List of Potential EPSCoR Partnership Opportunities at The Goddard Space Flight Center

Described below is some of the current engineering and scientific research being conducted at the Goddard Space Flight Center. If you have an EPSCoR faculty member at your university conducting similar research who may be interested in collaborating with one of these Goddard scientists and/or engineers, they should contact Dave Rosage at David.J.Rosage@nasa.gov or at 301-286-0904 to follow-up.

The Applied Engineering and Technology Directorate (AETD)

The Applied Engineering and Technology Directorate (AETD) at NASA/GSFC embraces the overall theme of Advanced Technology and Engineering for Tomorrow's Exploration (ATETE). AETD provides end-to-end engineering support to all projects within Goddard Space Flight Center focusing on the following areas:

Earth and Space

- State of the art scientific instruments
- Sub-orbital to orbital (small to medium) scope scientific missions
- Flagship scientific observatories missions
- End-to-end data systems

Exploration

- Avionics systems communications and navigation
- Unpressurized cargo
- Situational awareness and decision-making tools

Space Operations

- Flight Dynamics Facility and navigation systems
- Ground and space communications network
- Operations systems

We develop high performance and cost effective solutions to the most challenging problems on flight missions ranging from suborbital projects—

including balloons, sounding rockets, and airplanes—to interplanetary probes and flagship observatories. In addition, we acquire and distribute science data worldwide.

Research Area I: Technologies and Systems used to support NASA development, demonstration, testing, and flight performance with reduced operational risks during mission lifetimes.

1. **CubeSats**. A CubeSat is a 10 cm cube with a mass of up to 1 kg. Required research would develop components, technologies and systems to support NASA technology demonstration and risk reduction efforts. Research include addressing of miniature power, pointing, communication, command/telemetry, structure, deployable sub-systems and/or integration of such components into complete off-the-shelf "CubeSat bus" systems, minimizing "bus" weight/power/volume/cost and maximizing available payloads for future space application.

   Participating institutions will develop CubeSat components, technologies and systems to support NASA technology demonstration and risk reduction efforts. Student teams will develop miniature CubeSat power, pointing, communication, command/telemetry, structure, deployable (etc) sub-systems and/or integrate such components into complete off-the-shelf "CubeSat bus" systems, with a goal of minimizing "bus" weight/power/volume/cost and maximizing available "payload" weight/power/volume. NASA technologists will then use these components/systems to develop payloads that demonstrate key technologies to prove concepts and/or reduce risks for future Earth Science, Space Science and Exploration/Robotic Servicing missions. Flatley, Thomas P. (GSFC-5870)

2. **High performance multicore processing for advanced automation and science data processing on spacecraft.** The required research is in the area of software frameworks and architectures to utilize these platforms. The required research includes efficient inter-core communications, software partitioning, fault detection, isolation & recovery, memory management, core power management, scheduling algorithms, and software frameworks be done to enable a transition to these newer platforms.

   There are multiple multicore processing platforms in development that are being targeted for the next generation of science and exploration missions, but there is little work in the area of software frameworks and architectures to utilize these platforms. It is proposed that research in the areas of efficient inter-core communications, software partitioning, fault detection, isolation & recovery, memory management, core power management, scheduling algorithms, and software frameworks be done to enable a transition to these newer platforms. Participating institutions can select areas to research and work with NASA technologists to develop and prototype the resulting concepts. Wildermann, Charles P. (GSFC-5820)

3. **Mixed Signal and Mixed Technology Modeling**. VHDL-AMS is an IEEE standard hardware description language that can simulate mixed signal and mixed technology systems. The required research would assist GSFC by modeling complete instrument systems and their components. Several design trade-offs by this modeling effort are sought and these results would inform the specific hardware implementation or approach. Intellectual property (IP) should be maintained for use by subsequent flight instruments. An electronically accessible intellectual property design database that can be reused should be developed.

   VHDL-AMS provides for the architectural exploration of systems composed of mixed technologies (thermal, mechanical, electrical, optical, etc) in a single simulation environment prior to physical implementation. The EPSCoR universities could assist GSFC by modeling complete instrument systems and their components starting after the AO award and continuing through Phase A. The universities, in conjunction with GSFC engineers could quickly make several design trade-offs by this modeling effort and these results would inform the specific hardware implementation or approach. For example, it can be quickly determined if a 14-bit or 16-bit ADC will meet the performance requirements for a subsystem through actual simulation of that subsystem using both approaches. Commercial electronic design automation (EDA) companies such as Synopsys and Mentor Graphics sell VHDL-AMS tools. However most if not all EDA companies have a deep discount program for universities when it comes to the purchase of their EDA tools. This is to say that this will not be a financial burden for the universities to finance the acquisition of the EDA tools. Since the models and systems of our instruments will be highly parameterized, this intellectual property (IP) will/should be maintained for use by subsequent flight instruments. Therefore, part of this modeling effort should also involve creating an electronically accessible intellectual property design database that can be reused. It is recognized that semiconductor processes are today at 28 nm. and are getting smaller. Robyn King/564.

4. **Lasers and Electro-Optics**. GSFC seeks development of new concepts and optical technologies for future generation laser ranging, remote sensing laser instruments and optical communications systems for space applications. Specific topics include solid- state lasers, fiber and waveguide optical amplifier systems, optical parametric amplifiers, tunable infrared semiconductor lasers and single-photon detector arrays; and space qualification, testing, reliability analysis of diode laser arrays. Krainak, Michael A. (GSFC-5540).

5. **Development & Application of Super-Resolution Synthetic Aperture Radar (SAR) Data Processing Techniques**. Synthetic aperture radar (SAR) is an airborne or spaceborne coherent microwave remote sensing system that can provide high-resolution images of an observed area, night and day and nearly independent of the weather conditions. The required research applies mathematical tools such as parametric spectral estimation techniques, wavelet theory for enhancing performances of SAR data processing algorithms.

   Synthetic aperture radar (SAR) has been one of most important instruments for NASA's Earth science missions and space exploration. The most challenging problem with the SAR work is the development of robust and smart SAR data processing algorithms that take into account most of the prevailing instrument conditions when the SAR data had been recorded. There has been a large volume of work in the past on the development of SAR data processor and these efforts are continuing today for further enhancement of SAR data processing algorithms. However, these SAR data processing algorithms are based on the well known spectral estimation tool such as Fast Fourier Transform (FFT). The FFT approach, being a non-parametric, gives spectral resolution that is limited by the observation time. In recent years there has been a great interest in applying other mathematical tools such as parametric spectral estimation techniques, wavelet theory for enhancing performances of SAR data processing algorithms. Applications of these new mathematical tools to SAR data processing improves SAR image quality by many folds and hence is worth pursuing.

Research Area II: Engineering Advancements for NASA Exploration

6. **Analog Synthesis of Mixed Signal ASICS**. Digital synthesis opened up the path for the direct synthesis/realization of hardware through a *hardware description language (VHDL and Verilog*. The required research is for the proposer to work with the external commercial mixed signal ASIC companies to translate their "analog/mixed signal primitives" into a VHDL-AMS format such that analog and mixed signal components can be simulated and realized in hardware.

   There are several new radiation hardened mixed signal Structured ASIC platforms that are suitable for flight instrument electronics. Offerings from Sandia National Labs and Triad Semiconductor are just two examples. Digital synthesis opened up the path for the direct synthesis/realization of hardware through a hardware description language (VHDL and Verilog). However the path to realize analog hardware has been lacking. Most of the research in this area is in the universities. GSFC seeks to aggressively include these universities into our mixed signal ASIC instrument efforts. One way of achieving this is to have the universities work with the external commercial mixed signal ASIC companies to translate their "analog/mixed signal primitives" into a VHDL-AMS format such that analog and mixed signal components can be simulated and realized in hardware. GSFC engineers could manage this effort with heavy university participation. It is recognized that semiconductor processes are today at 28 nm. and are getting smaller. Robyn King/564.

7. **Instrument Detector Focal Plane Electronics**. The required work creates and maintains the focal plane electronics IP. This IP would be highly generic but parameterizable to meet the specific requirements of each imaging flight

instrument. There is an option of translating these "generic" focal planes electronic design into radiation hardened Structured ASICS.

GSFC produces many imaging instruments with detectors of various sizes. The accompanying focal plane electronics are designed from the ground up each time. It would be more efficient and more productive if the universities created and maintained the focal plane electronics IP. This IP would be highly generic but parameterizable to meet the specific requirements of each imaging flight instrument. The universities could also handle the job of translating these "generic" focal planes electronic design into radiation hardened Structured ASICS. GSFC engineers have a rich knowledge in designing focal plane electronics. GSFC seeks to transfer this knowledge/capability to the universities and let them manage this IP. It is recognized that semiconductor processes are today at 28nm and are getting smaller. Robyn King/564.

8. **Cell Mechanobiology in Space**. Research is sought to further our knowledge of mechanotransduction pathways with special interest in basic experiments to elucidate the role of mechanical factors on cellular responses and how these results might translate to phenomenon observed in microgravity. Such research would propose methods for maintaining the health and safety of a human crew beyond the biological effects studied under microgravity.

   The Obama Administration has asked NASA to shutdown the Constellation Program and in its wake, to pursue basic research that would lead to innovations for enabling extended missions in space. In this pursuit, the most important challenge is finding methods for maintaining the health and safety of a human crew. Although the adverse effects of microgravity are well-studied, the cellular mechanisms responsible for sensing changes in its physical microenvironment are not fully understood. Consequently, efforts for countering the biological effects of microgravity are superficial and have not directly targeted the fundamental processes at play. This solicitation is looking for research to further our knowledge of mechanotransduction pathways. We are interested in basic experiments to elucidate the role of mechanical factors on cellular responses and how these results might translate to phenomenon observed in microgravity. Yew, Alvin G. (GSFC-5960).

9. **Alternative Energy in Space**. Research is sought for novel methods of energy production, collection and storage in space. Methods should endeavor to minimize mass and identify broad applications for its use. Research may include computational modeling, basic experiments, advanced prototypes or some combination.

   Despite the miniaturization of spaceflight instruments, future missions will be more ambitious than ever and will require increasing demands for power. This is especially true for planetary probes to the outer planets where the intensity of sunlight is dramatically reduced. Advanced Sterling Radioisotope Generators (ASRG) have been considered for past and future projects and although promising, they may not be suitable for all mission architectures. This solicitation is seeking proposals for novel methods of energy production, collection and storage in space. Methods should endeavor to minimize mass and identify broad applications for its use. Proposals may include computational modeling, basic experiments, advanced prototypes or some combination. Yew, Alvin G. (GSFC-5960)

10. **Advanced nanocomposites for performance-enhanced spaceflight materials**. Research is sought to develop advanced nanocomposities for flight application and to establish a strong position to evaluate promising materials developed by outside researchers. GSFC seeks to develop this area and to establish a strong position to evaluate promising materials developed by outside researchers. Getty, Stephanie A. (GSFC-5410)

11. **Miniaturized devices for solid, liquid, and gas handling for future planetary science analytical instruments**. Research is sought to address gaps that exist in this area to complement lots of activities to look at how to autonomously handle sample in robotic Solar System exploration missions. Additional research is sought for support in testing such components or subsystems for relevant future mission applications.

    GSFC seeks externally developed solutions to address gaps that exist in this area to complement lots of activities going on across the center to look at how to autonomously handle sample in robotic Solar System exploration missions. GSFC seeks support in testing such components or subsystems for relevant future mission applications. Getty, Stephanie A. (GSFC-5410).

12. **Radiation Enablement**. Research is sought for development of radiation hardness assurance guidelines for commercial off the shelf (COTS) component assemblies and the development of test environment requirements for emerging technologies viewed as enabling to NASA.

    GSFC seeks development of radiation hardness assurance guidelines for commercial off the shelf (COTS) component assemblies and the development of test environment requirements for emerging technologies viewed as enabling to NASA. Anthony Sanders/561.

The Sciences and Exploration Directorate (Code 600)

The Sciences and Exploration Directorate is the largest Earth and space science research organization in the world. Its scientists advance understanding of the Earth and its life-sustaining environment, the Sun, the solar system, and the wider universe beyond. The Directorate is part of Goddard Space Flight Center in Greenbelt, Maryland.

Researchers in the Sciences and Exploration Directorate work with engineers, computer programmers, technologists, and other team members to develop the cutting-edge technology needed for space-based research. Instruments are also deployed on aircraft, balloons, and Earth's surface.

The Directorate's researchers share their findings and data with the scientific community. Education and Public Outreach programs explain the science to students and the general public.

Astrophysics Science Division (ASD)

The Astrophysics Science Division is on one of the largest and most diverse astrophysical organizations in the world, with activities spanning a broad range of topics in theory, observation, and mission and technology development. Scientific research is carried out over the entire electromagnetic spectrum—from gamma rays to radio wavelengths—as well as particle physics and gravitational radiation. Members of ASD also provide the scientific operations for two orbiting astrophysics missions— XTE and Swift, as well as the Science Support Center for the Fermi Gamma-ray Space Telescope. A number of key technologies for future missions are also under development in the Division, including X-ray mirrors, space-based interferometry, high-contrast imaging techniques to search for exoplanets, and new detectors operating at gamma-ray, X-ray, ultraviolet, infrared, and radio wavelengths. ASD has a strong suborbital research program, with four balloon programs and three sounding rocket programs at present. The Division supports research in the astronomical community through the High Energy Astrophysics Science Archive Research Center (HEASARC), which now also contains Cosmic Microwave Background data, as well as support services for observers using the Fermi, Suzaku, Integral, XMM-Newton, GALEX, RXTE, WMAP, and Swift missions. Finally, ASD has a strong Education and Public Outreach program, to convey the exciting discoveries from NASA missions to school teachers, students, and the public.

Earth Science Division (ESD)

The ESD's Mission is to improve life on Earth and to enable space exploration through the use of space-based observations. To study the planet from the unique perspective of space, ESD develops and operates remote-sensing satellites and instruments. ESD's goals are to:

- Advance understanding of the Earth System through exploration from the vantage point of space.
- Improve predictions of the Earth system through measurements and models.
- Provide leadership in Earth system science and technology including the development of new instruments, measurement missions, and models.
- Establish partnerships to promote Earth science.
- Enhance the nation's scientific and technological literacy.

ESD conducts a broad theoretical and experimental research program to answer the following questions:

- How does the Earth work?
- How is the Earth changing?
- How does our changing environment affect life on 'Earth?

The science focus areas include: atmospheric aerosols, atmospheric chemistry, atmospheric water cycle, carbon cycle and ecosystems, climate modeling and analysis, oceanography, polar climate change, terrestrial water cycle, and weather and short-term climate.

Heliophysics Science Division (HSD)

The Heliophysics Science Division's Mission is to explore the Sun's interior and atmosphere, discover the origins of its temporal variability, understand its influence over the Earth and the other planets, and determine the nature of the interaction between the heliosphere and the local interstellar medium.

The Heliophysics Science Division conducts research on the Sun, its extended solar-system environment (the heliosphere), and interactions of Earth, other planets, small bodies, and interstellar gas with the heliosphere. Division research also encompasses geospace -- Earth's uppermost atmosphere, the ionosphere, and the magnetosphere -- and the changing environmental conditions throughout the coupled heliosphere (solar system weather).

Scientists in the Heliophysics Science Division develop models, spacecraft missions and instruments, and systems to manage and disseminate heliophysical data. They interpret and evaluate data gathered from instruments, draw comparisons with computer simulations and theoretical models, and publish the results. The Division also conducts education and public outreach programs to communicate the excitement and social value of NASA heliophysics.

Major activities of HSD include:

- Leading science investigations involving flight hardware, theory, modeling, and data analysis that will answer the strategic questions posed in the Heliophysics Roadmap.
- Leading the development of new solar and space physics mission concepts and supporting their implementation as Project Scientists.
- Providing access to measurements from the Heliophysics Great Observatory (HGO) through our Science Information Systems.
- Communicating science results to the public and inspiring the next generation of scientists and explorers.

The HSD's strategic goals are to:

- Open the frontier to space environment prediction;
- Understand the nature of our home in space;
- Safeguard the journey of exploration.

Solar System Exploration Division (SSED)

SSED's Mission is to provide scientific expertise and leadership to support GSFC projects and to achieve NASA's strategic goals in the exploration of the solar system and beyond. The Solar System Exploration Division provides leadership in conceiving, defining, and implementing NASA's programs that advance our understanding of the solar system and the capability to explore. The Division plans, organizes, evaluates, and implements a broad program of theoretical and experimental research to explore the solar system and to study the formation and evolution of planetary systems. To do this, the Division conducts a broad program of innovative research that spans across astrochemistry, planetary systems, planetary geodynamics, space geodesy, planetary magnetospheres, comparative planetary studies, investigations of Earth as a planet, solar system data systems, and instrument development. The Division also engages in cross-cutting research in lunar exploration, astrobiology, and Mars exploration.

Major activities of the Division include:

- Developing theoretical models of the origin and structure of solar systems and their objects, and the processes that alter them.
- Designing experimental approaches and hardware to test these theories in the laboratory and on ground-based, aircraft, and space platforms.
- Collecting, interpreting, and evaluating data gathered from these experiments, and publishing conclusions based on experimental and theoretical research.
- Archiving and disseminating these data, providing expert user support to the community, and undertaking education and public outreach programs centered on our science missions and services.

What are the names of the scientists conducting the research? Please list all researchers in the respective research areas as follows:

Research Area 1: Astrophysics Science Division

Names of Scientists: William Oegerle, Director (Dark Energy), Joan Centrella Associate Director (Gravitational Astrophysics) , Neil Gehrels (Astroparticle Physics Lab Chief), Robert Petre (X-Ray Astrophysics Lab Chief), Tucker Stebbins (Gravitational Astrophysics Lab, Chief), Jonathan Gardner (Observational Cosmology Lab Chief), Jennifer Wiseman (Exoplanets and Stellar Astrophysics Lab, Chief)

Research Area 2: Earth Science Division

Names of Scientists: Peter Hildebrande, Director, Dorothy Zukor, Associate Director, James Hansen (Goddard Institute for Space Studies), William K. Lau, (Laboratory for Atmospheres Chief), David Adamec (Hydrospheric and Biospheric Sciences Lab Chief)

Research Area 3: Heliophysics Science Division

Names of Scientists: James Slavin, Director, Douglas Rabin, Associate Director Solar Physics, Adam Szabo (Heliospheric Physics Lab Chief), Melvyn Goldstein (Geospace Physics Lab Chief), Michael Hesse (Space Weather Laboratory, Chief)

Research Area 4: Solar System Exploration Division

Names of Scientists: Anne Kinney, Direcotr, Amy Simon-Miller, Associate Director, Jason Dworkin (Astrochemistry Lab, Chief, Reggie Hudson (Planetary Systems Laboratory Chief), Pamela Millar (Laser Remote Sensing Lab Chief), Steven Curtis (Planetary Magnetospheres Lab Chief), Herbert Frey (Planetary Geodynamics Lab Chief), Paul Mahaffy (Atmospheric Experiments Lab Chief).

What research themes are anticipated for this organization within the Center over the next five years? (Please describe each area of research and provide Key Words to describe the Research)

1. **Astrophysics Science**. The Astrophysics Science Division conducts a broad program of research in astronomy, astrophysics, and fundamental physics. Individual investigations address issues such as the nature of dark matter and dark energy, which planets outside our solar system may harbor life, and the nature of space, time, and matter at the edges of black holes.

Observing photons, particles, and gravitational waves enables researchers to probe astrophysical objects and processes. Researchers develop theoretical models, design experiments and hardware to test theories, interpret and evaluate the data, archive and disseminate the data, provide expert user support to the scientific community, and publish conclusions drawn from research. The Division also conducts education and public outreach programs about its projects and missions. Key words: astronomy, astrophysics, fundamental physics, dark matter, dark energy, solar system, black holes, photons, gravitational waves, gamma ray, high energy astrophysics, astroparticle, x-ray astrophysics, gravitational astrophysics, observational cosmology, exoplanets and stellar astrophysics

2. **Earth Science**. The Earth Sciences Division at NASA Goddard Space Flight Center plans, organizes, evaluates, and implements a broad program of research on our planet's natural systems and processes. Major focus areas include climate change, severe weather, the atmosphere, the oceans, sea ice and glaciers, and the land surface.

To study the planet from the unique perspective of space, the Earth Science Division develops and operates remote-sensing satellites and instruments. We analyze observational data from these spacecraft and make it available to the world's scientists. Our Education and Public Outreach efforts raise public awareness of the the Division's research and its benefits to society.

Key words: climate change, severe weather, the atmosphere, the oceans, sea ice and glaciers, land surface, remote sensing, carbon cycle, ecosystems, global modeling, mesoscale atmospheric processes, climate and radiation, atmospheric chemistry and dynamics, hydrospheric and biospheric sciences, cryospheric sciences, hydrological sciences, terrestrial information systems

3. **Heliophysics Science**. The Heliophysics Science Division conducts research on the Sun, its extended solar-system environment (the heliosphere), and interactions of Earth, other planets, small bodies, and interstellar gas with the heliosphere. Division research also encompasses geospace -- Earth's uppermost atmosphere, the ionosphere, and the magnetosphere -- and the changing environmental conditions throughout the coupled heliosphere (solar system weather).

Scientists in the Heliophysics Science Division develop models, spacecraft missions and instruments, and systems to manage and disseminate heliophysical data. They interpret and evaluate data gathered from instruments, draw comparisons with computer simulations and theoretical models, and publish the results. The Division also conducts education and public outreach programs to communicate the excitement and social value of NASA heliophysics.

Key words: Sun, solar system environment, geospace heliosphere, ionosphere, thermosphere, magnetosphere, solar system weather, interstellar gas, solar physics, geospace physics, space weather, solar disturbances, solar wind, magnetic reconnection, solar cycle, corona, solar wind plasma, interplanetary medium, UV radiation, magnetic dynamos

4. **Solar System Exploration**. The Solar System Exploration Division conducts theoretical and experimental research to explore the solar system and understand the formation and evolution of planetary systems. Laboratories within the division investigate areas as diverse as astrochemistry, planetary atmospheres, extrasolar planetary systems, planetary geodynamics, space geodesy, and comparative planetary studies.

Division scientists develop theoretical models of how planetary systems form and evolve and design experiments and hardware to test them. They collect, interpret, and evaluate experimental data and publish conclusions based on this research. The Division archives and disseminates the data, provides expert user support, and undertakes education and public outreach programs about the Division's science missions and services.

Key words: astrochemistry, planetary atmospheres, extrasolar planetary systems, planetary geodynamics, space geodesy, comparative planetary studies, laser remote sensing, planetary magnetospheres, atmospheric science