ABSTRACTS – 2010 EPSCoR RESEARCH PROPOSALS

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

Submitting Organization: UNIVERSITY OF ALASKA, FAIRBANKS

PI: Denise Thorsen, Ph.D.

Co-I/Science: Anupma Prakash, Ph.D., University Of Alaska, Fairbanks

Proposal Summary

Evapotranspiration (ET) measures water loss to atmosphere through soil evaporation and plant transpiration, and is a major component of both the land surface hydrologic cycle and the surface energy balance. Our recent proof-of-concept study has shown that multiscale ground-based data can be used to calibrate and adapt ET estimation models, e.g. the Two-Source Energy Balance (TSEB) model. Adapted models can subsequently use input from moderate resolution satellite images (~60m to 1km spatial resolution) to generate maps quantifying the magnitude and spatio-temporal variability of ET over large areas. Satellite-derived ET estimates within the continental US have been a focus of NASA-sponsored research. It is time to expand the focus and provide critically-needed, reliable ET estimates for Alaska.

We propose to set up two long-term ET experimental sites in interior Alaska (currently none exists) and use field data collected at these sites to refine the ET model for interior Alaska, especially accounting for variations in vegetation cover, topography, and frozen soils. We will use images from MODIS, ASTER, and LANDSAT, and limited SAR data for improved land cover characterization and land surface temperature calculations to serve as input for the TSEB model. This project has direct economic benefits for Alaska because spatially distributed ET estimates are critical for projecting water availability for both domestic and industrial (mostly oil and gas) use; for mitigating drought, wildfire, and flood hazards; and for agricultural, water resources, and wildlife management. This project builds on partnerships between University of Alaska Fairbanks, NASA centers, USDA, Alaska state agencies, and other educational partners, and serves as a preparatory science study for the planned NASA HyspIRI satellite mission. As our research capacity develops we will increase our scope to other regions of Alaska, in service of our larger goal of contributing quality Alaskan ET estimates to refine global ET values.

Optimizing Next-Generation Image Compression Transforms via Evolutionary Computation

Submitting Organization: UNIVERSITY OF ALASKA, FAIRBANKS

PI: Denise Thorsen, Ph.D.

Co-I/Science: Frank Moore, Ph.D., University of Alaska, Anchorage

Proposal Summary

This research will use evolutionary computation (EC) to optimize transforms that improve upon state-of-the-art wavelet-based lossy image compression techniques used onboard spacecraft for images of interest to NASA scientists. The resulting transforms will improve the quantity and/or fidelity of science imagery transmitted from NASA spacecraft over constrained space communications channels.

Key objectives:

1. Scientists at NASA's Jet Propulsion Laboratory developed the ICER family of wavelet transforms to improve upon the performance of older compression methodologies for space images. This research's first objective is to demonstrate that EC may be used to evolve sets of numerical coefficients describing novel transforms that are capable of outperforming the most commonly used ICER wavelet for the lossy compression of deep space images at a single resolution level. We will quantify the improvement (as indicated by a selected rate-distortion measure) that may be achieved by evolved transforms.

2. Wavelet-based compression schemes use the multiresolution analysis (MRA) scheme, which achieves additional compression through the recursive application of a given transform k times. This research's second objective is to extend or EC-based approach to optimize

MRA transforms that outperform wavelets for lossy image compression at a selected MRA level.

3. This research's third objective is to establish a low-cost methodology that achieves substantial improvements in image quality without necessitating a redesign of the overall imaging system. Instead, evolved transform coefficients may be substituted directly into

ICER's existing imaging framework.

Statement of methods and techniques:

Discrete wavelet transforms (DWTs) are described by four sets of coefficients:

1. h1 is the set of wavelet numbers for the compression DWT.

2. g1 is the set of scaling numbers for the DWT.

3. h2 is the set of wavelet numbers for the reconstruction DWT.

4. g2 is the set of scaling numbers for the reconstruction DWT.

This research will use EC to optimize wavelet and scaling numbers describing novel image compression and reconstruction transforms.

Each transform's fitness is determined by using it to compress and reconstruct space images from a training population under lossy conditions. Fitness reflects two attributes: mean squared error (MSE) and information entropy (IE). A fitness penalty is assessed if the average IE of compressed images from the training set exceeds that achieved by the selected ICER wavelet; otherwise, a fitness reward is granted if the evolved transform reduces average MSE in reconstructed images in comparison to the MSE in images reconstructed by that wavelet. This scheme guarantees that improved image quality is achieved without sacrificing compression capability. After the entire population is evaluated, fitness-driven selection, combined with various recombination operations such as mutation and crossover, produces a new generation of candidate solutions. Evolution continues over many generations, ultimately evolving an individual that outperforms the targeted wavelet for the compression and reconstruction of deep space images at a specified MRA level. Many large-scale runs utilizing supercomputing resources may be necessary to produce a solution that performs well on large test set of images.

Perceived significance:

When used in lossy compression schemes, wavelet transforms will always introduce error into reconstructed images. Reducing the amount of error as much as possible is essential to improving image quality. If the evolved transforms produced during this research outperform ICER's wavelets by reducing the size of compressed images, the error in reconstructed images, or both, then NASA will have a new state-of-the-art methodology for compression of images.

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

Submitting Organization: UNIVERSITY OF ALABAMA, HUNTSVILLE

PI: John Gregory, Ph.D.

Co-I/Science: Kuang-Ting Hsiao, Ph.D., University of South Alabama

Proposal Summary

Carbon fiber (CF) reinforced polymer matrix composite laminates, comprising aligned continuous carbon micro-fibers embedded in polymer matrices, have superior tensile properties in the in-plane directions (x and y directions) but are weak in the matrix sensitive properties such as compressive strength, shear strength, and impact tolerance. The research team plans to utilize z-direction aligned carbon nanofibers (CNFs) to pin through the CF arrays thus improving the matrix sensitive properties. The manufacturing of such composites involves two major steps: the fabrication of the CF/(Z-aligned CNF/epoxy) prepreg and the out-of-autoclave (OOA) process to turn the prepreg into a solid composite laminate. An electrical field is used to align CNFs during the manufacturing process. The new composite materials will be evaluated for mechanical and thermal performance improvements.

This research could benefit the aerospace, defense, energy, and transportation industries.

Goals and potential outcomes include:

Higher survival rate against impact damage, interlaminar crack growth, and fatigue failure

Higher stability against varying environmental temperature (high/medium/low)

Good affordability compared to the industrial state-of-the-art prepreg/autoclave processed composites, which are facing a significant challenge in scaling-up for today’s composite structure needs

The improved Z-direction thermal, electrical, and thermal-mechanical properties could be utilized in multifunctional composite structures

The team will actively seek opportunities for further developing the technology with aerospace companies and government agencies such as NASA, AFOSR, ONR, and NSF. Current collaborators include the Marshall Space Flight Center (MSFC), Langley

Research Center (LaRC), and an aerospace company (Spirit AeroSystems). Material test data and evaluation samples may be shared with potential partners for further technology development.

The educational components include: (1) recruiting graduate and undergraduate researchers; (2) offering a new course; (3) recruiting and retaining students from underrepresented groups to engage in the research activities at USA, AU, and TU.

Development of an Open-Architecture Mission Operations System to Support Multiple Small Spacecraft Missions

Submitting Organization: UNIVERSITY OF HAWAII, HONOLULU

PI: Luke Flynn, Ph.D.

Co-I/Science: Trevor Sorensen, Ph.D., University of Hawaii, Honolulu

Proposal Summary

The goal of the proposed work is to develop a comprehensive open set of software tools designed to support the operations of one or more small spacecraft missions. This set of tools operates within an architecture named COSMOS (Comprehensive Open-architecture Space Mission Operations Support). COSMOS will particularly be suited for small operations teams with a very limited development and operations budget, such as universities. The COSMOS tools will initially be installed in two mission operation centers at the University of Hawaii (UH) and NASA Ames Research Center (ARC); and used in support of three satellites being developed by UH and ARC.

Major components of COSMOS are the visualization tools, support tools, and underlying programs that produce and manipulate the data needed by the rest of COSMOS. Our basic philosophy is that its elements will be easy to port to a new location and to modify for operating with new satellites, even for students. This is enabled by being an 'open architecture' which means not only that the source code of its major elements and structure are available, but also that it is designed to accept external modules as plug-ins through standard, well-defined interfaces.

The results of the proposed work will also benefit SOMD as HSFL, in partnership with the ARC, will use COSMOS to create a functional mission operations test bed, capable of evaluating evolutionary techniques and technologies. The modular nature of COSMOS allows additional elements and functions to be rapidly integrated, evaluated, and potentially incorporated into planning, scheduling, and control and command systems. Knowledge developed through experimentation using the COSMOS system can then contribute to the development and operation of next generation mission operations systems and techniques. It is anticipated that COSMOS will be packaged and made available to universities, NASA, and other qualified users.

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

Submitting Organization: UNIVERSITY OF NORTHERN IOWA

PI: Ramanathan Sugumaran, Ph.D.

Co-I/Science: Athanasios Papanicolaou, Ph.D., University of Iowa, Iowa City

Proposal Summary

In Iowa, projected climate shifts (e.g., increases in extreme events) coupled with intense agriculture activities (e.g., increased demands for biofuel production) create a challenging set of questions and choices for scientists, policy makers, farmers, and businesses. Motivated by these challenges and opportunities, a NASA EPSCoR grant program is proposed that focuses on the links between net CO2 emissions, land use-changes, and soil organic carbon (SOC). Our long-term vision for the Iowa NASA EPSCoR project is to build research capacity within the state and region to quantify these links while establishing a program of national stature for carbon cycle studies in intense agricultural systems. To pursue this vision, we have assembled an external advisory board of experts in the field of carbon dynamics from NASA research centers and the USDA-National Soil Survey Center (NSSC). This specific research program brings together a qualified team of scientists to address this multidisciplinary project from four departments at two Iowa universities and the USDA National Laboratory for Agriculture & Environment (NLAE).

In this research program, we propose to investigate the impact of land-use changes and associated agricultural practices on SOC sequestration potential with the goal of providing better estimates of future trends in CO2 emissions within the region. In collaboration with the NASA collaborators the EPSCoR investigators have discussed and developed a two-pronged methodological approach (bottom-up, top-down) to meet our overarching goal of research capacity building. The bottom-up approach promotes understanding of the relationship between land use/land cover and CO2. The top-down approach provides understanding the carbon cycle at multiple scales. A central part of our methodological design is to intercompare and reconcile to the extent possible CO2 fluxes obtained from the bottom-up and top-down approaches. From the latter intercomparison we will be able to identify areas of improvement for the larger scale models.

The Carbon Cycle NASA EPSCoR program will test the development of methods and models of carbon budgets at a smaller, regional scale, which will eventually be applied at larger scales. The proposed analysis is a critical component of any system for determining carbon credits that may be developed in the future. Our research program is expected to lead to infrastructure, partnerships, and collection of unique data for elucidating the role of land-uses and management practices on carbon losses and gains in intense agricultural environments, thus achieving sustainable extramural funding for continued research and student training. . The NASA benefits from the proposed EPSCoR research program are ample as we will provide an improved understanding of how soil and atmospheric measurements taken at local and regional scale can be used to improve the biogeochemical models critical to NASA's forecasts of atmospheric composition, land cover, and climate at decade-to-century time scales. NASA collaborators will provide vital NASA/USGS Landsat and MODIS satellite imagery required to running the biosphere flux models. In addition, they will actively participate in the intercomparison exercises. Successful execution of the EPSCoR activities is expected to further NASA earth science priorities, provide excellent student training in carbon cycle and agricultural carbon issues, and give a high probability for future funding in this area.

Remote Sensing of the Cryosphere: Calibration and Validation

Submitting Organization: UNIVERSITY OF IDAHO, MOSCOW

PI: Aaron Thomas, Ph.D.

Co-I/Science: Hans-Peter Marshall, Ph.D., Boise State University

Proposal Summary

Estimates of the Snow Water Equivalent (SWE) - the volume of fresh water that a given snow-covered area represents - are required for water resource management, hydro-power, and flood forecasting. Over a billion people worldwide depend on snow-melt for water supply. Increases in temperature and precipitation will significantly alter the distribution of snow, greatly complicating prediction of this already poorly understood but critical water resource. Although snow covered area (SCA) can currently be accurately estimated from space using optical techniques, SCA only gives information about where snow is, but not how much water is stored (SWE). Estimating SWE using remote sensing techniques remains problematic, as manual ground-truth measurements in typically highly variable snow conditions are time-consuming. Much of the annual runoff in the Western U.S. originates as snow in the high elevations, where measurements are difficult and sparse, and spatial variability is large.

This project has two goals: 1) to improve estimates of snow properties from microwave remote sensing, and 2) to develop a focused research group within Idaho, which will become a leader in remote sensing of the Cryosphere, allowing Idaho researchers to compete nationally in Cryosphere and Hydrology programs at NASA, NSF, and other agencies. Microwave remote sensing has great potential for giving scientists and practitioners information about SWE at a global scale throughout the year, as these frequencies penetrate both clouds and the snowcover, and are sensitive to SWE. Active radar sensors have been chosen for the current European Space Agency CoreH20 mission. Results from the second NASA Cold Lands Processes Experiment (CLPX-II) campaigns in both Colorado and Alaska show that active airborne and space-borne radar have great promise for estimating SWE in a wide range of snow conditions. Despite the promise of microwave radar for retrieving SWE, practical application of space-borne microwave radar remains difficult due to: 1) sub-pixel heterogeneity of snow properties, and 2) sensitivity to snow grain size, both of which have a large but poorly understood effect on radar backscatter, and are both difficult to accurately measure and model. The major limitation towards solving these problems has been a lack of radar data in well-characterized snow conditions. This project will improve our ability to estimate SWE from space, leveraging unique new datasets that were recently collected by the Science PI, in addition to new ground-based and laboratory radar experiments. These data will allow our group to study the effect of snow properties on microwave radar using radiative transfer and detailed high-quality data that has been previously unavailable.

This project contains objectives in four major areas, all of which focus on improving our ability to measure snow properties from space, and which will position Idaho as a leader in remote sensing of the Cryosphere: 1) analysis of unique, existing radar datasets recently collected by the Science-PI; 2) measurement and analysis of a high-resolution spatial database of radar and snow properties in Idaho and Greenland; 3)measurement and analysis of continuous temporal database of radar and snow properties at a local site in Idaho; and 4) E/PO: initiation of a long-term undergraduate research program with the Idaho NASA Space Grant Consortium and development of a strong education and public outreach program in collaboration with the Discovery Science Center of Idaho, Boise State's NSF K-12 program, and the Boise State McNair Program.

Molecular Mechanisms of Cellular Mechanoreception in Bone

Submitting Organization: UNIVERSITY OF IDAHO, MOSCOW

PI: Aaron Thomas, Ph.D.

Co-I/Science: Julia Oxford, Ph.D., Boise State University

Proposal Summary

Microgravity leads to reduced mechanical load on the skeleton, increased fragility, and subsequent bone fracture. Forces normally applied under load stimulate bone formation by osteoblasts and suppress bone resorption by osteoclasts, leading to maintenance of bone mass. In contrast, an absence of loading leads to a net decrease in bone mass, due to the suppression of bone formation by osteoblasts and an increase in bone resorption. While these facts have been well established, the precise molecular and cellular mechanisms that regulate homeostasis of the living skeletal tissues are not well understood. In the proposed work, cells will be maintained under simulated microgravity conditions. Novel molecular targets that have potential for development of countermeasures to bone loss caused by microgravity will be assessed. The anticipated result from these studies is a more thorough understanding of the effect of microgravity on the novel mediators of mechanoreception. Through this understanding, we will be able to describe the extent to which key molecules regulate mechanoreception. Mechanisms of mechanoreception, and pathways of signal transduction must be understood if we are to determine how skeletal tissues respond to forces. Development of methods to prevent or treat bone loss depends on an improved understanding of the mechanisms that cause the problem. Determining how the body translates mechanical loading (physical force) into the cellular signals that control bone structure may reveal how aging, inactivity, and space flight uncouple bone formation from resorption. This line of investigation may lead to the development of preventive or therapeutic strategies for bone loss due to microgravity.

CubeLab Standard for Improved Access to The International Space Station for Science Payloads

Submitting Organization: UNIVERSITY OF KENTUCKY, LEXINGTON

PI: Suzanne Smith, Ph.D.

Co-I/Science: James Lumpp, Ph.D., University Of Kentucky, Lexington

Proposal Summary

The end of the Shuttle program will leave the US in a precarious position. This is most acutely evident for future access to the International Space Station (ISS). By leveraging a new standard called the CubeLab, we propose to pave the way for a wide variety of payloads to fly to the ISS, provide improved access for research payloads, and help the United States fulfill NASA's vision for the International Space Station.

We propose an innovative research program that brings together academic, industrial, and NASA partners to usher in a new era in access to space for industrial, educational, and NASA payloads on the ISS. NASA collaborators from multiple Mission Directorates and NASA Research Centers across the country will work with Kentucky's academic experts to leverage expertise in small spacecraft development. In this project, the team will 1) develop a robust, radiation tolerant, standardized CubeLab "bus", 2) enhance infrastructure in Kentucky to test and flight qualify ISS payloads, and 3) apply these technologies and capabilities to flight qualify, launch, and operate a NASA Astrobionics experiment on the ISS.

As a result, the proposed research will 1) produce a portable standardized bus that will accelerate the development of future ISS research CubeLabs, 2) further strengthen the collaborations among the researchers in Kentucky, as well as between the participating NASA Mission Directorates and Centers, 3) enhance the research capabilities in Kentucky to design, develop and operate spacecraft and payloads, 4) result in a sustainable program with Kentucky serving as integrator for future CubeLab payloads, and finally, 5) will fly a NASA payload to carry out astrobionics research and disseminate research results that would otherwise have not been possible.

NASA Mission Directorates: SOMD, ESMD

MARSLIFE: Modes of Adaptation, Resistance and Survival for Life Inhabiting a Freeze-dried-radiation-bathed Environment

Submitting Organization: LOUISIANA BOARD OF REGENTS

PI: John Wefel, Ph.D.

Co-I/Science: Brent Christner, Ph.D., Louisiana State University and A&M College

Proposal Summary

The presence of water on Mars and on a number of planetary moons (e.g., Europa, Enceladus, Ariel, and Triton) suggests that multiple loci within the solar system may plausibly support microbial life. In this context, the overarching theme of the project proposed here, MARSLIFE, is that selective pressures in terrestrial extreme environments serve as "training grounds" that enrich for microbial phenotypes that may dominate extraterrestrial habitats on Mars and elsewhere. The MARSLIFE program will: (i) investigate existing and novel microorganisms with tolerances to cold, desiccation, and radiation as models for astrobiology; (ii) use laboratory simulators to assess responses of selected extremophiles to temperature, pressure, and radiation conditions that exist in a range of extraterrestrial environments; (iii) characterize biological resistance mechanisms to freezing, desiccation, and radiation, and (iv) improve technologies for the detection and sampling of microorganisms under conditions similar to the surface of Mars. The expected outcomes include(a) the development of fundamental astrobiological "signatures" and operational capabilities that would promote the success of future NASA-driven life detection missions, (b) inform policies on planetary protection, and (c) lay the foundation for a new space research enterprise in Louisiana. This multi-disciplinary Astrobiological initiative is under the direction of Science PI Brent Christner in the Department of Biological Sciences and involves the Department of Physics & Astronomy at Louisiana State University, collaborating with NASA Ames and the Balloon Program Office at NASA Wallops, plus researchers at Southern University (Physics), and Louisiana Tech University (Computer Science). Both graduate and undergraduate students will be involved/trained yielding a multi-cultural project team fully capable of making major scientific advances. The collaborative relationships nurtured within the context of MARSLIFE will produce technologically informed, interdisciplinary scientists and foster new technology and educational opportunities in Louisiana.

Learning how to breathe: what can we learn about antiquity, biological iron oxidation, and respiration on oxygen from modern Fe-oxidizing bacteria.

Submitting Organization: MAINE SPACE GRANT CONSORTIUM

PI: Terry Shehata, Ph.D.

Co-I/Science: David Emerson, Ph.D., Bigelow Laboratory For Ocean Sciences

Proposal Summary

This proposal has an ambitious agenda to harness bioinformatics together with the power of modern single cell sorting and genomics techniques to understand an ancient problem with the potential to shed light on two significant biological mysteries: the evolution of aerobic respiration, and the capacity for bacteria to use reduced iron as an energy source. The work is of direct relevance to three of the major goals laid out in the 2008 NASA Roadmap for Astrobiology (1). In order of priority, Goal 5 aims to, 'Understand the evolutionary mechanisms and environmental limits of life.' Goal 7, recognition of biosignatures that can help to '....reveal and characterize past and present life in ancient samples from Earth, extraterrestrial samples measured in situ or returned to Earth...', and finally Goal 4, the integration of biosciences and geosciences to better understand how life adapted to environmental conditions through Earth history, and in turn may have influenced those conditions. To carry out this work will require developing the infrastructure for establishing a bioinformatics pipeline at the single cell genome center (SCGC) that has recently been established at Bigelow. This user service facility is the first of it's kind. In addition, a full time postdoctoral student will carry out much of the research, and we will sponsor at least six internships in bioinformatics and genomics for undergraduate students from Maine colleges and universities.

Development of advanced turbulent flow prediction models for NextGen air transport

Submitting Organization: UNIVERSITY OF MISSISSIPPI

PI: Peter Sukanek, Ph.D.

Co-I/Science: Dibbon Walters, Ph.D., Mississippi State University

Proposal Summary

This proposal outlines a program to enhance research competiveness in Mississippi while addressing critical technology needs for the Subsonic Fixed Wing project (SFW) and Environmentally Responsible Aviation (ERA) project of NASA¿s Aeronautics Research Mission Directorate (ARMD). We will establish a new, collaborative research effort focused on computational fluid dynamics (CFD) and turbulence modeling for analysis and design of future generation aircraft systems. Our effort will capitalize on existing strengths within the state, including expertise and infrastructure in computational science and engineering, while establishing new working relationships between two of the state¿s research universities and a NASA research asset. The goals of our three-year effort are to: establish long-term collaborative relationships between investigators at Mississippi State University and Jackson State University, and researchers at NASA GRC; develop, implement, and validate novel turbulence modeling methods and next-generation software tools for film cooling and low-pressure turbine aerodynamics simulations; provide increased education and training in engineering and computational science to graduate and undergraduate students in Mississippi, including those from traditionally under-represented groups; and identify, pursue, and obtain extramural funding from non-EPSCoR sources to sustain a long-term research program in computational analysis for aerothermodynamics applications. Our research effort will combine a novel framework for hybrid RANS-LES turbulence modeling, based on a rigorous mathematical interpretation of the turbulence terms in the governing equations, with next-generation CFD flow solver technology that will allow the efficient solution of problems with up to billions of computational mesh elements. Successful completion of our effort will result in: new enabling technologies for gas turbine analysis and design; an established multi-institutional research program in Mississippi that can successfully compete for extramural funding in this area; and significant enhancement of the education and training of graduate and undergraduate students, including members of under-represented groups at the state¿s largest minority-serving institution (JSU).

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

Submitting Organization: MONTANA STATE UNIVERSITY, BOZEMAN

PI: Angela Des Jardins, Ph.D.

Co-I/Science: Brock LaMeres, Ph.D., Montana State University, Bozeman

Proposal Summary

The goal of this project is to design, prototype, and test a novel radiation tolerant flight computer. Our system uses a fault mitigation strategy that can detect, recover, and repair damaged regions of a computer using tile-based reconfiguration of a reprogrammable hardware fabric. This type of spatial fault mitigation has the ability to recover from the three main types of radiation effects observed in aerospace flight systems implemented on reprogrammable fabrics: Single Event Upsets (SEU), Single Event Functional Interrupts (SEFI), and Total Ionizing Dose (TID). This project will build upon existing research that has been conducted over the past two years at Montana State University under the direction of Science-PI Dr. LaMeres. In this previous work, a prototype computing system has been developed and demonstrated in the laboratory that can continue operation in the presence of emulated faults caused by all three of the above mentioned radiation effects. In this project, we will mature this technology from Technical Readiness Level (TRL) 3 to TRL-5 by testing our system in the Radiation Effects Facility at Texas A&M University. As part of this project, we will develop the necessary support hardware to facilitate ion chamber testing and characterize our computer system's fault tolerance. The specific tasks of this project include: 1) increasing the complexity of our computer system for testing in a representative environment; 2) development and packaging of a spatial radiation sensor; and 3) development of a spatially aware configuration SRAM verification circuit (i.e., a scrubber).

In this project we will develop and test a tile-based, soft processor computing system. In this approach, a field programmable gate array (FPGA) is divided into equally sized tiles which represent a quantum of resources that can implement a soft processor and can also be individually reprogrammed using partial reconfiguration (PR) of the FPGA. At any given time, three of the processors are configured in Triple Modular Redundancy (TMR) with the rest reserved as spare processor tiles. In the event that the TMR voter detects a fault, a recovery process is initiated that will attempt to reset, reinitialize, and resynchronize the faulted tile. If the tile reset is not successful, a spare processor is brought online from one of the unused tiles to replace the faulted circuit. Once the new TMR triplet is operational, an attempt is made to recover the previously faulted tile using partial reconfiguration. After PR, the recovered tile is reintroduced into the system as an available spare. If the system tries to use the recovered tile for a second time and immediately experiences a fault, the tile is marked as permanently TID damaged and is no longer available for use. The mitigation strategy in this project has the advantage of addressing the two main logical fault types experienced in SRAM-based FPGAs (fabric SEUs and SRAM SEFIs) in addition to being able to continue operation despite localized TID damage can extend the useful life of flight hardware. A spatial radiation sensor gives more fault tolerance to this system by providing information to the SRAM scrubber circuit as to where potential faults may have occurred.

This project was defined to meet the objectives of the ESMD Advanced Avionics and Processor Systems (AAPS) project. AAPS is part of the Exploration Technology Development Program, which manages a variety of technologies needed by the Constellation Program and other unmanned missions. This project will contribute to the objectives of the NASA AAPS reconfigurable computing task which includes: 1) modular reusable computing resources for avionics and other space infrastructure; 2) dramatically reduced flight spares requirements; 3) self-configuring and interconnection of sub-systems; 4) significant improvements in system fault detection and self-repair; 5) increased efficiency; and 6) improved safety and reliability.

Site Assessments in Cold and Alpine Environments for Wind Power Generation

Submitting Organization: UNIVERSITY OF NEW HAMPSHIRE, DURHAM

PI: David Bartlett, Ph.D.

Co-I/Science: James Koermer, Ph.D., University of New Hampshire, Plymouth

Proposal Summary

Wind turbines are often cited as a viable, partial solution for energy production. However, more studies are needed to assess the feasibility of this technology, especially when it comes to colder and/or alpine environments. Ice accretion in cold climates can cause significant impacts on these turbines. This accretion can also lead to potential safety hazards due to thrown ice. Additional problems can include difficult installation and maintenance locations. Site selection of wind farms is already difficult due to political constraints, but the natural environment can contribute to other significant problems. Considerable work has already been conducted (mostly in Europe) on ice accretion and its impact on wind turbines. However, most currently published studies dealt with specific areas, focused on installing anemometers and then checking their data out a priori for the economic viability of turbines for that region.

The proposed project would be a collaborative effort between Plymouth State University (PSU), the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL), the Mount Washington Observatory (MWO), and NASA Glenn Research Center (GRC). These institutions have a history of dealing with meteorology, terrain characterization, wind turbines, icing, and other related cold phenomena research.

The first objective of the proposed research plan is to gather more spatially coherent surface observational data, augmented with specialized data from ice detector sensors. The second objective of this research is to combine mesoscale, terrain feature, and icing models to model site specific conditions in order to estimate environmental suitability. Field measurements from the first objective will be used to verify model accuracy and modify the models to provide a high-confidence site prediction capability. The third objective would be to deploy prototype NASA GRC remote ice detector equipment. The NASA system provides real-time information about cloud base, cloud top, and supercooled liquid water conditions producing icing with elevation using microwave radiometers. Surface-based data and data from PSU radiosondes would be used for ground truth. The NASA data would provide important information for verifying meteorological and icing models. The final objective would be to develop some general end-to-end guidelines that could be used as a basis for considering and selecting future wind turbine sites in these harsh environments.

In summary, the proposed project team would involve partners from academia, government, and private non-profit research organizations. The focus is on developing a capability for virtually selecting and evaluating potential wind turbine sites. Virtual prospecting would lead to efficient preliminary screening and identification of high power potential areas, assessing environmental impacts and site viability, and determining turbine design-specific elements, such as turbine hub height. There are also potential side benefits for a better characterization of terrain-induced icing conditions that can be detrimental to aviation in cold and complex terrain environments.

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

Submitting Organization: UNIVERSITY OF NEVADA, RENO

PI: Christian Fritsen, Ph.D.

Co-I/Science: Hans Moosmuller, Ph.D., Desert Research Institute

Proposal Summary

Direct radiative forcing by aerosols is second in importance for climate change only to that of greenhouse gases. Uncertainty of aerosol forcing is much larger than that of greenhouse gas forcing, however, due to lack of knowledge of aerosol optical properties and their inhomogeneous distribution.

Monitoring of aerosol radiative forcing is needed on a global scale, which is only possible with satellite remote sensing, for example by NASA's Earth Observing System. However, satellite measurements of aerosol radiative forcing are still mostly qualitative due to:

Lack of information on aerosol optical properties, especially on the spectra of aerosol light absorption.

Ground truthing procedures based on sun-sky photometers that do not have a direct connection to in situ measurements of aerosol optics.

Nevada is currently lacking a substantial program in aerosol satellite remote sensing despite the presence of leading research groups in aerosol optics. We propose to build research and educational capacities in this area by:

Utilizing and expanding the existing research capacity for in situ measurements of aerosol optical properties to improve aerosol retrieval in satellite remote sensing with a focus on the highly climate-relevant aerosol single scattering albedo.

Connecting the existing NASA ground-based remote sensing network (AERONET) with first-principle-based in situ measurements of aerosol optical properties to establish a direct, traceable connection with satellite retrievals.

Establishing a University of Nevada, Reno course on satellite remote sensing of the atmosphere to contribute to development of Nevada's STEM workforce in this area.

Coordination with NASA is facilitated by leading NASA aerosol satellite remote sensing scientists:

Dr. Michael Mishchenko - Program Manager: Global Aerosol Climatology Project; Project Scientist: GLORY Satellite Mission; NASA Goddard Institute for Space Studies.

Dr. Anthony Strawa - Lead: Aerosol and Cloud Microphysics Group, Atmospheric Physics Branch, Earth Sciences Division, NASA AMES Research Center.

PR NASA EPSCoR: Nanostructured III-N solar cells for space applications

Submitting Organization: UNIVERSITY OF PUERTO RICO, SAN JUAN

PI: Gerardo Morell, Ph.D.

Co-I/Science: Maharaj Tomar, Ph.D., University of Puerto Rico, Mayagüez

Proposal Summary

The objective of this proposal is to understand the fundamental material processes and charge transport of III-N based semiconductors and nanostructures for high efficiency solar cells. MOCVD and molecular beam epitaxy (MBE) will be used for material growth. We propose to study the (a) kinetics and growth of InxGa1-xN and related semiconductors b) growth of nanostructures and quantum dots to create intermediate bands for multiple-excitation-generation, c) effective p- and n-doping in InxGa1-xN system, and d) 2-D electron gas in GaN/InxGa1-xN heterojunctions and interface chemistry.

Joe Loferski predicted the energy band gaps (Eg) for photovoltaic (PV) solar cells to range from 1.0 to 2.0 eV range. III-N semiconductors inherently have greater radiation hardness and high breakdown fields. They provide opportunity for band gap engineering ranging from 0.7 eV (InN) to 3.8 eV (GaN), and InxGa1-xN solid solution that can cover the entire visible and near infrared solar spectrum. Therefore, GaN/InxGa1-xN based single and double junction solar cells with higher radiation hardness could be fabricated.

Theoretical prediction that over 60% electrical conversion efficiencies may be achieved by photon induced transitions in intermediate bands, where InxGa1-xN material system provides excellent opportunity. The theoretical criteria suggest that intermediate bands could be achieved by introducing suitable nanoparticles in InxGa1-xN. The concept of intermediate bands is attractive if the concept of intermediate band is realized in InxGa1-xN material, very high efficiency solar cells could be developed in near future. Vapor phase reaction of metal organic chemical vapor deposition (MOCVD) is well established for the growth of III-N materials and it will be used to grow InxGa1-xN material system, intermediate bands, and other nanostructures. Effective p- doping is a challenge in InxGa1-xN for p+-n homojunction based optoelectronic devices. The proposed research will be complementary to NASA mission.

Development of Advanced Anodes and Electrolytes for NASA Battery Systems

Submitting Organization: BROWN UNIVERSITY

PI: Peter Schultz, Ph.D.

Co-I/Science: Brett Lucht, Ph.D., University Of Rhode Island

Proposal Summary

High-energy-density lithium ion batteries are critical for almost all of NASA Exploration Mission Systems Directorate (EMSD) applications and robotics programs in the Science Mission Directorate (SMD), in which reduction of battery weight or increase in energy density can result in enormous cost savings. In order to develop the next generation of lithium ion batteries that can meet NASA applications, new electrode materials, architectures and electrolytes are necessary that can result in substantially higher energy-density batteries. Our proposed research is focused on (1) the development of new flame retardant and stable electrolytes and (2) new durable silicon anode architectures, that will contribute to NASA's goal of developing "ultra high energy cells". Our effort on electrolytes has three primary components: optimization of the electrolyte for reduced flammability; optimization of electrolyte performance with high voltage (5 V Vs Li/Li+) and the generation of stable solid electrolyte interphase on silicon anode materials. Our effort on silicon anodes has two components: a systematic characterization of the mechanical properties of lithiated silicon; development of a new anode architecture in which a silicon film is supported by a flexible elastomer substrate. Such a design eliminates stresses due to substrate constraint and results in a durable electrode. For educational outreach, we partner with "Leadership Alliance" to recruit students from minority and underrepresented groups for summer research. The students will work on independent research projects related the NASA-EPSCoR effort. In addition, a faculty member from a Rhode Island undergraduate institution will work on a summer project each year during the course of this grant. A NASA EPSCoR grant will help establish deep expertise in Rhode Island to enable the state's researchers to compete for NASA and non-NASA funding in the area of lithium battery materials.

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

Submitting Organization: UNIVERSITY OF CHARLESTON

PI: Mitchell Colgan, Ph.D.

Co-I/Science: Tony Reynolds, Ph.D., University Of South Carolina, Columbia

Proposal Summary

Successful performance of the work described in this proposal will make significant contributions to NASA capabilities in both the Aeronautics and the Space Operations Mission Directorates. Development of the technology under study, friction extrusion, will provide both NASA and the aerospace industry with new tools for reducing the cost of structures and waste of strategic material while simultaneously increasing the performance of metallic structures. In addition, the technology may provide useful adjunct tools for extending space missions by enabling methods for extra-terrestrial fabrication of hardware. The proposed work will contribute to the overall research infrastructure, higher education, and economic development of the EPSCoR jurisdiction as follows: (1) The PI¿s will enhance their capabilities in the areas of friction based processing, process visualization/volumetric image correlation, and process simulation. (2) Highly qualified graduate students will be trained in areas relevant to the aerospace industry. (3) Research relevant to the aerospace industry is increasingly important to the EPSCoR jurisdiction as significant expansion by the aerospace industry is taking place in South Carolina and the anticipated economic development will be enhanced by providing trained engineers to accommodate this expansion. Further, successful development of the friction extrusion process could lead to substantial reductions in the cost of titanium parts and structures in general. This is based on synergies between the friction extrusion process and low cost titanium powder technologies currently being developed elsewhere: friction extrusion is a path to consolidation of powder into wrought product which does not require an intermediate melting step.

The overarching goals of the proposed research are (1) to develop an in-depth understanding of the physics of the friction extrusion process in order to enable its use for a wide range of high value added manufacturing applications and (2) provide highly trained graduates for the aerospace workforce of the future. In this regard, three PhD graduate students will be supported to conduct a rigorous and creative study of the friction extrusion process. These students will be mentored by highly qualified principal investigators with the net result that the friction extrusion technology will be better understood and greatly improved while the students further their education and enhance the scientific knowledge base for our nation. The proposed research includes a balance between experimental characterization of the friction extrusion process and modeling/simulation of the process. Critical experiments designed to correlate starting material morphology and composition, extrusion die geometry, die rotation rates and extrusion pressures will be performed. Careful measurement of process response and specialized visualization techniques will be employed to provide validation for the numerical simulations to be developed. In turn, the simulations will be used to help guide process modifications for improved process productivity and product quality.

NASA personnel from Langley Research Center have agreed to participate in project planning and oversight so that NASA priorities are appropriately addressed.

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

Submitting Organization: UNIVERSITY OF CHARLESTON

PI: Mitchell Colgan, Ph.D.

Co-I/Science: Fanglin (Frank) Chen, Ph.D., University Of South Carolina, Columbia

Proposal Summary

NASAs mission to explore inhospitable environments such as the Moon and Mars, and to support the International Space Station requires substantial use of electrical power and oxygen for extremely long durations to support manned missions. The unitized regenerative solid oxide fuel cell (SOFC) cycle is one of the most attractive choices for supplying power for communications, advanced life support, survey equipment and rovers, and oxygen for crew habitats. A bi-electrode supported cell (BSC) technology recently developed at NASA Glenn Research Center demonstrates very competitive performance, such as high power density, high efficiency, and potentially improved durability. ENrG Inc. (in Buffalo, NY) has an agreement with NASA to continue that development with the objective of commercializing the BSC technology. However, there are several key technical challenges that need to be resolved in order to increase the technical readiness level of the BSC technology for implementation in the forthcoming missions. The central research objective of this NASA EPSCoR project is to establish the underlying science and engineering that can accelerate the development of high power density regenerative BSC technology to support NASAs planetary exploration missions. Integrated approach and multidisciplinary tasks are planned to systematically develop new electrode compositions and microstructures, to optimize cell performance through cell and component testing and mathematical modeling, to evaluate the degradation mechanisms using electrochemical impedance spectroscopy, and to explore strategies for performance and durability enhancement. This project is a collaborative effort involving four faculty members at the University of South Carolina with complimentary expertise. The SOFC program at the University of South Carolina has active interaction with the SOFC team at NASA Glenn Research Center as well as ENrG, Inc. The project will enhance scientific research, particularly as it relates to clean energy and the hydrogen economy, in the EPSCoR jurisdictions of South Carolina.

Enhanced Raman Detection of Minerals, Microbes, and Biomarkers through the Development of Advanced Plasmonic Nanomaterials

Submitting Organization: SOUTH DAKOTA SCHOOL OF MINES & TECHNOLOGY

PI: Edward Duke, Ph.D.

Co-I/Science: Chaoyang Jiang, Ph.D., University Of South Dakota

Proposal Summary

This project will develop advanced plasmonic nanomaterials as substrates for enhanced Raman detection of minerals, microbes, and biomarkers. The scientific merits of this proposal arise from recent theoretical and experimental advancements in plasmonic nanomaterials, namely, that Surface Enhanced Raman Scattering (SERS) based on metallic nanostructures can provide substantially detailed and valuable molecular information. This project directly supports the design of compact chemical and biochemical detectors for NASA's planetary exploration by providing Raman-active nanostructured materials. The project will focus on the synthesis, surface modification, and characterization of porous silver nanotube networks (PSNNs). Furthermore, SERS detection of minerals, microbes, and biomarkers with the newly developed PSNNs will be systematically investigated, and the structures of PSNNs will be optimized for the highest sensitivity. This proposal describes an integrated plan to (1) develop PSNNs with superior sensitivities for SERS detection of chemical and biochemical compounds of interest to NASA, (2) establish a multi-institutional research team in South Dakota focused on chemical sensing utilizing advanced plasmonic nanomaterials, (3) strengthen collaborations with scientists at the NASA Ames Research Center (ARC) to develop and evaluate innovative nanomaterials based on PSNNs for planetary exploration, (4) enhance multi-level education on plasmonic nanomaterials and chemical sensing for undergraduate and graduate students, including Native American students, and (5) collaborate with industrial partners to promote economic development activities. This project will be carried out through collaboration of faculty members (from three research universities and one tribal college in South Dakota), research scientists, graduate and undergraduate students, and industrial partners. It will also be monitored by scientists in NASA ARC for both research and education activities. The successful outcomes of this project include the establishment of a multi-institutional research cluster, the development of advanced plasmonic nanomaterials of PSNNs, the education of students, and the promotion of economic development activities.

Heating Rate Sensor and Analytic Tools for Prediction of Surface Heat Flux and Temperature of TPS via In-Depth Sensor Data

Submitting Organization: VANDERBILT UNIVERSITY

PI: Dr. Alvin Strauss, Ph.D.

Co-I/Science: J.I. Frankel, Ph.D., University of Tennessee, Knoxville

Proposal Summary

The proposed research aligns with NASA's hypersonic flight needs for accurately quantifying heat flux in severely hostile environments. Both thermal protection systems (TPS's) and structurally integrated thermal protection systems (SITPS's) are required for maintaining vehicle and propulsion integrity at significantly elevated temperatures and heat fluxes. Hypersonic combustor effectiveness can also be evaluated by accurate estimation of heat losses from the flow to the surrounding structure. In these applications, accurate surface predictions are required for both temperature and heat flux. The overall goal of this project is to significantly improve the estimation of surface temperature and heat flux through in-depth measurements. In-depth substrate measurements require the use of analytic tools for extracting stable and accurate surface predictions. Guidelines for instrumentation and controlled laboratory testing for calibration of test coupons before installation and use for a ground test or in-flight test will be developed. The guidelines will provide analytic tools and procedures for determination of sensor time constants, material properties (if needed), and prediction and verification of the surface temperature and heat flux. A combined experimental and analytical approach is proposed motivated by several recent theoretical observations and a newly developed heating rate sensor (K/s). Additionally, locating the onset of transition in hypersonic flows may be determined though the rate based sensor portion of the investigation. Our research partners shall provide technical guidance, insight, samples, and facilities on mutually beneficial aspects of the program. The proposed experimental test facilities will be unique to the State of Tennessee. These new facilities will provide significant capabilities for attracting future research funds while providing a model facility for advancing education.

Development, Characterization, and Validation of an Aerogel/RTV Based Cryogenic Propellant Tank

Submitting Organization: VANDERBILT UNIVERSITY

PI: Alvin Strauss, Ph.D.

Co-I/Science: Jeffrey G. Marchetta, Ph.D., The University of Memphis

Proposal Summary

Long duration space missions will require new, reliable technologies in managing and storing cryogenic propellants. Cryogenic propellant tanks in space, such as an orbiting propellant depot, and on planetary surfaces (e.g. Moon, Mars) are exposed to incidentsolar radiation causing an increase in pressure as the liquid vaporizes (self pressurization). Here we propose a novel tank design which combines the elastomeric properties of the space qualified polymer RTV 655 with the thermal insulation properties of mechanically reinforced crosslinked silica aerogels. In this design the aerogel slabs are embedded in the elastomer sheets forming a protective sleeve around the aerogel slabs. This eliminates the need for metals since the cryogenic liquid holder is itself an insulating material.

In addition to the development of the RTV encapsulated crosslinked aerogel cryogen tank, we will develop a novel finite volume based Computational Fluid Dynamic (CFD) model of the tank self-pressurization process. The proposed model will significantly enhance the simulation capability because it can be directly applied to all heat transfer phase change problems including those that the value of latent heat is significantly larger than the sensible internal energy. The simulation will be validated using existing experimental data on tank self-pressurization and will be utilized to assess the suitability and thermal performance of the RTV encapsulated crosslinked aerogel material for cryogenic tank applications.

Remote Thermal Ion Measurements and Integrated Magnetospheric Modeling

Submitting Organization: WEST VIRGINIA UNIVERSITY

PI: Majid Jaraiedi, Ph.D.

Co-I/Science: Amy Keesee, Ph.D., West Virginia University

Proposal Summary

Earth's space plasma environment, or geospace, is dominated by several important electrodynamic and plasma-physics processes. The magnetospheric plasma sheet undergoes changes during global events called magnetospheric storms. We will study the thermal and magnetic energy balance in the magnetosphere by focusing attention on the ion populations of the plasma sheet and inner magnetosphere and examining their heating and transport during storms in a multidisciplinary approach.

We propose the following objectives:

Objective 1: Identify ion heating events in the magnetotail plasma sheet.

Objective 2: By identifying initial and boundary conditions for the magnetosphere that result in enhanced ion heating, identify physical processes responsible for this heating.

Objective 3: Determine the amount of ion heating at reconnection exhausts in simulations of reconnection as a function of initial conditions and number of exhaust crossings.

Objective 4: Develop a research and education program at WVU focused on experimental space plasma science.

The primary methodology is analysis of energetic neutral atom data from NASA missions IMAGE and TWINS. This analysis establishes the location and timing of ion heating events in the magnetosphere. Ion heating occurs as a result of many complex processes, including solar wind forcing, magnetic reconnection, and ionospheric outflow. To differentiate between the mechanisms we combine in situ and ground-based measurements from multiple sources with simulations performed using the Comprehensive Ring Current Model (CRCM), the BATS-R-US model, and two massively parallel reconnection models. The in situ measurements are obtained from plasma instruments aboard geosynchronous spacecraft and magnetospheric survey spacecraft such as THEMIS. The ground-based measurements of geomagnetic activity are provided by the MEASURE magnetometer array. Global magnetospheric-plasma simulations such as BATS-R-US, made available through Goddard/CCMC, allow us to place these information-rich observations in physical context while microscale reconnection simulations can yield characteristic ion heating signatures for basic field geometries. We complement these analytical, modeling, and theoretical efforts with the development of research and education experiences for graduate and undergraduate students through involvement in these projects and a new experimental space plasma physics program. The unique capabilities of the science team in energetic neutral atom data analysis, in

magnetospheric modeling, and in magnetic reconnection modeling, coupled with their strong collaboration with scientists at Goddard Space Flight Center, provide a solid foundation on which to build an integrated space physics research program at West Virginia University that will achieve scientific objectives consistent with NASA core science goals.

Spray Heat Transfer Mechanisms

Submitting Organization: WEST VIRGINIA UNIVERSITY

PI: Majid Jaraiedi, Ph.D.

Co-I/Science: John Kuhlman, Ph.D., West Virginia University

Proposal Summary

A Monte Carlo model will be developed for spray cooling with boiling, based upon the fundamental physical mechanisms that occur in the process, but simplified so predictions are computed in a reasonable run time. Impingement of the huge number of droplets onto a heater surface, and subsequent detailed fluid, heat transfer, and phase change processes occurring in the liquid film forming on the heater will be modeled via a combination of time scale analysis, experimental data, and Computational Fluid Dynamics results. Monte Carlo modeling of spray cooling is a unique and innovative approach that will be far more efficient than first-principles attempts to simulate the fluid flow, heat transfer, and phase change processes that occur when individual spray droplets impinge onto a heater surface and interact with the liquid film, vapor bubbles, and one another.

This work will result in a spray cooling model that can be used in the design of practical spray cooling heat rejection systems for application in future spacecraft and aircraft. For example, the "Tropospheric Wind Sounder" would utilize an LDA pumped laser requiring rejected heat fluxes on the order of 100 W/cm2 or greater. A related mission, the "Global Wind Observing Sounder", is mentioned in the NASA Science Mission Directorate (SMD) 2007-2016 Science Plan summary. Another potential application of spray cooling is for use in future commercial manned and unmanned missions. The CFES (Compact Flash Evaporator System), which was under development at NASA GRC for application to the Crew Exploration Vehicle that was to replace the Space Shuttle would be an example of such a system. Our research will help enable such future space missions through development of improved fundamental understanding of spray cooling, leading to a validated spray cooling model to guide spray cooling system design.

Nanostructured Photovoltaics for Space Energy Applications

Submitting Organization: UNIVERSITY OF WYOMING

PI: Paul Johnson, Ph.D.

Co-I/Science: Wenyong Wang, Ph.D., University Of Wyoming

Proposal Summary

In this project we propose to investigate quantum dot sensitized ternary oxide solar structures for NASA's future space power applications. Published work on metal oxide solar devices has mainly focused on binary oxides. Compared with simple binary materials, ternary metal oxides offer more freedom in the tuning of chemical and physical properties, and thus have the potential to improve device performance. In addition, ternary oxides also exhibit better corrosion resistance than binary materials. Therefore, combining ternary oxides with quantum dots (QDs) provides significant advantages for light absorption, charge separation, and charge transport, and will create more robust solar cells with improved efficiency.

This proposal has three main research objectives: 1) study of quantum dot sensitization of single crystal ternary oxide surfaces, 2) fabrication and characterization of ternary oxide nanowire solar cells, and 3) study of long term device stability issues. The proposed research is aimed at gaining a fundamental understanding of the basic science behind QD sensitization and device operation of ternary oxide solar structures. This project also brings together researchers from different academic disciplines at UW to initiate an important energy-focused research direction that is in line with a state wide energy effort and will improve local research infrastructures in the jurisdiction of Wyoming.

This project will make significant contributions to NASA's Science Mission Directorate, especially to NASA's Power and In-Space Propulsion Program. We have established collaboration with the research group of Nanomaterials and Nanostructures for Space Photovoltaics at the NASA Glenn Research Center. Our investigation will complement and enhance the NASA group's study on nanostructured photovoltaics. Together, our joint effort will achieve a better understanding of the processes that are essential to photovoltaic operation and realize solar cells with improved performance that are suited for NASA's applications.