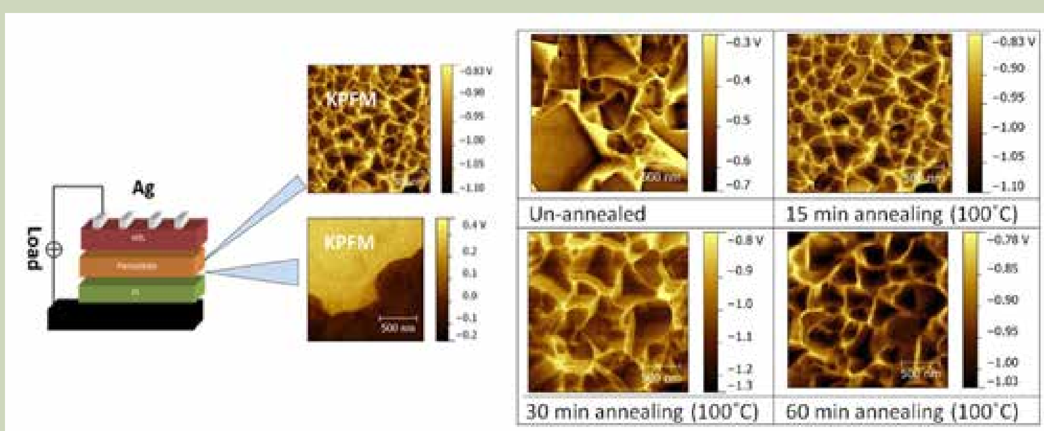


Lithium-ion battery of the flexible composite anode lights up a red light-emitting diode.

Next-generation Perovskite Solar Cells

The perovskite solar cells have high efficiency over 20% and may be fabricated by low-cost roll-to-roll or printing techniques. Scientists from South Dakota State University is pursuing the technology of the next-generation solar cells based perovskite materials. Kelvin probe force microscopy (KPFM) is used to investigate the nanoscale charge transport in perovskite solar cell, which is critical for understanding the fundamental chemistry and physics of these novel materials and devices.

Nanoscale kelvin probe force microscopy (KPFM) measurement showing the charge transport in perovskite solar cell.



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

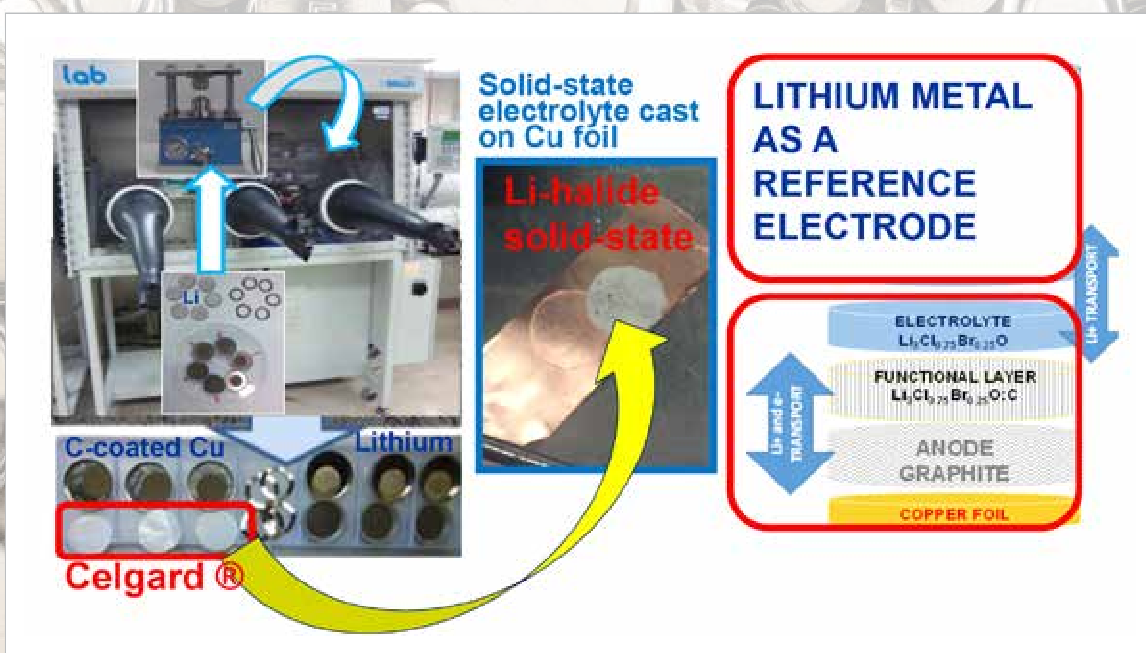
South Dakota School of Mines and Technology/NASA Glenn Research Center, Human Exploration & Operations, Space Technology and Science Mission Directorates

Recent NASA EPSCoR efforts in South Dakota were focused on development of the lithium-ion battery components, such as anode, cathode, all-solid-state electrolyte, and separation membrane. These studies have been supported by modeling and simulations for evaluation of the electrochemical cell cyclability and durability. A new approach in terms of lithium-ion battery components, such as a new electrically conducting polymer for lithium-ion battery anode, a new separation polyacrylonitrile and solid-state electrolyte membranes have been developed and tested. Furthermore, silicene as a low-dimensional allotrope of silicon with expected broad area of applications including microelectronics and lithium-ion battery anodes has been synthesized and tested at in a LIB half-cell configuration. In comparison to bulk silicon currently investigated as the most promising anode material with the highest specific capacity, silicene can be considered as an ideal material due to its metallic conductivity, layered structure, and mechanical stability in lithiation-delithiation cycles. To understand the silicene properties in terms of lithium-ion transport, a collaboration with Pacific Northwest and Brookhaven National Laboratories was initiated and is currently in progress.

Development of the solid-state electrolyte resulted in a safe battery design that was tested at 100˚C and demonstrated stable performance in 100 cycle experiment at 1C.

Dr. Alla Smirnova
Science PI
South Dakota School of Mines & Technology

Dr. James J. Wu
NASA Technical Monitor
Glenn Research Center



CR2025 half-cell assembly within an Ar-glove box: Li-halide forms a solid-state electrolyte membrane (center) and used instead of traditional Celgard® separation membrane (left) in absence of liquid electrolyte. Lithium metal is used as a reference electrode. On the right -schematic of the half-cell all-solid-state assembly.

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

Graduate student Behzad Bahrami working on next generation perovskite solar cell.

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

Dr. George E. Ponchak
NASA Technical Monitor
NASA Glenn Research Center

Printable spacecraft has been a vision for NASA for the past five years, and South Dakota is helping it become a reality. Printable spacecraft will allow humanity to explore planet surfaces as well as remote and difficult to approach areas of Earth, by printing deployable electronic platforms, in-situ during a mission. A team of ten South Dakota faculty experts works together with NASA in this project, led by Dimitris Anagnostou, Associate Professor, South Dakota School of Mines and Technology. One of the research goals of this project is to develop highly efficient printable perovskite solar cells as a reliable source of power in space environment, and this effort of coordinated by Prof. Qiquan Qiao in South Dakota State University.

This project provides opportunities for students in the related fields of materials science, electromagnetics, energetics, solar cells and chemistry. Moreover, this research is making an impact on the physical, institutional, and information resources of the South Dakota infrastructure through new state-of-the-art equipment.

200 µm

Advanced Bioelectrochemical Module (BEM) for Waste-to-Electricity Generation during Long-term Space Exploration

South Dakota School of Mines and Technology, NASA Kennedy Space Center, Ames Research Center, Jet Propulsion Laboratory, Space Technology and Human Exploration & Operations Mission Directorates, International Space Station

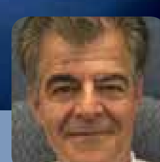
Namita Shrestha is a graduate student in the laboratory of Prof. Gadhamshetty, Science PI at the SD School of Mines and Technology. Their team is developing a next-generation bioelectrochemical module that employs extremophiles for generating electricity from solid waste generated during NASA exploration missions.

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

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

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

Venkataramana Gadhamshetty, Ph.D., P.E.
Science PI
South Dakota School of Mines and Technology



Dr. Ali Shaykhian
NASA Technical Monitor
Kennedy Space Center

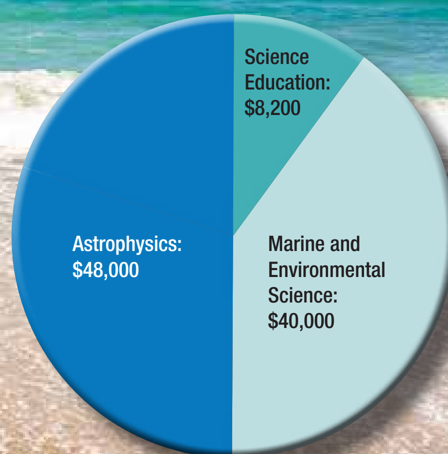
Virgin Islands Research Infrastructure Development

Two International Astrophysics Conferences Held at UVI in 2017

Thanks to continuing support from NASA-EPSCoR including a national NASA-EPSCoR award supporting its Etelman Observatory and a NASA-RID infrastructure award which supports new physics faculty and many undergraduate researchers, the University of the Virgin Islands (UVI) has dramatically grown its physics program in the past 4 years. Starting with 2 faculty working with 2 undergraduate research students and granting only an A.S. physics degree, UVI-physics now has 7 faculty and researchers working with 23 research students and grants a B.S. physics degree. (See page 108)

Highlighting this rapid growth this summer, UVI hosts its first-ever International Astro physics Conference from June 6-9 on St. Thomas, bringing together ~50 researchers from all over the world to discuss the exciting new field of Gravitational Wave Astrophysics. This conference is the first such international astrophysics conference to be held at UVI and will be followed just 4 weeks later by a second international conference (July 10-14) discussing the nature of Active Galactic Nuclei.

These conferences mark UVI's rising profile in the astrophysics and physics education community. The goal of the UVI physics program is not only to grow the university's research capacity but to rapidly and dramatically increase the number and achievement level of STEM students, particularly students interested in physics and engineering disciplines.



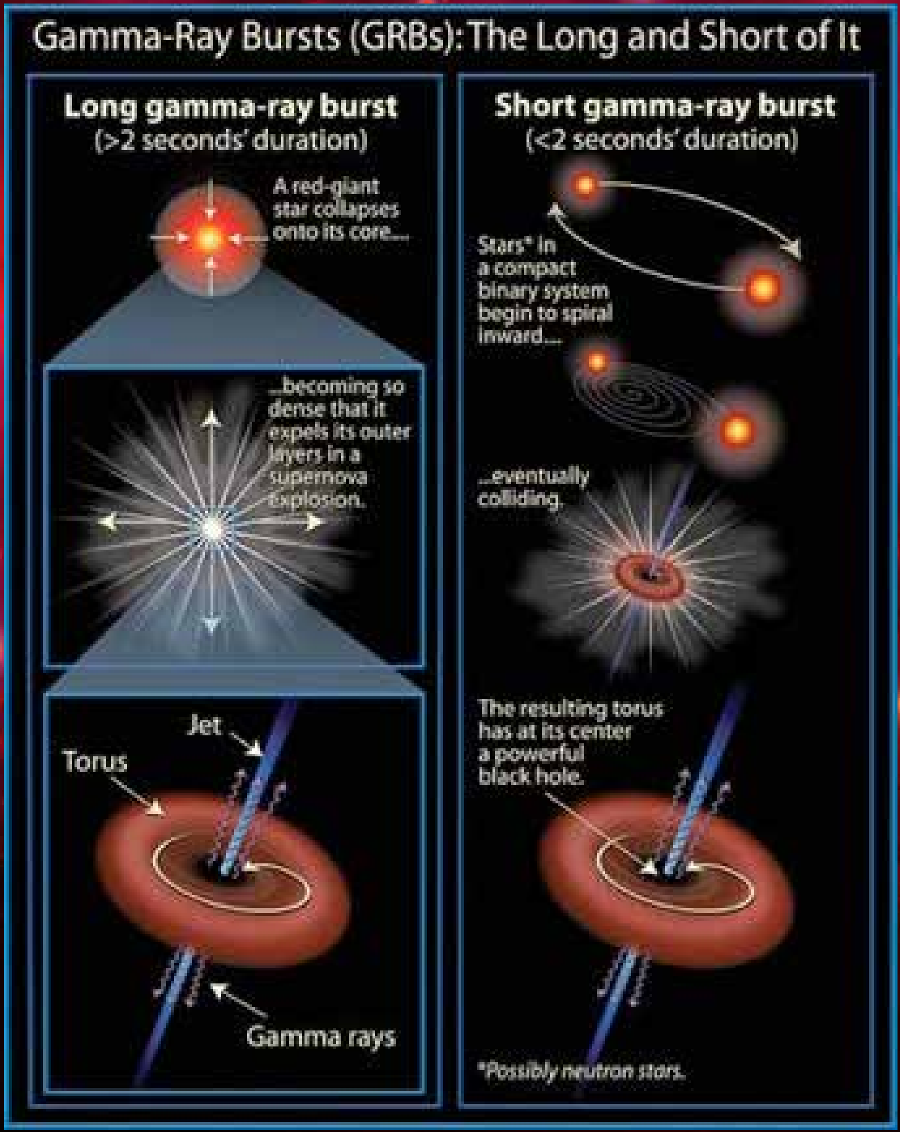
https://observatory.uvi.edu/
https://www.youtube.com/watch?v=BOhuilgi_jk

Dr. David C. Morris
VI EPSCoR Director
University of The Virgin Islands

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

University of the Virgin Islands/NASA Goddard Space Flight Center, Science Mission Directorate

The University of the Virgin Islands physics department will partner with scientists from NASA's Goddard Space Flight Center to develop a low-cost gamma-ray-burst detecting nano-satellite (BurstCube). This project will leverage previous work at UVI in GRB studies and x-ray detector development and will support student research opportunities in UVI's new physics undergraduate degree program. UVI BurstCube will be only one in a constellation of BurstCube units under development by a consortium of groups at various institutions. The combined constellation will be able to add significantly to the detection rate of GRBs. Moreover, expertise in astrophysics hardware development and data analysis developed through this project will continue to grow technical capability in this arena at UVI.



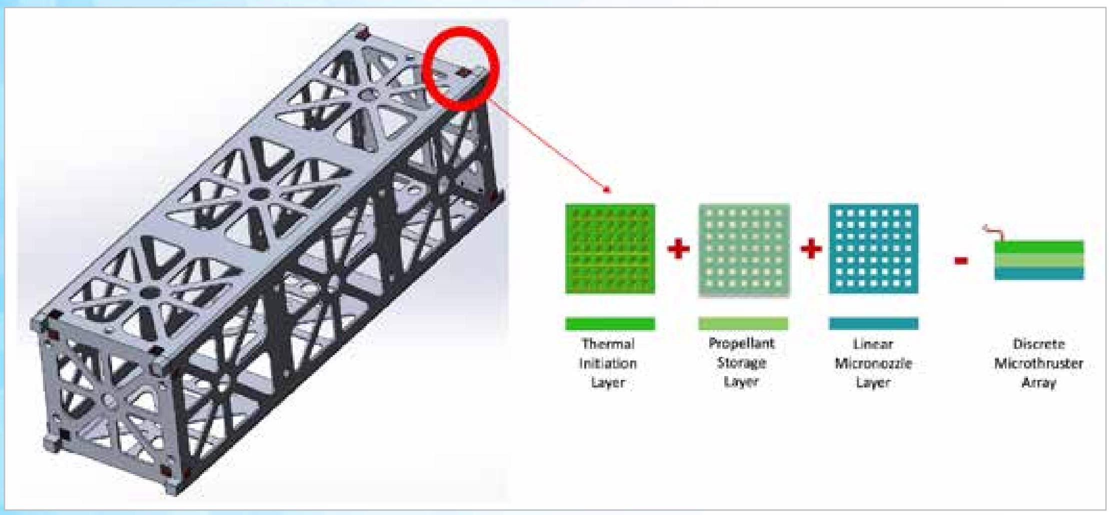
Dr. Antonio Cucchiara
Science PI
University of The Virgin Islands

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

Vermont Research Infrastructure Development

Discrete Solid Propellant Thruster for Small Satellite Precision Control

NASA, and the aerospace industry in general, have recently begun to develop and deploy constellations of small satellites to perform imaging, sensing and telecommunications missions. Small satellites are well-suited to this role as they are inexpensive to build and launch, making it feasible to build constellations consisting of hundreds, or even thousands, of satellites. As the satellites get smaller, however, there is increased demand for precision propulsion capabilities so the satellites can maintain their relative position and orientation in the network. To address this demand, GreenScale Technologies is collaborating with the University of Vermont to develop a micropropulsion system that uses an array of microfabricated solid rocket motors that can be independently fired to generate sub-micronewton levels of thrust. This system is designed to use a Chemical Blowing Agent (CBA) as the propellant. A CBA is a chemical compound that thermally decomposes from a solid into a gas, and is specifically selected for the dramatic expansion ratio during this process. There are several key benefits of a system using CBA as the propellant. The first is that the CBA of interest is a non-toxic powder that can be safely handled with minimal personal protection. The second is that the system can be integrated, stored and launched without pressurization, allowing it to easily integrate with spacecraft that are being launched as secondary payloads with minimal risk to the primary payload. Finally, as CBAs are frequently used in industry, they are readily available and low cost. These key benefits make this system an attractive fit for future NASA small satellite missions, and the small satellite market in general. Preliminary experiments have shown that a microthruster assembly can be created that uses the CBA as a propellant, and with the support of NASA EPSCoR funding, on-going work will fabricate and test the microthruster array.



Rendering of the microthruster arrays on a 3U CubeSat frame, with a callout showing the different layers of the array.

Prof. Darren Hitt
ND EPSCoR Director
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

Ultrasound Helps Small Particles Penetrate into Biofilms by an Oscillatory Diffusion Mechanism

Biofilms form when microorganisms, such as bacteria or algae, attach to a surface and surround themselves with a matrix of extracellular polymeric substance (or EPS). The interactions between the microorganisms within a biofilm are controlled by the diffusive transport of chemicals, nutrients and minerals within the protein matrix that makes up the biofilm. A group of scientists at the University of Vermont have recently discovered that exposure of a biofilm to moderate-intensity ultrasound can dramatically increase the rate of diffusion of certain substances into the biofilm. The initial discovery was reported by Ma et al. (J. Acoust. Soc. Am., Aug 2015), who showed experimentally that a suspension of small (~400nm diameter) protein capsules (liposomes) containing a fluorescent liquid exhibit dramatically greater penetration into an alginate hydrogel, which was used as a synthetic biofilm structure, than occurs with molecular diffusion alone (Figure 1).

Ultrasound, like any acoustic signal, causes the fluid elements within the biofilm to oscillate back and forth over a distance that depends on the frequency and amplitude of the ultrasound. When the fluid contains nanoparticles, these particles pass repeatedly through the pore spaces within the entangled proteins that make up the biofilm. However, the small particles will become temporarily trapped in the hydrogel protein network or otherwise impeded in their oscillatory motion. When this occurs, the ultrasonic forcing leads the particles to exhibit a behavior that appears similar to molecular diffusion, but at a much faster rate. To demonstrate this proposed diffusion mechanism, we developed a simple one-dimensional stochastic model of oscillatory particle motion with random particle hold-up. In the limit of small time step, we showed that this stochastic model reduces to the standard diffusion equation, and we derived an expression for the effective diffusion coefficient induced by the ultrasonic forcing (Marshall, JASA Express Letters, 2016). The discovery that ultrasound can enhance penetration of nanoparticles into biofilms has a wide range of potential applications, enabling an ability to selectively inject matter into biofilms either for mitigation purposes or to modify or control the biofilm process.

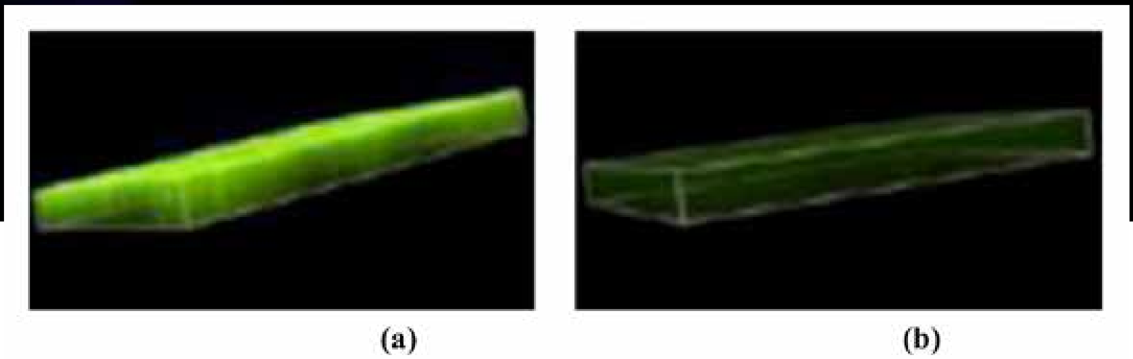


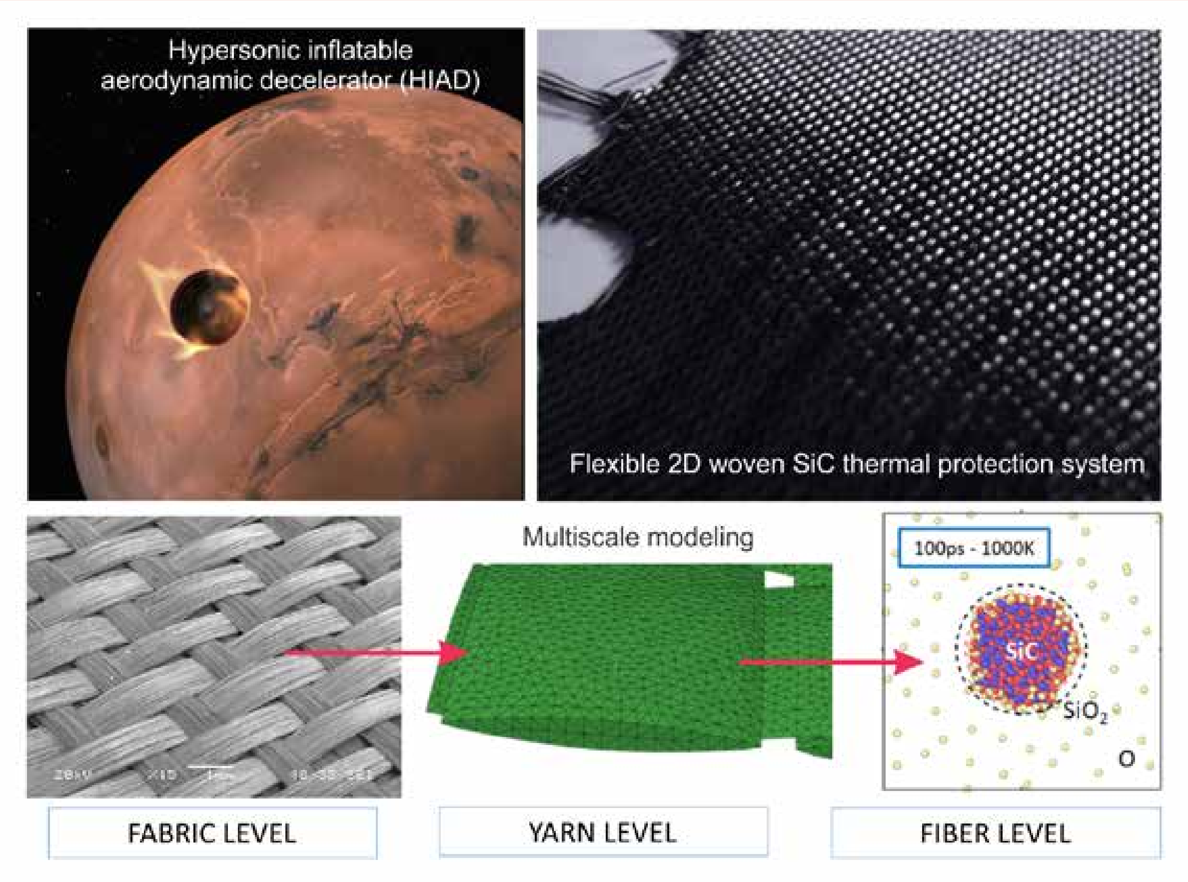
Figure 1. A slice of an alginate hydrogel film showing penetration of fluorescent liposomes into the film (a) with ultrasound exposure and (b) without ultrasound. The film thickness is approximately 120 micrometers, and the film is covered by a liposome suspension. (From Ma et al., J. Acoust. Soc. Am., Aug 2015)

Dr. Junru Wu
Science PI
University of Vermont

NASA Technical Monitor:
Dr. Duane Pierson, PhD
Johnson Space Center

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

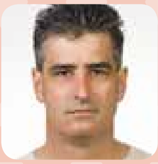
University of Vermont/NASA Ames Research Center, Langley Research Center, Human Exploration & Operations and Space Technology Mission Directorates



Flexible Heat-Resistant Woven Ceramic Fibers for Inflatable Atmospheric-Entry Thermal Protection Systems.

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 and carbon fibers. Our experiments have shown that exposure to high-enthalpy air and oxygen plasmas results in severe embrittlement over shorter time scales, with degradation rates up to 200 times higher than those reported for static heating in conventional furnaces in the presence of molecular oxygen. The origin of the accelerated embrittlement in oxidizing plasmas is associated with the formation of a viscous silica surface layer leading to critical flaws at high-temperature. These findings are important for developing outer ceramic fabric materials in new flexible thermal protection systems used by NASA for exploration of Mars, Venus and other planets. Current focus is on developing in-situ mechanical experiments and multiscale computer simulations to study embrittlement of these flexible TPS materials under space atmospheric entry conditions, and broad dissemination of the scientific results to general public and high-school students using creative video production.

Prof. Frederic Sansoz
Science PI
University of Vermont

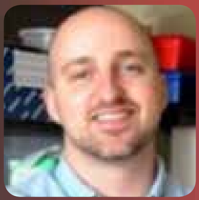


Dr. Anthony Calomino
NASA Technical Monitor
Langley Research Center

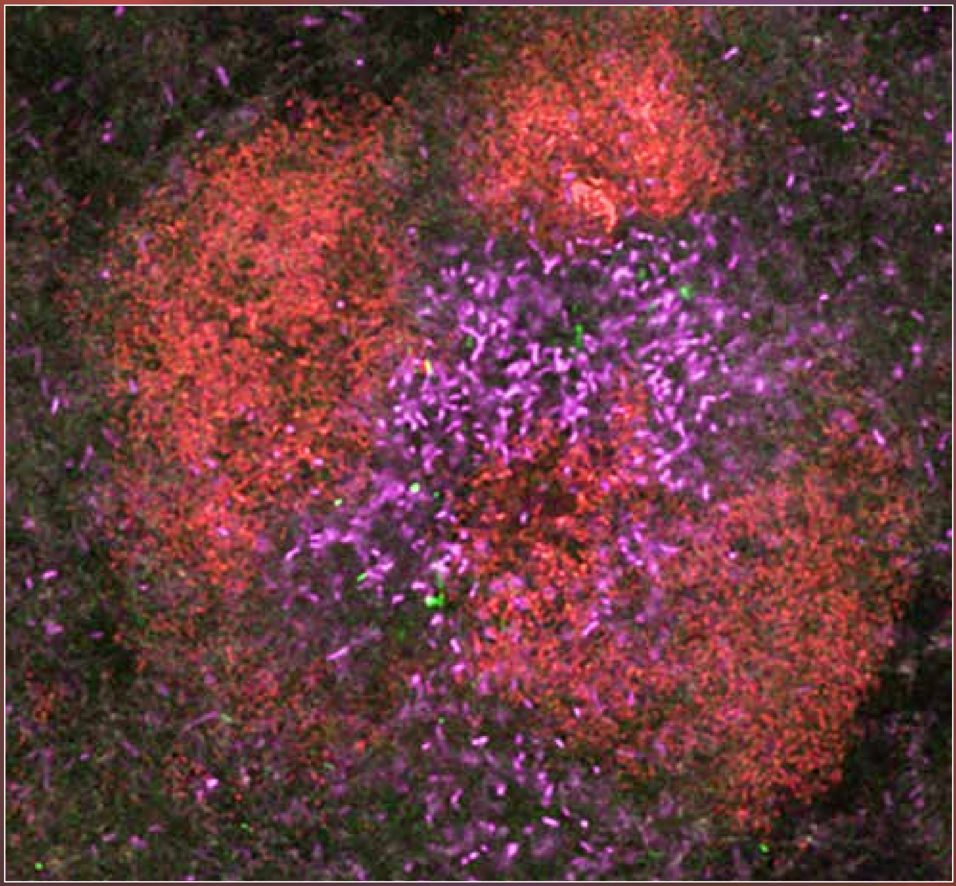
Characterization and Modeling of Biofilm Development by a Model Multi-species ISS Bacterial Community

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

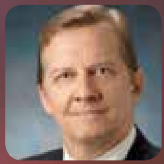
The bacteria that contaminate the potable water reclamation system on the International Space Station are similar to those that colonize drinking water systems on Earth. We eat and drink these bacteria every day and they play important roles in water taste and pipe corrosion. It is therefore surprising that we know so little about how these bacteria work together to form these tenacious communities, called biofilms, in water pipes. Our research uses a powerful combination of wet-lab microbiology and computational modeling to understand how these bacteria interact. One of our methods is to use fluorescent in-situ hybridization to determine where specific species are within biofilms (Figure), as this spatial information is important to determine whether interaction is by touch or long-distance and can tell us whether relationships are antagonistic or mutually beneficial. Our goal is to use this knowledge to better control drinking water bacterial communities in space and on the ground.



Dr. Matthew Wargo
Science PI
University of Vermont



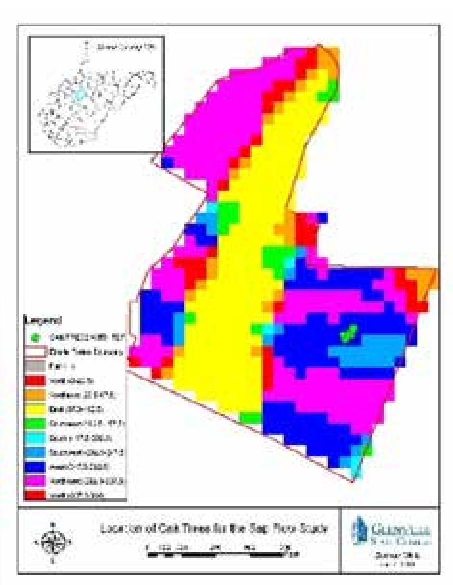
ISS bacteria grown in a mixed-species biofilm, with Ralstonia in purple, Sphingomonas in green, and Chryseobacterium in red; other bacteria present but not fluorescent.



Dr. Mark Ott
NASA Technical Monitor
Johnson Space Center

West Virginia Research Infrastructure Development

Transpiration and Water Use of Several Hardwood Species in Appalachian Forest

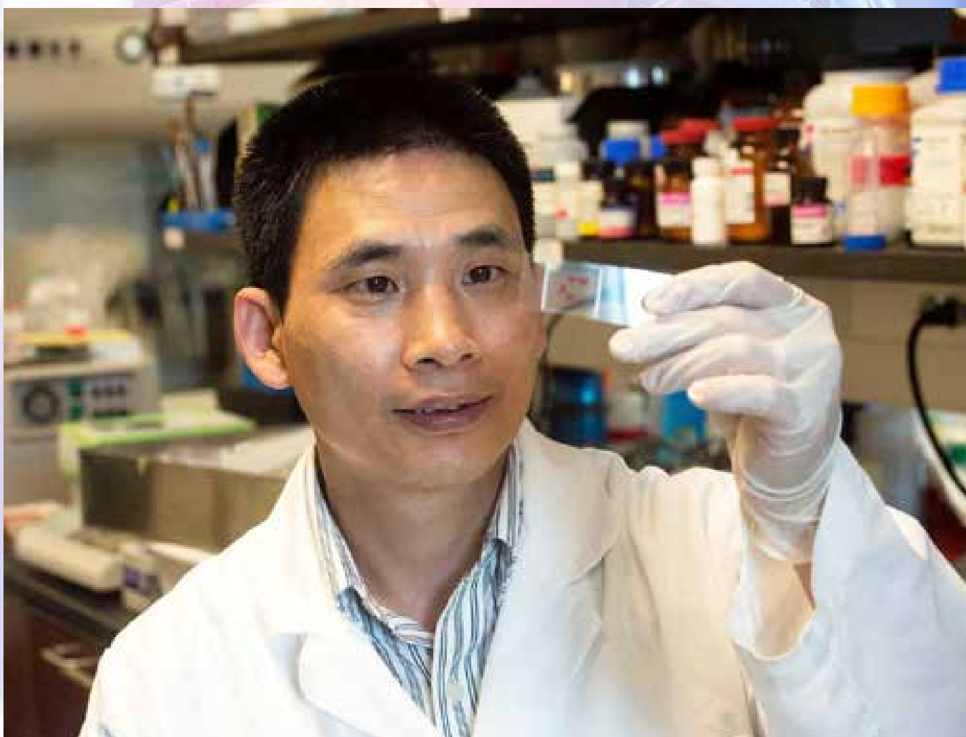


The Appalachian forest is one of the most diverse and productive ecosystems in the northeastern United States. It has been the subject of numerous research studies on watershed management, biodiversity conservation, logging and other silvicultural practices. However, only a few limited studies have attempted to quantify water consumption of mixed hardwood trees and their contribution to forest water balance. Understanding the ability to compete for water resources and the differential utilization of water by plants without the destructive excavation of roots needs to be explored in this ecosystem. The use of sap flow gauges to quantify water use can, therefore, be an indispensable tool for further exploration of the impacts of vegetation communities on the productivity of the Appalachian forest. The main objective of this study is to estimate daily and seasonal water use by several mature oak species in a mixed hardwood forest. The study is important in characterizing the contribution of the mixed hardwood trees on the hydrology or water balance of Appalachian forest. The site selected for this project is a relatively dry site with west facing slope, 30-37% average slope and approximately 300 m in elevation. The sapwood area is an important parameter in scaling the sap flow estimates to total water use. The probe was inserted into the sapwood at a depth of 30 mm using a drill bit and covered with a reflective bubble wrap for insulation.

Dr. Majid Jaridi
WV EPSCoR Director
West Virginia University

Mechanical Unloading and Irradiation-Induced Musculoskeletal Loss and Dysfunction: Molecular Mechanisms and Therapeutic Nanoparticles

West Virginia University/NASA Johnson Space Center, Human Exploration & Operations Mission Directorate



Science-PI Dr. Miaozong Wu examines tissue pathophysiological alterations after exposure to space environmental risk factors.

Space exploration is a continuing effort relying on both new technology development and humans' health improvement. This grant (NNX13AN08A) allowed us to investigate the adverse effects of space environmental risk factors on the musculoskeletal system and to successfully identify three compounds, including cerium oxide nanoparticles, zinc oxide nanoparticles and acetaminophen, which exhibit protective effects on musculoskeletal loss induced by irradiation and mechanical unloading. A patent application has been filed to the U.S. Patent and Trademark Office. Key findings have been presented at the national conferences (Annual conferences of ASGSR, HPS and ASSE), and published in peer-reviewed journals (Cellular Physiology and Biochemistry, Journal of Occupational Health, and Free Radical Biology & Medicine). Given that some identified compounds are already widely used in human health-related products (medicine and food additives), our findings provide clinically applicable strategies to prevent musculoskeletal disorders not only for astronauts but also the general public with similar hazard exposures. Additionally, this grant has provided exceptional research opportunities to thirteen students, clinical fellows and researchers; supported a STEM course development (PHAR801-Space Biology and Nanomedicine); helped three junior faculty establish their research careers; and developed productive collaborations with industry (Akina), professional society (Bioscience Association of West Virginia), and investigators from Huntington VAMC.

Dr. Honglu Wu
NASA Technical Monitor
Johnson Space Center

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

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

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

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

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

Dr. Konstantinos Sierros
Science PI
West Virginia University

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

Renishaw core metal foam.
Photo by Michael Petch.

Fast Traversing Autonomous Rover for Mars Sample Collection

West Virginia University/NASA Jet Propulsion Laboratory, Ames Research Center, Science Mission Directorate, Human Exploration & Operations Mission Directorate

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

Dr. Yu Gu
Science PI
West Virginia University

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

Heather Justice
NASA Technical Monitor
Mars Rover Driver
Jet Propulsion Laboratory

JPL's Athena rover on the Mars yard.

Wyoming Research Infrastructure Development

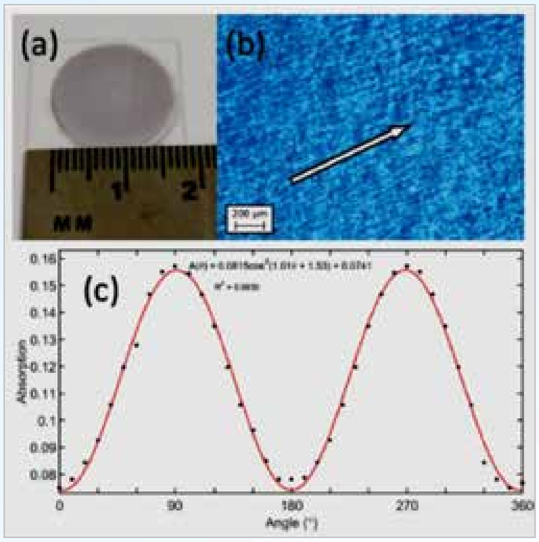


Figure 1: Macroscopic alignment of carbon nanotubes. (a) 1.5 cm diameter film of aligned carbon nanotubes. Aligned carbon nanotubes can be used for applications such as optical polarizers. (b) Polarized optical microscopy image showing aligned nanotube domains. (c) Absorption of light at 990 nm as the nanotube film was rotated. The increasing and decreasing absorption with rotation angle shows the preferential absorption of light along the nanotube axis in an aligned film.

In this first seed project, we were able to enrich specific metallic carbon nanotubes for optical and electrical investigations. We demonstrated that unenriched nanotubes could be highly aligned along their one-dimensional axis (Figure 1). As seen in Figure 1, aligned nanotubes can be used to preferentially absorb light along the alignment axis, making them optical and far-infrared polarizers. This work was carried out by a UW undergraduate student and a graduate student. Our next step will be to demonstrate alignment in highly enriched carbon nanotubes, which we hope to show optical polarization behavior for specific wavelengths.

In the second project, which was spearheaded a UW graduate student and a post-doctoral fellow, we built an optical setup to measure the adhesion strength of ice on various substrates. Optical measurements of substrates with and without ice showed that the presence of ice changed the vibrational properties of the substrate. This optical diagnostic is important for in situ measurements of ice adhesion, which is particularly important for aircraft control surfaces and ice-sensitive, critical infrastructure.

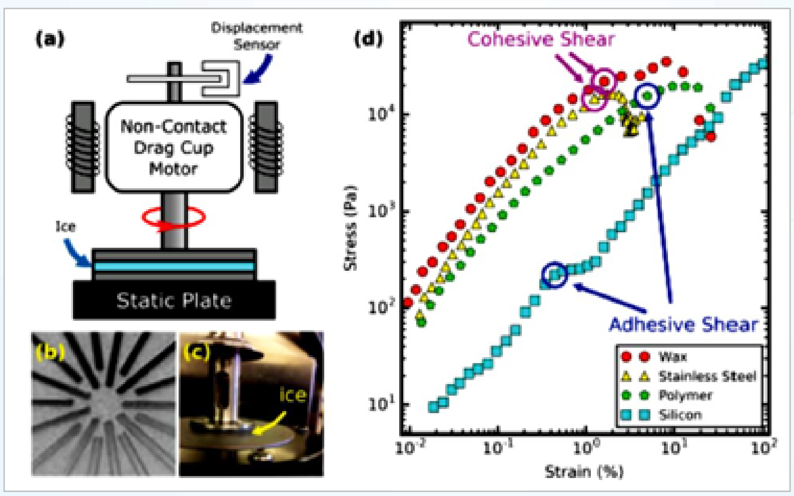


Figure 2: Rheological testing. (a) Rheometer schematic. The smooth bottom plate can either rotate or remain stationary. (b) Serrated top plate used for rheometer testing. The ice adheres to the grooved plate much more strongly than the smooth plate. (c) Picture of the serrated top plate and the smooth bottom plate of the rheometer with ice between them. (d) Measured stress-strain curves of ice grown onto wax (red), stainless steel (yellow), polymer (green), and silicon (light blue). The ice failure mode (cohesive or adhesive) is noted on each curve.

In conjunction with the optical measurements, we worked with the Alvarado lab in Chemical Engineering to measure the stress-strain profiles of ice grown on substrates using a rheometer (Figure 2). These tests are important for establishing how ice mechanically behaves, so we can correlate our optical measurements with well-understood mechanical measurements. Further work will explore how we can quantitatively assess, using the optical technique, ice adhesion strength on various surfaces. Once our optical technique can yield similar results as our mechanical tests, we will commence work on testing new icephobic coatings and materials.

http://www.uwyo.edu/materialscience/

https://pubs.acs.org/doi/pdf/10.1021/acs.nanolett.7b00421

Dr. Shawna McBride
WY EPSCoR Director
University of Wyoming

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, Space Technology and Science Mission Directorates

Science PI:
Dr. Bart Geerts
University of Wyoming

NASA Technical Monitor:
Dr. Walt Petersen
Marshall Space Flight Center

The Ka-band (1.2 cm) Profiling Radar (KPR), funded by this project, has been combined with the W-band (0.3 cm) the Wyoming Cloud Radar (WCR) whose profiling capability was funded by a previous NASA EPSCoR grant (Geerts, PI, 2001-2004). 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 relates to 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 NASA GPM, 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. This platform has been used for many years, mainly for NSF-funded projects (Fig. 1). The WCR and KPR were deployed succesfully for the first time on the UWKA in the 2017 SNOWIE campaign (Seeded and Natural Orographic Wintertime clouds – the Idaho Experiment). The KPR was mounted in a PMS can on the aircraft's right wing (Fig. 2). The KPR, along with the WCR and Wyoming Cloud Lidar (WCL), were centerpiece instruments providing detailed observations of the microphysical and dynamical characteristics of the study clouds. The UWKA was joined by two 'Doppler on Wheels' (DOW) Radars and range of ground-based sensors placed throughout the study region.

(Above)
Fig. 1: The UW King Air taxying on an ice runway in the SNOWIE (Seeded and Natural Orographic Wintertime clouds – the Idaho Experiment) project in Jan-Mar 2017.

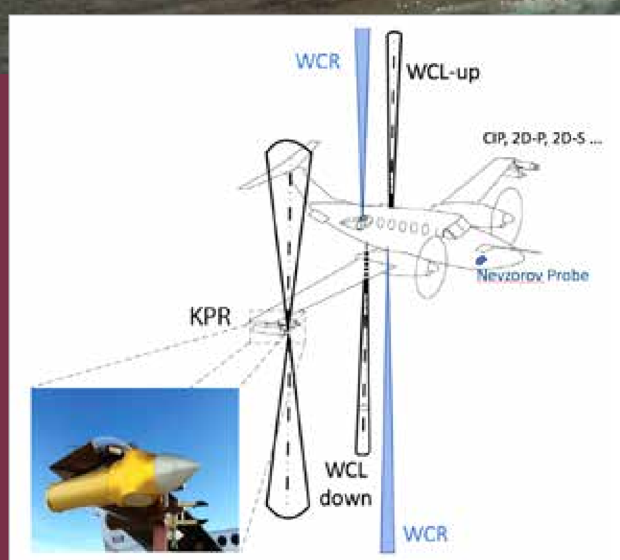
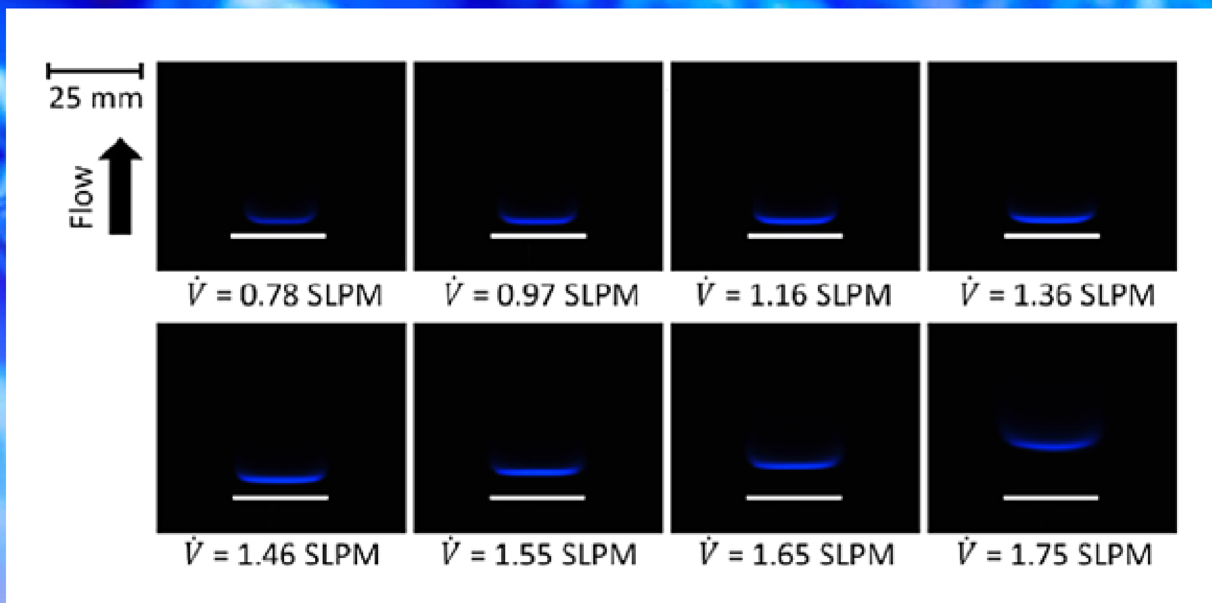


Fig. 3: New UWKA configuration to study cloud and precipitation profiles. The combination of dual-frequency radars (WCR and KPR) plus lidar (WCL) with in situ measurements of particle size distribution and particle shape/phase serves as a new and unique capability in cloud physics research. For the first time, dual-frequency radar (and lidar) algorithms of cloud properties (effective radius, LWP, snow mass, precipitation rate …) can be evaluated directly with in situ measurements. This is of interest to the NASA GPM mission.

WY

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

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



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

Low temperature (or "cool") flames have recently received increased attention because of their importance in advanced combustor designs, such as Homogeneous Charge Compression Ignition (HCCI) engines, as well as their role in autoignition and engine knock. This research seeks to complement and provide terrestrial insights into ongoing research being conducted by the Combustion Branch at the NASA Glenn Research Center (GRC) on cool flames in microgravity aboard the International Space Station (ISS). Fuel handling equipment, necessary to produce liquid fuel cool flames, has been developed and researchers are nearing readiness for ignition of cool flames using liquid fuels of logistical importance. Additionally, a method for modifying chemical kinetics models which describe flame chemistry has been implemented to allow for the numerical simulation of cool flames. A reduced chemistry model which includes reactions that lead to cool flames alone, without transition to a hot flame, has been produced. This capability will be applied to produce reduced chemistry models for heptane and decane cool flames, for future comparison with experimental data.

Members of the Belmont Energy Research Group (BERG) at the University of Wyoming are pictured, including Science PI Dr. Erica Belmont (left) and Ph.D. Candidate Emily Beagle (right).

NASA Technical Monitor:
Dr. Daniel L. Dietrich
Glenn Research Center

Advanced Optical Measurements of Ice Adhesion on Icephobic Aircraft Surfaces

University of Wyoming/NASA Glenn and Langley Research Centers, Aeronautics Research and Human Exploration & Operations Mission Directorates

Dr. William Rice
Science PI
Assistant Professor of Physics and Astronomy
University of Wyoming

Dr. Christopher Wohl
NASA Technical Monitor
Langley Research Center

Ice accretion on aircraft, helicopter, spacecraft, rovers, and airflow control surfaces is a significant problem for commercial, military, and NASA aerospace operations. It is estimated that these ice-related problems cost the aerospace industry over a billion dollars a year and cause nearly 10% of all weather-related aircraft fatalities. Despite the pressing need for ice mitigation on mission critical surfaces, icephobic materials are difficult to design and evaluate, since (1) ice adhesion is poorly understood and (2) current testing methods are destructive and not adaptable to real-world conditions. Here, we propose to design and build an optical system to examine ice adhesion on several aerospace-relevant surfaces. The proposed optical system will measure the vibration frequencies of the surface with and without ice. Since the adhered ice strains the underlying substrate lattice, we expect that the vibrational frequencies of the material will energetically shift proportional to the ice adhesion strength, a phenomenon that is well known in semiconductor science. In order to establish the accuracy of this optical technique for iced surfaces, we will evaluate the same iced surfaces using shear strength measurements and x-ray diffraction. Once the validity of the optical method has been established, we will test multiple NASA-provided coatings to examine icephobicity material trends and enhance NASA's numerical ice model (LEWICE). Finally, based off the results obtained at Wyoming, we will miniaturize the optical setup for testing at NASA facilities.

Pictured is a graduate student, Dr. Bill Rice, and a Post Doc examining optics and instrumentation in the lab for observation of ice adhesion on different surfaces.

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SP-2018-02-160-KSC