NASA Ames Research Center – Research Priorities for NASA EPSCoR
May 17, 2023

1. **Entry Systems: Safely delivering spacecraft to Earth & other celestial bodies**
    a. Diagnostics for Arc Jet Characterization -- Arc jet testing of atmospheric entry vehicle thermal protection materials is important, as it provides a method of delivering flight-like heat fluxes to potential heat shield materials. Interest in new arc jet diagnostics is twofold. First, inherent in this ground test capability is the need to link the acquired ground test data to flight conditions. We are interested in experimental characterization of the flow with the goal of providing validation data and boundary conditions for modeling efforts aimed at making this link. Second, the advancement of nonintrusive diagnostics in recent years has expanded the potential for implementing additional arc jet health monitors. Simple sensors that can quickly inform the operator of off-nominal performance would inform maintenance intervals and could save hardware from damage.
    b. Oxidation Protection of Porous Carbon Substrates for Ablative Applications -- Oxidation protection of carbon substrates is important for extending the usability of carbon composites in high temperature and/or oxidizing environments, such as aerospace structural and thermal protection materials. We are interested in evaluating approaches to apply ceramic oxide coatings on carbon substrates and composites used for spacecraft heat shields where oxidation limits the performance of the material system. Cost and scale-up feasibility should also be considered as the approach is being developed. Ideally, the approach should be able to impart the protection on a porous carbon substrate (not just an external coating) with little mass increase for the substrate.
    c. Thermal and Mechanical Property Measurements of Carbon and Organic Fiber Single Filaments and Tows – For thermo-mechanical modeling and characterization of 3-D woven thermal protection systems, longitudinal thermal conductivity and mechanical properties (Young's Modulus) of single filament fibers (C PAN fibers and phenolic fibers) are required, but such data is challenging to measure. In addition to single fiber property measurements, there is interest in characterizing the relaxed state (unloaded) thermal conductivity (longitudinally and transversally) in hybrid yarns consisting of blended carbon and phenolic fibers. Understanding the change in thermal conductivity as the hybrid yarns are loaded is also sought. Mechanical properties of the hybrid carbon phenolic yarn including Young's modulus and Poisson's ratio are also requested. Complimentary micro-CT of the tested tows to directly relate the microstructure composition of the hybrid yarn with the new experimental values measured would be valuable.
    d. Improvements for Entry, Descent, and Landing -- Improvements, either in the form of experiments or modeling & simulation, are sought for physics relevant to NASA entry, descent, and landing (EDL). Such relevant physics could include shock layer radiation and kinetics (e.g., quantum chemistry, radiation mechanism measurements, etc.), thermal protection system material updates (micro to macroscale), aerodynamic heating and dynamic stability, plume surface interaction, reaction control system interaction, guidance, navigation and control algorithm improvements, or numerical methods for high speed fluid dynamics.

2. **Advanced Computing and IT systems: Enabling NASA's advanced modeling and simulation**
   a. Planning and decision support systems for integrated, collaborative human and robot lunar surface exploration.
   b. Virtual assistants in support of more autonomous human spaceflight operations for time-critical events, such as spacewalks and medical care.
   c. Integrated data systems for onboard support of troubleshooting and problem-solving, including sensor telemetry and engineering data.
   d. Data visualization systems to provide integrated representation of engineering and sensor data for onboard procedure execution and diagnostic support.
   e. Computational Aerosciences: Technologies and large-scale simulations to support NASA's aviation needs for safe, efficient, environmentally sustainable aircraft.
   f. Quantum computing algorithms

3. **Aerosciences and Airborne Science**
   a. Testing on the ground in wind tunnels before you take to the sky.
   b. Airborne Science for examining our own world & beyond from the sky, including air quality, smoke observations and modeling, coral reefs, coastal aquatic quality, ocean carbon, and current observations and modeling.
   c. Air Traffic Management: Transforming the way we fly with NextGen air transportation.
   d. Unmanned Aerial Systems, including developing novel approaches for composite materials manufacturing to advance urban air mobility.

4. **Astrobiology and Life Science: Understanding life on Earth - and in space**
   a. Limits of habitability
   b. Emergence of life, how does a habitable planet become inhabited
   c. Biosignatures – Life detection
   d. Space Radiation

5. **Cost-Effective Space Missions: Enabling high value science to low Earth orbit & the Moon**

   Research in novel technology and mission architectures to advance cost effective space mission needs. Development and validation of new spaceflight architectures, technologies, and operations for complex and autonomous space flight and supporting systems:

   a. Develop unique small spacecraft concepts, instruments, and spacecraft technologies, including re-entry solutions for CubeSats; low cost, low volume, and low power software-defined radio transponder suitable for CubeSat/SmallSat deep space missions; and flight dynamics orbital trajectory investigations for lunar, Mars, and other orbits.
   b. Advance technologies for spacecraft vehicle and system-autonomy, robotics, and flight vehicle environment awareness and operation.
   c. Advance swarm technologies.
   d. Develop unique small spacecraft mission concepts and technologies for orbital debris removal.

e. Develop mission concepts to scout and characterize moon and Mars environments, identify risks, prospect for resources, and establish critical infrastructure, including low cost lunar sample return and low cost SC inspection infrastructure for human exploration missions and cislunar activity.
f. Develop mission concepts to enable high value science for Earth and lunar orbits.
g. Develop and advance fluidic engineering architecture, materials, methods, and components to accelerate development of novel automated fluidic systems for space biology, astrobiology, and in-space health monitoring.
h. Develop novel and low-cost approaches to manage space flight mission operations and support ground support systems.
i. Develop novel approaches for maintaining and utilizing spaceflight engineering test facilities and labs.
j. Instrument development (drills, cameras, spectrometers, dielectric, etc.) for low-cost missions
k. Mars aero-explorer support
l. Network exploration with Aeolus

6. **Intelligent/Adaptive Systems: Complementing humans in space**
   a. Use of system autonomy and robotics
   b. Human systems integration
   c. Nanotechnology electronics and sensors, including solid state nanopore sensors

7. **Space and Earth Science: Understanding our planet, our solar system, and everything beyond**
   a. Laboratory experiments and theoretical calculations dedicated to the understanding of our universe by complementing astronomical observations and astrophysical/astrochemical modeling
   b. Asteroid sample return and sample analysis
   c. Observations / analysis of planetary systems, interstellar medium, and galaxies
   d. Advanced active and passive remote sensing and in-situ sensors, including radiometers and spectrometers
   e. Measurements of aerosols, cloud properties, water vapor, trace gases, and radiation budget
   f. Air quality, chemistry, smoke observations, and modeling
   g. Atmospheric dynamics and climate
   h. Exoplanets: Finding worlds beyond our own
   i. Lunar Sciences: Rediscovering our Moon, searching for water

8. **Exoplanets: Finding worlds beyond our own**
   a. Exoplanet observations (including exoplanet atmosphere spectral characterizations with JWST, exoplanet demographics with Kepler/K2, TESS, and Pandora). Characterizing binary star exoplanet hosts (ground-based precursor science, PICTURE, Roman CGI).

b. Exoplanet theory: modeling of climates and atmospheres, biosignature detectability, exoplanet stability dynamics an formation
c. Laboratory astrophysics characterizing atmospheres and surface biosignatures, generating high-resolution spectroscopic line lists
d. Astrobiology and search for life (e.g., bio signatures assessment framework)
e. High-contrast imaging: coronagraph instrument designs, trades, and technology demonstrations for the Habitable Worlds Observatory (HWO, top recommendation of Astro2020) including PIAA designs for Habex/LUVOIR
f. Spectroscopic characterization for transits: development of slitless, silicon grisms for JWST NIRCam and for transit spectroscopy with MIRI
g. Binary star exoplanet technologies: contributed mode to Roman coronagraph instrument to enable Alpha Centauri observations with Multi-Star Wavefront Control mode, and HWO follow-up
h. On-sky instruments and mission developemnt: speckle interferometric instrument on WIYN and Gemini telescopes, small mission development (e.g., ACESat) and instruments (coronagraph on EXCEDE)