FY2025 Section 3: Research Focus Areas (RFAs)

3.1 Electrified Vertical Takeoff and Landing (eVTOL), Electric Powertrain Technologies
Mission Directorate: Aeronautic Research Mission Directorate (ARMD)
NASA Glenn Research Center

Research Overview: With their unique ability to take off and land from any spot, as well as hover in place, vertical lift vehicles are increasingly being contemplated for use in new ways that go far beyond those considered when thinking of traditional helicopters. NASA's Revolutionary Vertical Lift Technology (RVLT) project is working with partners in government, industry, and academia to develop critical technologies that enable revolutionary new air travel options, especially those associated with Advanced Air Mobility (AAM) such as large cargo-carrying vehicles and passenger-carrying air taxis. These new markets are forecast to rapidly grow during the next ten years, and the vertical lift industry's ability to safely develop and certify innovative new technologies, lower operating costs, and meet acceptable community noise standards will be critical in opening these new markets.
NASA is conducting research and investigations in Advanced Air Mobility (AAM) aircraft and operations. AAM missions are characterized by ranges below 300 nm, including rural and urban operations, passenger carrying as well as cargo delivery. Such vehicles will require innovative propulsion systems, likely electric or hybrid-electric, that will need reliable, safe, efficient, and high-power density electro-mechanical powertrain technology.

The target application is eVTOL vehicles sized to carrying four to six passengers with missions as described in References 1-6. Challenges related to insulation of motor windings and the phenomena of partial discharge are discussed in the literature (examples: references 7,8). Challenges related to lubrication of electrified vehicle are also discussed in the literature (examples: references 9,10).

This research opportunity is relevant to aerospace propulsion and is of mutual interest to NASA, FAA, DoD, and the US vertical lift vehicle industry.

Research Focus Area: Research contributing to partial-discharge free motors for aviation propulsion having a continuous power rating in the range 50 – 400 kW.

Focus Area: Of special interest are: (a) techniques for measuring partial discharge and/or other markers of insulation degradation during experiments using twisted-pair wires, motorretes, stators, and/or electric machines; (b) thermo-mechanical aging of stators and/or test units representing material systems for stators; (c) research toward improved understanding of multifactor aging of stators.

Research Identifier: **RFA-001**
POC: Dr. Timothy Krantz, timothy.l.krantz@nasa.gov
Dr. Michael Hurrell, michael.j.hurrell@nasa.gov

Research Focus Area: Lubrication and cooling technologies specifically optimized for long life and highly efficient eVTOL motors, including interest in single-fluid approaches for combined cooling and lubrication of inverters, motors, and gearboxes.

Focus Area: Research to reduce the power losses associated with the lubrication while also meeting requirements for low wear and appropriate cooling.

Research Identifier: **RFA-002**

POC: Dr. Timothy Krantz, timothy.l.krantz@nasa.gov
Dr. Michael Hurrell, michael.j.hurrell@nasa.gov

References:

1) Silva, C.; Johnson, W.; and Solis, E. "Multidisciplinary Conceptual Design for Reduced-Emission Rotorcraft." American Helicopter Society Technical Conference on Aeromechanics Design for Transformative Vertical Flight, San Francisco, CA, January 2018.
2) Johnson, W.; Silva, C.; and Solis, E. "Concept Vehicles for VTOL Air Taxi Operations." American Helicopter Society Technical Conference on Aeromechanics Design for Transformative Vertical Flight, San Francisco, CA, January 2018.
3) Patterson, M.D.; Antcliff, K.R.; and Kohlman, L.W. "A Proposed Approach to Studying Urban Air Mobility Missions Including an Initial Exploration of Mission Requirements." American Helicopter Society 74th Annual Forum, Phoenix, AZ, May 2018.
4) Silva, C.; Johnson, W.; Antcliff, K.R.; and Patterson, M.D. "VTOL Urban Air Mobility Concept Vehicles for Technology Development." AIAA Paper No. 2018-3847, June 2018.
5) Antcliff, K. Whiteside, S., Silva, C. and Kohlman, L. "Baseline Assumptions and Future Research Areas for Urban Air Mobility Vehicles," AIAA Paper No. 2019-0528, January 2019.
6) Silva, C., and Johnson, W. "Practical Conceptual Design of Quieter Urban VTOL Aircraft." Vertical Flight Society 77th Annual Forum, May 2021.
7) Tallerico, T., Salem, J., Krantz, T. and Valco, M., "Urban Air Mobility Electric Motor Winding Insulation Reliability: Challenges in the Design and Qualification of High Reliability Electric Motors and NASA's Research Plan." NASA TM-20220004926, 2022.
8) Petri, T., Keller, M. and Parspour, N. "The Insulation Resilience of inverter-fed Low Voltage Traction Machines: Review, Challenges, Opportunities." IEEE Access (2022).
9) Chen, Yan, Swarn Jha, Ajinkya Raut, Wenyang Zhang, and Hong Liang. "Performance characteristics of lubricants in electric and hybrid vehicles: a review of current and future needs." Frontiers in Mechanical Engineering 6 (2020): 571464.
10) Bustami, Bayazid, Md Mahfuzur Rahman, Mst Jeba Shazida, Mohaiminul Islam, Mahmudul Hasan Rohan, Shakhawat Hossain, Alam SM Nur, and Hammad Younes. "Recent Progress in Electrically Conductive and Thermally Conductive Lubricants: A Critical Review." Lubricants 11, no. 8 (2023): 331.

Research Focus Area: Development of Characterization Techniques to Determine Rate and Temperature Dependent Composite Material Properties for the LS-DYNA MAT213 Model

Research Identifier**: RFA-003**

Mission Directorate: Aeronautic Research Mission Directorate (ARMD)

POC: Robert Goldberg robert.goldberg@nasa.gov
Justin Littell justin.d.littell@nasa.gov
Mike Pereira mike.pereira@nasa.gov

Research Overview: Overview of MAT213 - MAT213 is an orthotropic macroscopic three-dimensional material model designed to simulate the impact response of composites which has been implemented in the commercial transient dynamic finite element code LS-DYNA [1-5]. The material model is a combined plasticity, damage and failure model suitable for use with both solid and shell elements. The deformation/plasticity portion of the model utilizes an orthotropic yield function and flow rule. A key feature of the material model is that the evolution of the deformation response is computed based on input tabulated stress-strain curves in the various coordinate directions.

The damage model employs a semi-coupled formulation in which applied plastic strains in one coordinate direction are assumed to lead to stiffness reductions in multiple coordinate directions. The evolution of the damage is also based on tabulated input from a series of load-unload tests. A tabulated failure model has also been implemented in which a failure surface is represented by tabulated single valued functions. While not explicitly part of MAT213, when using the model, interlaminar failure is modeled using either tie-break contacts or cohesive elements.

The MAT213 model has the ability to incorporate both rate dependency and temperature dependency in the material response, which, potentially, could be important aspects of the dynamic and impact response of composites. To date, very little has been done to assess the effectiveness of the rate- and temperature-dependence modeling approaches, or to assess the importance of incorporating these effects in dynamic crush and impact problems. In dynamic crush problems, such as drop weight tests on composite structures, differences in response at different loading rates have been observed [6,7]. In ballistic impact tests of composite panels significant temperature rises have been documented [8]. But a fundamental understanding of the effect of strain rate and temperature is needed.

For this task we are focused on developing techniques and recommended approaches to characterize the rate dependent material parameters required for input into MAT 213 using tests at the coupon scale or similar fundamental types of tests at higher structural scales. In addition, we would like to characterize the effects of temperature changes under dynamic loading to assess the need for incorporating temperature dependence in dynamic models. To carry out this task, we are interested in having NASA-supplied composite materials and structures tested at high loading rates and/or potentially varying temperatures representative of what would exist in crash and impact events. It is expected that the tests will be conducted at the proposer's facility. NASA will attempt to provide a material for which quasi-static room temperature data are available.

A particular additional area of interest is in characterizing the post-peak material response, which can be important in simulating the response of actual structures. Currently, in many cases post peak material parameters are correlated based on the results of structural level tests. A need exists to develop capabilities and methods to characterize material parameters based on lower scale tests that are applicable for the analysis of full structures.

Research Requirements

Coupon Level Testing. Specific tests at a range of strain rates and/or temperatures that are of interest could include the following:

- Tension in the 1-direction
- Compression in the 1-direction
- Tension in the 2-direction
- Compression in the 2-direction
- Shear in the 12-direction
- Shear in the 21-direction
- 45 degrees off axis tension

Note that other tests may be conceived and conducted to develop methods to fully characterize the material of interest and to meet the goals of the project. Within the constraints of time and budget it may be necessary to prioritize tests where rate effects are expected to be more important.

Test Requirements

i. Test coupons will be machined by the grant recipient from flat panels supplied by NASA.
ii. For all tests the full set of test data must be recorded and supplied in electronic tabular format. For the tension, compression and shear tests that are conducted, the tabulated stress-strain curve, all the way to failure, must be provided. Raw data such as loads must also be supplied.
iii. All specimens must be measured and weighed prior to testing
iv. Testing is to be conducted at appropriate and relevant rate and temperature conditions.
v. The test environmental conditions must be recorded and documented
vi. A minimum of three repeats for each loading condition must be conducted
vii. Full Field Digital Image Correlation (DIC) must be used to measure deformations and strains

Deliverables

a. Full tabulated data supplied in electronic tabular format
b. All DIC images and associated calibration files
c. A final report detailing the procedures and results.

References:

1. Khaled, B., Shyamsunder, L., Schmidt, N. Hoffarth, C. and Rajan, S., "Development of a Tabulated Material Model for Composite Material Failure, MAT213. Part 2: Experimental

Tests to Characterize the Behavior and Properties of T800-F3900 Toray Composite", DOT/FAA/TC-19/51, Nov. 2018

2. T. Achstetter, "Development of a composite material shell-element model for impact applications", *PhD Dissertation,* George Mason University, 2019
3. Goldberg, R.K.; Carney, K.S.; DuBois, P.; Hoffarth, C.; Harrington, J; Rajan, S.; and Blankenhorn, G.: "Development of an Orthotropic Elasto-Plastic Generalized Composite Material Model Suitable for Impact Problems", *Journal of Aerospace Engineering*, Vol. 29, no. 4, 04015083, 2016.
4. Goldberg, R.K.; Carney, K.S.; DuBois, P.; Hoffarth, C.; Khaled, B.; Rajan, S.; and Blankenhorn, G.: "Analysis and Characterization of Damage Utilizing a Generalized Composite Material Model Suitable for Impact Problems", *Journal of Aerospace Engineering*, Volume 31, Issue 4, 10.1061/(ASCE)AS.1943-5525.0000854, 04018025, 2018.
5. Goldberg, R.K.; Carney, K.S.; DuBois, P.; Hoffarth, C.; Khaled, B.; Shyamsunder, L.; Rajan, S.; and Blankenhorn, G.: "Implementation of a tabulated failure model into a generalized composite material model", *Journal of Composite Materials*, Vol. 52, Issue 25, pp. 3445-3460.
6. Chambe, J.-E., Bouvet, C., Dorival, O., Rivallant, S. and Ferrero, J.-F. "Effects of dynamics and trigger on energy absorption of composite tubes during axial crushing", Int. J. Crashworthiness, 26(5), 2021.
7. Haluza, R., "Measurement and explicit finite element modeling of dynamic crush behavior of carbon fiber reinforced polymer composites", Ph.D. Dissertation, Pennsylvania State University, 2022
8. Johnston, J. P., Pereira, J. M., Ruggeri, C. R., & Roberts, G. D. (2018). High-speed infrared thermal imaging during ballistic impact of triaxially braided composites. *Journal of Composite Materials*, *52*(25), 3549-3562.

Intellectual Property Rights: All data and analysis methods will be publicly available and no intellectual property rights will be assigned to any of the parties involved in this research.

Research Focus Area: Multiscale Modeling of Heterogeneous Materials with NASMAT
Research Identifier: **RFA-004**
Mission Directorate: Aeronautic Research Mission Directorate (ARMD)
POC: Trenton M. Ricks, PhD trenton.m.ricks@nasa.gov
Dr. Steven M. Arnold steven.m.arnold@nasa.gov

Research Overview: The NASA Multiscale Analysis Tool (NASMAT) is a versatile platform for performing computationally efficient multiscale analyses of heterogeneous materials. NASMAT offers the user flexibility to define an arbitrary number of length scales (levels) where a variety of micromechanics theories can be implemented at each level [1]. Micromechanics theories can be selected to balance accuracy and computational efficiency and range from analytical (Mori-Tanaka) to several semi-analytical (method of cells) formulations. NASMAT can also be coupled with external software and used to perform multiscale analyses of more complex structures. For example, if NASMAT is coupled with a finite element software, NASMAT effectively acts as an anisotropic, evolving, nonlinear material model which is called at individual integration points within the elements.

Submitters are encouraged to review recent publications from the development team prior to submitting a proposal [1-4]. The selected publications are intended to provide a broad background of current NASMAT activities and should not be interpreted as providing direction on proposed topics. Backends to incorporate user-defined features within NASMAT will be provided by the development team if required. Alternatively, developed models may be incorporated into the open-source MatLab code (https://github.com/nasa/Practical-Micromechanics) accompanying Ref. [5]. Proposed topics should be aligned with one or more Key Elements outlined in the Vision 2040 study [6].

Research Requirements

Submitters are encouraged (but not required) to develop tools, methods, models (e.g., deformation or damage) and software that could be incorporated into NASMAT by the development team in the future. Topics of interest include, damage/failure modeling, multiscale model hand-shaking, evolving microstructures, multi-physics modeling, approaches to enable massively multiscale modeling, and experimental techniques to generate sub-coupon scale validation data. Proposals associated with primarily determining effective elastic properties will not be favorably viewed. Possible material systems include ceramic and polymer matrix composites and metallic systems with applications including unidirectional, woven, nano-reinforced, or short-fiber composites, additive manufacturing, and shape-memory alloys. Proposals demonstrating the need of multiscale modeling for structural problems (e.g., thermos-mechanical loading) are encouraged.

Alternatively, submitters are encouraged to consider submitting proposals involving novel experimental methods that can be utilized to validate existing capabilities within NASMAT. Experimental approaches that can be used to validate mesoscale or microscale modeling are desirable as well as those that aim to validate constituent constitute models under multi-axial and non-proportional loading.

A. Deliverables

1. A final report detailing the models, procedures, and results
2. Model results (if applicable) to be provided in a suitable electronic format
3. Source code for any developed modeling approaches
4. Raw and processed experimental digital data (if applicable)
5. Detailed documentation of new experimental equipment (if applicable)

References:

1. Pineda, E. J., Bednarcyk, B. A., Ricks, T. M., Arnold, S.M., Henson, G. (2021). Efficient multiscale recursive micromechanics of composites for engineering applications. *International Journal for Multiscale Computational Engineering*, 19(4), 77-105.

2. Ricks, T. M., Pineda, E. J., Bednarcyk, B. A., McCorkle, L. S., Miller, S. G., Murthy, P. L., & Segal, K. N. (2022). Multiscale Progressive Failure Analysis of 3D Woven Composites. *Polymers*, *14*(20), 4340.
3. Bednarcyk, B. A., Ricks, T. M., Pineda, E. J., Murthy, P. L., Mital, S. K., Hu, Z., & Gustafson, P. A. (2022). Multiscale Recursive Micromechanics of Three-Dimensional Woven Composite Thermal Protection Materials Thermal Conductivities. *AIAA Journal*, *60*(12), 6506-6519.
4. Gustafson, P. A., Pineda, E. J., Ricks, T. M., Bednarcyk, B. A., Hearley, B. L., & Stuckner, J. (2023). Convolutional Neural Network for Enhancement of Localization in Granular Representative Unit Cells. *AIAA Journal*, 1-13.
5. J. Aboudi, S.M. Arnold, B.A. Bednarcyk (2021). *Practical Micromechanics of Composite Materials Course Textbook,* Elsevier
6. X. Liu, Furrer, D., Kosters, J., & Holmes, J. (2018). Vision 2040: a roadmap for integrated, multiscale modeling and simulation of materials and systems. NASA/CR-2018-219771.

Intellectual Property Rights: All data and analysis methods will be publicly available and no intellectual property rights will be assigned to any of the parties involved in this research.

3.2 Clean Energy, Climate Change and Orbital Debris

Space Technology Mission Directorate (STMD)

STMD rapidly develops, demonstrates, and infuses revolutionary, high-payoff technologies through transparent, collaborative partnerships, expanding the boundaries of the aerospace enterprise. STMD employs a merit-based competition model with a portfolio approach, spanning a range of discipline areas and technology readiness levels. By investing in bold, broadly applicable, disruptive technology that industry cannot tackle today, STMD seeks to mature the technology required for NASA's future missions in science and exploration while proving the capabilities and lowering the cost for other government agencies and commercial space activities.

Research Focus Area: Earth-observing capabilities to support breakthrough science and National efforts to reduce greenhouse gas emissions (including CO2, CH4, N2O, HFCs).

Research Identifier: **RFA-005**

POC: Sweterlitsch, Jeffrey, Ph.D. jeffrey.j.sweterlitsch@nasa.gov

Research Focus Area: U.S. Climate Change Research Program focusing on carbon capture and Utilization.

Research Identifier: **RFA-006**

POC: Sweterlitsch, Jeffrey, Ph.D. jeffrey.j.sweterlitsch@nasa.gov

Research Focus Area: Addressing Orbital Debris: Control the long-term growth of debris population.

Research Identifier: **RFA-007**

POC: Bo Naasz, Ph.D. Bo.j.naasz@nasa.gov

3.3 Space Technology / Aeronautic Research

Space Technology Mission Directorate (STMD)
Aeronautics Research Mission Directorate (ARMD)

NASA Glenn Research Center

Research Focus Area: Development of advanced soft magnetic materials for high-power electronic systems

Research Identifier: **RFA-008**
POC: Dr. Ronald Noebe ronald.d.noebe@nasa.gov

Description: NASA is interested in the development of advanced soft magnetic materials for use in high-efficiency, high-power electrical systems for power conversion, conditioning, and filtering. Such materials will be enabling in future electrical propulsion systems for electrified aircraft and nuclear electric power and propulsion systems. Topic areas of interest include:

- Development and investigation of new materials and processing methods for soft magnetic materials with improved performance at frequencies covering the kHz to MHz range, capable of operating at 200 - 400 °C without cooling. A primary goal for inductors and transformers would be a material capable of operating with switching frequencies in the range of 10 – 100 kHz with an induction field at least 0.8 T, with low losses and can store at least 20 $kW \cdot kg^{-1}$.
- There is significant interest in the development of techniques to measure and characterize magnetostriction in foils and films, especially as a function of temperature and in the fundamental study of magnetostriction in amorphous-nanocrystalline alloys.
- Development of soft magnetic materials optimized to work at cryogenic (77 K and below) temperatures to be used in conjunction with superconducting systems for power filtering/conditioning. Also of interest is the development of characterization techniques for measuring magnetic properties (B-H loops, permeability, loss, magnetostriction) at low temperature.

Research Focus Area: Development of high-temperature structural refractory alloys and silicides and environmental coatings for refractory alloys.

Research Identifier: **RFA-009**
POC: Dr. Ronald Noebe ronald.d.noebe@nasa.gov

Description: NASA is interested in the development of alloys for use at temperatures between 1200 and 2000 °C for structural components in high-speed aircraft, space nuclear power and propulsion applications, surface fission power, high-temperature heat pipes and thermal radiators, and other applications involving extreme temperatures and environments. Topic areas of interest include:

- Development of next generation W-, Mo-, Ta-, or Nb-based alloys

- Fundamental understanding of the effect of interstitial elements on the properties of refractory metal alloys
- Development of refractory metal medium and high entropy alloys, with high strength, ductility, and moderate environmental resistance.
- Development of multi-principal element silicides for structural applications
- Understanding of processing-microstructure-property relationships in refractory alloys and silicides and the effect of alloying on intrinsic deformation and fracture mechanisms.
- Development of powder processing techniques for refractory metal alloys and silicides with an eye towards AM applications
- Development of protective coatings for refractory alloys or development of refractory alloys with inherent environmental resistance
- High-temperature mechanical properties and development of high-temperature test techniques for refractory materials

3.4 In Space Manufacturing /On Demand Manufacturing of Electronics (ODME)

Space Operations Mission Directorate (SOMD)
Exploration Systems Development Mission Directorate (ESDMD)
Space Technology Mission Directorate (STMD)

NASA's In Space Manufacturing program is developing new technologies that can support NASA mission architecture and to enable commercialization of the LEO microgravity environment. One such manufacturing technology of primary interest is on-demand printed microelectronics, sensors and semiconductors. NASA ODME project is developing next-generation technologies for deposition of materials to very high feature resolutions and very thin depositions, into the nanometer range. These new systems require new development of materials and processing techniques. ODME works with NASA Flight Opportunities to provide parabolic and suborbital fight testing validation of these processes and materials. Device structures can be, but are not limited to spacecraft health monitoring sensors, environmental monitoring sensors, human health monitoring sensors, energy harvesting devices, energy storage devices and supporting hardware. New semiconductor devices are being enabled with space manufacturing technologies, to eventually enable neuromorphic computing for advanced AI applications and many other exciting next-generation developments.

Research Focus Area: Advanced Manufacturing of Sensors and Electronics
Research Identifier**: RFA-010**

POC: Jessica Koehne, Ph.D.Jessica.E.Koehne@nasa.gov

Research Focus Area: Additive manufacturing and additive manufacturing of electronics
Research Identifier**: RFA-011**

POC: Curtis Hill curtis.w.hill@nasa.gov

Research Focus Area: LEO manufacturing support (additive, advanced materials, thin layer processing)
Research Identifier**: RFA-012**

POC: Curtis Hill curtis.w.hill@nasa.gov

Research Focus Area: Lunar manufacturing of solar cells and sensors
Research Identifier**: RFA-013**

POC: Curtis Hill curtis.w.hill@nasa.gov

Research Focus Area: Materials development for additive manufacturing
Research Identifier**: RFA-014**

POC: Curtis Hill curtis.w.hill@nasa.gov

Research Focus Area: Technology maturation through commercial (sub)orbital flight testing

Research Identifier**: RFA-015**

POC: Curtis Hill

Note: The awardees may have opportunity to seek Flight Opportunity support for flight testing.

3.5 Center for Design and Space Architecture

Mission Directorate: Exploration Systems Development Mission Directorate (ESDMD)
Space Technology Mission Directorate (STMD)

NASA Johnson Space Center
Robert L. Howard, Jr., Ph.D. robert.l.howard@nasa.gov

Research Focus Area: Crew-worn restraints and mobility aids for microgravity spacecraft cabin environments

Research Identifier**: RFA-016**

POC: Robert L. Howard, Jr., Ph.D. robert.l.howard@nasa.gov

Explanation: Traditionally, microgravity spacecraft cabins have included restraints and mobility aids such as handrails and foot restraints to enable crew to navigate the interior of the vehicle in the weightless conditions of orbital spaceflight. This focus area is concerned with alternatives to vehicle-based restraints and mobility aids. Instead, this research area investigates passive (non-powered) restraints and mobility aids that are worn on the crew members' clothing or carried on their person, such that the spacecraft does not need to provide any hardware to enable crew restraint and mobility.

Research Focus Area: Crew quarters internal architectures compatible with both microgravity and fractional gravity domains

Research Identifier**: RFA-017**

POC: Robert L. Howard, Jr., Ph.D. robert.l.howard@nasa.gov

Explanation: NASA and commercial industry are developing plans for human missions to destinations including the Moon, Mars, and deep space. Traditionally, each destination has been viewed in isolation, with spacecraft designed uniquely for that environment. Additionally, there are very few NASA standards that govern the design of crew quarters. This focus area investigates common designs for crew quarters that can be used across lunar habitats, Mars habitats, and deep space habitats, including the definition of functions and capabilities to be included in crew quarters, as well as the design and layout of components needed to implement these functions and capabilities.

Research Focus Area: Repair, Manufacturing, And Fabrication (RMAF) Facility for the Common Habitat Architecture

Research Identifier**: RFA-018**

PC: Robert L. Howard, Jr., Ph.D. robert.l.howard@nasa.gov

Research Overview: Missions beyond LEO are challenging for traditional survivability paradigms such as redundancy management, reliability, sparing, orbital replacement, and mission aborts. Distances, transit durations, crew time limitations, onboard expertise, vehicle capabilities, and other factors significantly limit the ability of human spaceflight crews to respond to in-flight anomalies. There is a need for a Repair, Manufacturing, and Fabrication (RMAF) facility to increase the capability of the crew to recover from spacecraft component failures by combing aspects of machine shop, soft goods lab, and repair shop into an IVA capability for both microgravity and surface spacecraft. An RMAF is responsible for restoring damaged components to working order (repair), keeping components in service or properly functioning (maintenance), and creating new components from raw or scavenged materials (fabrication). This responsibility extends not only to the habitat, but to all other elements sharing the same destination environment (e.g., landers, rovers, robots, power systems, science instruments, etc.). The RMAF serves both the physical operability needs of the architectural systems and contributes in two ways to the psychological well-being of the crew: one the peace of mind from understanding the capacity to respond to failures, and two, the capacity to fabricate items that serve recreational or relaxation purposes. The RMAF has potential applicability to a wide variety of in-space habitation needs.

NASA is exploring space architectures that can serve as next steps to build upon the current Artemis program. The Common Habitat Architecture Study is based on a suite of common spacecraft elements that can be used for long-duration human spaceflight in multiple destinations, including the Moon, Mars, and deep space. NASA is seeking engineering and architectural research to aid in the development of an RMAF facility capable of packaging within mid deck of the Common Habitat, a Skylab-like habitat that uses the Space Launch System (SLS) core stage liquid oxygen tank as the primary structure, with a horizontal orientation. Because most habitats intended for use beyond LEO do not return to Earth, yet may operate for decades, it can be assumed that even low probability failures will eventually occur and there must be a way to recover from them and continue the mission. Thus, the Common Habitat must include the RMAF capability. The RMAF speaks to an overarching gap of inability to mitigate spacecraft component failures. Limited in-space experiments have been conducted with 3D printing, welding, soldering, and other RMAF tools, but they have yet to be integrated into an operable spacecraft facility. The RMAF goes beyond the replacement of failed components with spares and focuses on the capabilities to restore failed components to working order, making them effectively the new spare.

1) Research Focus:

Proposed studies will assess the needs of an RMAF system for long-duration, deep space habitation and create one design solution to increase crew and vehicle survivability. Prior research has identified a list of 53 component-level critical failures that could render a subsystem or element inoperable. Fourteen repair, maintenance, and fabrication functions have been identified as collectively being able to recover a system from any of these failures. This establishes the target capability of the RMAF. Proposers will design a workspace within the volume limitations of the Common Habitat, while still accommodating these fourteen functions and will determine the associated mass impacts.

Critical Failures Requiring RMAF

1. Actuator FOD
2. Actuator overpressure
3. Actuator underpressure
4. Adhesive failure
5. Bad wireless connection
6. Belt break
7. Broken cables
8. Broken electrical connection
9. Broken physical structure
10. Bulb burnout
11. Bulb shatter
12. C&W software failure
13. Connector overtorque
14. Connector pin/connection failure
15. Connector under torque
16. Consumable depletion
17. Cracked housing
18. Cracked screen
19. Debris clog
20. Debris impact damage
21. Debris in motor
22. Diaphragm damage (digital)
23. Electrical lead failure
24. Electrical short
25. Fabric erosion
26. Fabric tear
27. Failed electrical connection
28. Fin breakage / bending/ding
29. Fluid line rupture
30. Fuse blown
31. Kinked line
32. Material abrasion / erosion
33. Material corrosion
34. Material delamination
35. Material stretching
36. Motor failure
37. Physical obstruction
38. Potting failure
39. Power surge
40. Pressure bladder puncture, tear, or rip
41. Spring too weak or too stiff
42. Structural bending
43. Structural buckling
44. Structural burst
45. Structural crack/fracture
46. Structural deformation
47. Structural gouge
48. Structural membrane disjoin
49. Structural rupture / puncture
50. Structural seal failure
51. Structural shear
52. Surface chemical contamination
53. Wire detach, split, tear, rip, or break

Generic RMAF Functions to Repair Critical Failures

1. Soldering
2. Drilling
3. Metal cutting and bending
4. Metallurgical analysis
5. Bonding metal, composite, and other surfaces
6. Electronics analysis and repair
7. Computer/Avionics inspection/testing and repair
8. CAD Modeling / Software Coding / Computer Analysis
9. Material Handling (inclusive of the range from large ORUs and small fasteners)
10. Precision Maintenance (manipulation, inspection, repair of small/delicate components)
11. 3D Printing (metal, plastic, and printed circuit board)
12. Soft goods (including thermoplastics, sewing, cutting, and patching)
13. Dust/Particle/Fume Mitigation
14. Welding

A design solution should include a mass equipment list (MEL), CAD model, and Concept of Operations document. CAD models must be in a format capable of being opened by Rhino 7 and must also be suitable for incorporation in Virtual Reality using the Unreal Engine 5. Physical prototyping and iterative human-in-the-loop (HITL) testing are encouraged but are not required.

2) **References:**

[1] Howard, Robert, "Opportunities and Challenges of a Common Habitat for Transit and Surface Operations," in 2019 IEEE Aerospace, Big Sky, MT, 2019.

[2] Howard, Robert, "Stowage Assessment of the Common Habitat Baseline Variants," in 2020 AIAA ASCEND, Virtual Conference, 2020.

[3] Howard, Robert, "Design Variants of a Common Habitat for Moon and Mars Exploration," 2020 AIAA ASCEND, AIAA, Virtual Conference, 2020.

[4] Howard, Robert, "A Multi-Gravity Docking and Utilities Transfer System for a Common Habitat Architecture," in 2021 AIAA ASCEND, Las Vegas, NV + Virtual, 2021.

[5] Howard, Robert, "A Two-Chamber Multi-Functional Airlock for a Common Habitat Architecture," in 2021 AIAA ASCEND, Las Vegas, NV + Virtual, 2021.

[6] Howard, Robert, "A Common Habitat Base camp for Moon and Mars Surface Operations," in 2021 AIAA ASCEND, Las Vegas, NV + Virtual, 2021.

[7] Howard, Robert, "A Common Habitat Deep Space Exploration Vehicle for Transit and Orbital Operations," in 2021 AIAA ASCEND, Las Vegas, NV + Virtual, 2021.

[8] Howard, Robert. "A Safe Haven Concept for the Common Habitat in Moon, Mars, and Transit Environments." 2021 AIAA ASCEND. Las Vegas, NV + Virtual. November 8-17, 2021.

[9] Howard, Robert, "Down-Selection of Four Common Habitat Variants," in 2022 IEEE Aerospace, Big Sky, MT, 2022.

[10] Howard, Robert, "Internal Architecture of the Common Habitat," in 2022 IEEE Aerospace Conference, Big Sky, Montana, 2022.

3) **Proposer-Coordinated Contributions to Proposed Work:**
Proposer to indicate any contributions to the proposed work that the Proposer has arranged, in the event of a NASA award, and that would be in addition to NASA EPSCoR awarded funding. This may include funding or other in-kind contributions such as materials or services (Proposal should indicate the estimated value of the latter)

   a. **From Jurisdiction or Organization that would partner with the Jurisdiction**
   Encouraged but None are required. Proposer shall indicate if any has been arranged for the proposed work.

4) **Other NASA-Coordinated Contributions to Proposed Work**
The following contributions will be provided to the proposed work that would be in addition to NASA EPSCOR awarded funding, and in the event of an award.

   a. **From NASA organization other than EPSCoR**
   None.

   b. **From Organization partnering with NASA**
   None.

5) **Additional Agreement Clauses applicable to Cooperative Agreements awarded for this Call Area**
Nonadditional.

6) **Intellectual Property Rights:** All technologies developed through this research will be submitted through NASA's New Technology Reporting System prior to any public dissemination. Unless otherwise determined by the NASA New Technology Office, all data and analysis methods will be publicly available and no intellectual property rights will be assigned to any of the parties involved in this research. Proposer to indicate any specific intellectual property considerations in the Proposal.
7) **Additional Information:**
   NASA will support a telecon with the Proposer prior to the submission of Proposals, to answer Proposer's questions and discuss Proposers anticipated approach towards this Research Request. Contact information is provided in section (5). NASA welcomes opportunities to co-publish results proposed by EPSCoR awardee. NASA goal is for widest possible eventual dissemination of the results from this work when other restrictions allow.

3.6 Astrophysics

Science Mission Directorate (SMD)

Research Focus Area: Astrophysics Technology Development

Research Identifier**: RFA-019**

POCs: Dr. Hashima Hasan hhasan@nasa.gov
Dr. Mario Perez mario.perez@nasa.gov

NASA's strategic objective in astrophysics is to discover how the universe works, explore how it began and evolved, and search for life on planets around other stars. Three broad scientific questions flow from this objective:

- How does the universe work?
- How did we get here?
- Are we alone?

Each of these questions is accompanied by a science goal that shapes the Astrophysics Division's efforts towards fulfilling NASA's strategic objective:

- Probe the origin and destiny of our universe, including the nature of black holes, dark energy, dark matter and gravity
- Explore the origin and evolution of the galaxies, stars and planets that make up our universe
- Discover and study planets around other stars, and explore whether they could harbor life

To address these Astrophysics goals, the Astrophysics Research Analysis and Technology Program invites a wide range of astrophysics science investigations from space that can be broadly placed in the following categories.

(i) The development of new technology covering all wavelengths and fundamental particles, that can be applied to future space flight missions. This includes, but is not limited to, detector development, and optical components such as primary or secondary mirrors, coatings, gratings, filters, and spectrographs.

(ii) New technologies and techniques that may be tested by flying them on suborbital platforms such as rockets and balloons that are developed and launched by commercial suborbital flight providers or from NASA's launch range facilities, or by flying them on small and innovative orbital platforms such as CubeSats.

(iii) Studies in laboratory astrophysics. Examples of these studies could include atomic and molecular data and properties of plasmas explored under conditions approximating those of astrophysical environments.

(iv) Theoretical studies and simulations that advance the goals of the astrophysics program

(v) Analysis of data that could lead to original discoveries from space astrophysics missions. This could include the compilations of catalogs, statistical studies, algorithms and pattern recognition, artificial intelligence applications, development of data pipelines, etc.

(vi) Citizen Science programs, which are a form of open collaboration in which individuals or organizations participate voluntarily in the scientific process, are also invited. The current SMD Policy (https://smd-prod.s3.amazonaws.com/science-red/s3fs-public/atoms/files/SPD%2033%20Citizen%20Science.pdf) on citizen science describes standards for evaluating proposed and funded SMD citizen science projects. For more information see the https://science.nasa.gov/citizenscience webpage, that provides information about existing SMD-funded projects.

(vii) Great Observatory Maturation Program (GOMAP): : https://science.nasa.gov/astrophysics/programs/gomap

Proposals should address the goals of the Science Mission Directorate's (SMD) Astrophysics Research Program, defined in SMD's *Science 2020-2024: A Vision for Scientific Excellence* (available at http://science.nasa.gov/about-us/science-strategy). Proposers are encouraged to read this *NASA Science Plan*, the *Astrophysics Roadmap* (available at https://science.nasa.gov/astrophysics/documents/astrophysics-roadmap), and the report of National Academy of Sciences Decadal Survey on Astronomy and Astrophysics 2020, *Pathways to Discovery in Astronomy and Astrophysics for the 2020s*,(available at https://www.nap.edu/catalog/26141/pathways- to-discovery-in-astronomy-and-astrophysics-for-the-2020s)

Investigations submitted to the Astrophysics research program should explicitly support past, present, or future NASA astrophysics missions. These investigations can include theory, simulation, data analysis, and technology development. Information on the Astrophysics research program and missions is available at https://science.nasa.gov/astrophysics.

3.7 NASA Biological and Physical Sciences (BPS)

Science Mission Directorate (SMD)
NASA Headquarters Biological and Physical Sciences Division

Research Focus Area: Fundamental Physics
Research Identifier**: RFA-020**
POC: Mike Robinson michael.p.robinson@nasa.gov

Research Overview: Quantum mechanics is one of the most successful theories in physics. The behavior of exotic matter such as superfluids and neutron stars is explained by quantum science, as are everyday phenomena such as the transmission of electricity and heat by metals. The frontline of modern quantum science involves cross-cutting fundamental research. Another frontier encompasses understanding how novel quantum matter—such as high-temperature superconductivity and topological states—emerges from the interactions between many quantum particles. Quantum science is central to the field of precision measurement, which seeks to expand our knowledge of the underlying principles and symmetries of the universe by testing ideas such as the equivalence between gravitational and inertial mass.

Quantum physics is a cornerstone of our understanding of the universe. The importance of quantum mechanics is extraordinarily wide ranging, from explaining emergent phenomena such as superconductivity, to underpinning next-generation technologies such as quantum sensors. Laser-cooled cold atoms are a versatile platform for quantum physics on Earth, and one that can greatly benefit from space-based research. The virtual elimination of gravity in the reference frame of a free-flying space vehicle enables cold atom experiments to achieve longer observation times and colder temperatures than are possible on Earth. The NASA Fundamental Physics program plans to support research in quantum science that will lead to transformational outcomes, such as the discovery of phenomena at the intersection of quantum mechanics and general relativity that inform a unified theory, the direct detection of dark matter via atom interferometry or atomic clocks, the creation of exotic quantum matter than cannot exist on Earth, quantum sensors to search for physics beyond the standard model, and others.

Research Focus: Proposals are sought for ground-based theory and experimental research that may help to develop concepts for future flight experiments in fundamental physics.

Additional Information: All publications that result from an awarded EPSCOR study shall acknowledge NASA Biological and Physical Sciences (BPS). Additional information on BPS can be found at: https://science.nasa.gov/biological-physical

Research Focus Area: Soft Matter Physics
Research Identifier**: RFA-021**
POC: Mike Robinson michael.p.robinson@nasa.gov

Research Overview: Granular material is one of the key focus areas of research in the field of soft matter. The fundamental understanding of physics of granular materials under different gravity condition is of key importance for deep space exploration and long-term habitation to sample collection from asteroids to improving the understanding of granular material handling on earth. Also, fundamental understanding of granular materials can help us understand motions in large bodies on earth (e.g.- landslides) that can help us save lives in case of natural emergencies.

Research Focus: This research topic focuses on developing fundamental knowledge base in the field of-

- Rheology of granular materials (both wet and dry)
    - Impact of anisotropy and structure
    - Impact of electrostatic charging
- In depth understanding of stress distribution in granular materials
- Dynamics of interparticle interaction and short range forces in granular materials

Both experimental and theoretical/numerical work will be in scope.

Additional Information: All publications that result from an awarded EPSCOR study shall acknowledge NASA Biological and Physical Sciences (BPS). Additional information on BPS can be found at: https://science.nasa.gov/biological-physical

Research Focus Area: Fluid Physics
Research Identifier**: RFA-022**
POC: Brad Carpenter bcarpenter@nasa.gov

Research Overview: The goal of the microgravity fluid physics program is to understand fluid behavior of physical systems in space, providing a foundation for predicting, controlling, and improving a vast range of technological processes. Specifically, in reduced gravity, the absence of buoyancy and the stronger influence of capillary forces can have a dramatic effect on fluid behavior. For example, capillary flows in space can pump fluids to higher levels than those achieved on Earth. In the case of systems where phase-change heat transfer is required, experimental results demonstrate that bubbles will not rise under pool boiling conditions in microgravity, resulting in a change in the heat transfer rate at the heater surface. The microgravity experimental data can be used to verify computational fluid dynamics models. These improved models can then be utilized by future spacecraft designers to predict the performance of fluid conditions in space exploration systems such as air revitalization, solid waste management, water recovery, thermal control, cryogenic storage and transfer, energy conversion systems, and liquid propulsion systems.

Research Focus: The research area of fluid physics includes the following themes:
Adiabatic two-phase flow
Boiling and condensation
Capillary flow
Interfacial phenomena
Cryogenic propellant storage and transfer

Additional Information: All publications that result from an awarded EPSCOR study shall acknowledge NASA Biological and Physical Sciences (BPS). Additional information on BPS can be found at: https://science.nasa.gov/biological-physical

Research Focus Area: Combustion Science
Research Identifier**: RFA-023**
POC: Brad Carpenter bcarpenter@nasa.gov

Research Overview: One of the goals of the microgravity combustion science research program is to improve combustion processes, leading to added benefits to human health, comfort, and safety. NASA's microgravity combustion science research focuses on effects that can be studied in the absence of buoyancy-driven flows caused by Earth's gravity. Research conducted without the interference of buoyant flows can lead to an improvement in combustion efficiency, producing a considerable economic and environmental impact. Combustion science is also relevant to a range of challenges for long-term human exploration of space that involve reacting systems in reduced and low gravity. These challenges include: spacecraft fire prevention; fire detection and suppression; thermal processing of regolith for oxygen and water production; thermal processing of the Martian atmosphere for fuel and oxidizer production; and processing of waste and other organic matter for stabilization and recovery of water, oxygen and carbon. Substantial progress in any of these areas will be accelerated significantly by an active reduced- gravity combustion research program.

Research Focus: The research area of combustion science includes the following themes:
Spacecraft fire safety
Droplets
Gaseous – premixed and non-premixed
High pressure – transcritical combustion and supercritical reacting fluids
Solid fuels

Additional Information: All publications that result from an awarded EPSCOR study shall acknowledge NASA Biological and Physical Sciences (BPS). Additional information on BPS can be found at: https://science.nasa.gov/biological-physical

NASA Biological and Physical Sciences (BPS)
NASA Marshall Space Flight Center (MSFC) / EM41

Research Focus Area: Materials Science
Research Identifier**: RFA-024**
POC: Brad Carpenter bcarpenter@nasa.gov

Research Overview: The goal of the microgravity materials science program is to improve the understanding of materials properties that will enable the development of higher-performing materials and processes for use both in space and on Earth. The program takes advantage of the unique features of the microgravity environment, where gravity-driven phenomena, such as sedimentation and thermosolutal convection, are nearly negligible. On Earth, natural convection leads to dendrite deformation and clustering, whereas in microgravity, in the absence of buoyant flow, the dendritic structure is nearly uniform. Major types of research that can be investigated include solidification effects and the resulting morphology, as well as accurate and precise measurement of thermophysical property data. These data can be used to develop computational models. The ability to predict microstructures accurately is a promising computational tool for advancing materials science and manufacturing.

Research Focus: The research area of materials science includes the following themes:

Glasses and ceramics
Granular materials
Metals
Polymers and organics
Semiconductors

Additional Information: All publications that result from an awarded EPSCOR study shall acknowledge NASA Biological and Physical Sciences (BPS). Additional information on BPS can be found at: https://science.nasa.gov/biological-physical

Research Focus Area: Growth of plants in "deep space-relevant" Earth soils or conditions

Research Identifier**: RFA-025**
POC: Sharmila Bhattacharya SpaceBiology@nasaprs.com

Research Overview: As human exploration continues to move further out beyond Low Earth Orbit (BLEO), exploration missions will need to become increasingly self-sufficient, and will not be able to rely as heavily on resupply efforts from Earth, as they now do within Low Earth Orbit (LEO). The NASA Space Biology Program is interested in basic research that will ultimately translate into the ability to grow edible plants and crops in deep space environments. Research supported by our program has already demonstrated that 1) edible plants can be grown in the LEO environment of the International Space Station (Massa *et al.*, 2017), and that 2) model (non-edible) plant organisms can germinate from seeds planted in lunar regolith obtained from the Apollo 11, 12, and 17 missions (Paul *et al.*, 2022; for a historic perspective refer to Ferl and Paul, 2010). While both these results are very promising, there is still much work that needs to be done to move exploration efforts to the point where astronauts can begin to think about practicing agriculture in harsh deep space environments such as the lunar and Martian surfaces.

While much of Space Biology's funded plant research efforts have focused on experiments conducted in spacecraft, or in the presence of simulated spaceflight/deep-space stressors, the program is interested in exploring other potential niches that exist here on Earth that may provide important insights into how both plants and the surrounding environment can be manipulated to support crop growth under harsh, inhospitable conditions. As early humans spread out across the globe, they have repeatedly encountered extreme environments that were far from being innately supportive of agriculture and settlement. Despite these challenges, humans have often found ways to live and even flourish in such environments, either by finding food sources that were robust enough to grow under such conditions, and/or by altering the terrain through irrigation and natural farming (soil modification with natural composts, crop rotation, etc.) to enable crop growth. Therefore, for this research focus area, Space Biology is soliciting proposals that will provide insights into how plants grow and continue to adapt to Earth's extreme geochemically diverse environments, as well as how these environments can be manipulated to support such growth.

Research Focus: This Space Biology Research Emphasis requests proposals for hypothesis-driven studies that will either provide a better understanding of the mechanisms by which some plants are able to grow and thrive in extreme or geochemically diverse environments on Earth or will identify plants and/or alternative methods that can be used to facilitate plant/crop growth in such extreme environments. Ideally, pilot studies funded from this opportunity will lead to additional future funded research that may translate to improved agricultural methods and tools that can be utilized in extreme environments on earth and eventually in harsh environments of the lunar and Martian surfaces.

Such topics of study may include, but are not limited to:

- Characterizing the molecular and/or biological mechanisms by which plants already known for their agricultural robustness are able to grow in soil types found in Earth's more extreme environments, including volcanic soils and sands (deserts), clay, etc. Particular emphasis may be given to edible plants.
- Identifying new plants that are able to grow in such soil samples and characterizing their growth and vitality.
- Genetic modification of plants to improve growth and robustness in such soils.
- Identifying or engineering microbiomes that will optimize plant growth and vitality in such soils.
- Testing or developing new composting methods or other natural methods to enrich such soils which will enable them to better support plant growth.

If logistics and costs permit, proposed studies may be conducted on location directly in the types of environments mentioned above, however, proposed studies may also use soil samples collected (or purchased) from these environments. It will be up to the proposer to identify the extreme environment/soil samples they will use for their studies, as well as provide justification in their proposal as to why these environments/soils were chosen and have relevance to space exploration.

Additional Information: While the Space Biology Program can be contacted at SpaceBiology@nasaprs.com for general questions about this RFA, the program itself is not able to foster collaborations between applicants and NASA scientists or NASA-funded scientists. If potential applicants are seeking to establish such collaborations for their project, then we recommend that they consult the NASA Task Book (at https://taskbook.nasaprs.com) to identify potential collaborators. The NASA Task Book is a database that contains information about all the projects that the NASA Space Biology Program has funded since 2004. Here applicants will also find the names of investigators that have been funded by our program as well as their contact information.

All publications that result from an awarded EPSCOR study shall acknowledge the Space Biology Program within NASA's Biological and Physical Science (BPS) Division. If the NASA GeneLab Data Systems (genelab.nasa.gov) is used, GeneLab shall be referenced in the resulting publication and included in the keyword list. All omics data obtained from this study shall be uploaded to the NASA GeneLab (https://genelab.nasa.gov).

References:

Ferl RJ, Paul AL. Lunar plant biology--a review of the Apollo era. Astrobiology. 2010 Apr;10. doi/10.1089/ast.2009.04173:261-73. doi: 10.1089/ast.2009.0417.

Massa GD, Dufour NF, Carver JA, Hummerick ME, Wheeler RM, Morrow RC, Smith TM. VEG-01: Veggie hardware validation testing on the International Space Station. Open Agriculture. 2017 Feb;2(1):33-41. doi.org/10.1515/opag-2017-0003 , Feb-2017.

Paul AL, Elardo SM, Ferl R. Plants grown in Apollo lunar regolith present stress-associated transcriptomes that inform prospects for lunar exploration. Commun Biol. 2022 May 12;5(1):382. doi: 10.1038/s42003-022-03334-8. PMID: 35552509; PMCID: PMC9098553.

Research Focus Area: The impact of space-associated stressors on energy metabolism and oxidative stress.

Research Identifier**: RFA-026**
POC: Sharmila Bhattacharya SpaceBiology@nasaprs.com

Research Overview: The spaceflight environment is known to impose cellular and physiological changes in living systems that are common across species and even across the taxonomic biological kingdoms. These changes can not only adversely impact the well-being of entire organisms, but of entire ecosystems in spacecraft and planetary habitats. In order to help enable life to thrive in space, an understanding of both the effects of these changes, and the mechanisms by which these changes occur, is critical. Recent Space Biology-funded research that employed muti-omics and system biology approaches to profile the transcriptomic, proteomic, metabolomic, and epigenetic responses to spaceflight in tissue samples collected from astronauts, as well as other organisms flown in space, showed that mitochondrial dysfunction is a common consequence of exposure to the spaceflight environment across diverse biological systems (da Silveira *et al*., 2020). These results, however, are not the only findings that indicate that space travel has an impact on biological pathways responsible for cellular and physiological energy metabolism. There are a plethora of studies demonstrating that exposure to space-associated stressors induces oxidative stress and changes within the biological pathways responsible for redox responses in plant, animal, and fungal model systems (Choi *et al.*, 2019; Hateley, *et al*., 2016; Tahimic and Globus, 2017; Nislow et al., 2015), which both regulate and are regulated by mitochondrial function. Furthermore, additional research with the plant model *Arabidopsis thaliana* has shown that exposure to microgravity downregulates the expression of genes encoding proteins associated with the chloroplast (Land *et al*., 2024), thus providing mechanistic data of how space-associated stressors can impact photosynthesis.

While these studies have provided important clues on how the stressors encountered during space exploration dysregulate energy metabolism and homeostasis, a mechanistic understanding of how these stressors, either individually or in combination, contribute to this dysregulation and the impact that such dysregulation has on the overall health of an organism is needed. Therefore, for this research focus area, Space Biology is soliciting ground-based proposals that elucidate the effects of spaceflight related stressors on energy metabolism and/or oxidative stress.

Research Focus: This Space Biology Research Emphasis requests proposals for hypothesis-driven studies that will characterize the impacts that stressors associated with space exploration have on cellular energy metabolism and/or redox responses, and how changes in these processes impact the overall health of an entire organism, or in the case of microbial studies, the health of individual microbes or of communities containing multiple microbes. Such stressors may include, but are not limited to, simulated microgravity or partial gravity, changes in atmospheric pressure or composition (*i.e.*, oxygen and carbon dioxide concentrations), hypoxia, and ionizing radiation (radiation sources that are easily accessible in a laboratory environment, such as X-ray or gamma radiation, can be used).

Such topics of study may include, but are not limited to:

- Characterizing how space-relevant stressors impact mitochondrial integrity and function in eukaryotic organisms, and how changes in these properties impact the overall fitness of the entire organism (within plant/animal/microbial models) or of an entire community (within unicellular models).

- Characterizing how space-associated stressors impact the accumulation of reactive oxygen species cellular redox responses, and how changes in these properties impact the overall fitness of the entire organism (within plant/animal models) or of an entire community (within unicellular models).
- Characterizing how space-associated stressors impact chloroplast integrity and function in plant model systems, and how changes in these properties impact the overall fitness of the entire organism.
- Characterizing the response of prokaryotic organisms to these stressors with the goal of gaining a heuristic understanding of how such stressors impact energy-related metabolic pathways.
- The identification of cross species biosignatures in response to oxidative stress or stressors that impact energy metabolism/homeostasis.

Investigators are also welcome to propose additional types of studies, including those that focus on other cellular components or processes, as long as the overall research focus of the proposed project address the emphasis of this RFA, which is how spaceflight stressors impact energy metabolism/homeostasis and/or oxidative stress/redox responses. Applicants may propose to use any plant or microbial model system for their studies, but animal models will be limited to cell cultures or invertebrates (excluding cephalopods), and applicants will be expected to include their rationale and justification for their choice of model system, and space-relevant variables to be tested in their proposal.

Additional Information: While the Space Biology Program can be contacted at SpaceBiology@nasaprs.com for general questions about this RFA, the program itself is not able to foster collaborations between applicants and NASA scientists or NASA-funded scientists. If potential applicants are seeking to establish such collaborations for their project, then we recommend that they consult the NASA Task Book (at https://taskbook.nasaprs.com) to identify potential collaborators. The NASA Task Book is a database that contains information about all the projects that the NASA Space Biology Program has funded since 2004. Here applicants will also find the names of investigators that have been funded by our program as well as their contact information.

All publications that result from an awarded EPSCOR study shall acknowledge the Space Biology Program within NASA's Biological and Physical Science (BPS) Division. If the NASA GeneLab Data Systems (genelab.nasa.gov) is used, GeneLab shall be referenced in the resulting publication and included in the keyword list. All omics data obtained from this study shall be uploaded to the NASA GeneLab (https://genelab.nasa.gov).

References:

Choi, W-G, Barker, RJ, Kim S-H, Swanson, SJ, Gilroy, S. Variation in the transcriptome of different ecotypes of Arabidopsis thaliana reveals signatures of oxidative stress in plant responses to spaceflight. Botany. 2019. 106(1): 123-136. DOI: 10.1002/ajb2.1223 da Silveira WA,…Beheshti A. Comprehensive Multi-omics Analysis Reveals Mitochondrial Stress as a Central Biological Hub for Spaceflight Impact. Cell. 2020. 183(5): 1185-1201 DOI:10.1016/j.cell.2020.11.002

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Research Focus Area: The role of genetic diversity in enabling life to thrive in space.

Research Identifier**: RFA-027**
POC: Sharmila Bhattacharya SpaceBiology@nasaprs.com

Research Overview: While model systems provide an invaluable tool for helping researchers gain an understanding of how biological systems respond to the harsh environmental factors and stressors that may be encountered during space exploration, much of this research has been conducted using specimens with limited genetic diversity. For example, many animal and plant studies use inbred strains/lines or specific cultivars, respectively, and many microbiology studies use organisms that have the same genetic background, or groups of organisms with limited genetic variability between them. The use of such specimens for initial studies is both appropriate and necessary to reduce variability caused by genetic diversity, which can contribute to "noisy" data when trying to characterize the impacts that multiple space-associated stressors have on biological systems. However, in natural populations, organisms within a single species can be highly genetically diverse and this diversity can translate into vastly different responses to the same stressor among individuals. Therefore, for this research focus area, Space Biology is soliciting proposals that will characterize how genetic diversity impacts the ability of organisms to respond to space-associated stressors as well as how genetic diversity impacts the organism overall fitness under these conditions.

Research Focus: This Space Biology Research Focus Area requests proposals for hypothesis-driven studies that will increase our understanding of how genetic variability or different genetic background modulates an organism's ability to respond to environmental stressors encountered during space exploration. Such stressors may include, but are not limited to, simulated microgravity or partial gravity, changes in atmospheric pressure or composition (*i.e.*, oxygen and carbon dioxide concentrations), hypoxia, and ionizing radiation (radiation sources that are easily accessible in a laboratory environment, such as X-ray or gamma radiation, can be used.

Such topics of study may include, but are not limited to:

- Comparing the responses (and the resulting overall fitness) of multiple genetic backgrounds within a single species to space-associated stressors.
- Following up on previously published observations regarding an organism's response to space-associated stressors and testing how different genetic background/mutations alter that response.
- Use of forward/and or reverse genetic approaches to identify genes or family/subset of genes that modulate an organism's overall fitness in and response to the presence of space-associated stressors.
- Using synthetic biology approaches to engineer organisms that are better able to tolerate exposure to space-associated stressors.
- Population studies using microbes or plant/animal models with a quick generation time to examine how genetic diversity impacts overall survival, fitness and/or evolution in the presence of space-associated stressors.

Investigators are also welcome to propose additional types of studies as long as the overall research focus of the proposed project address the emphasis of this RFA, which is how genetic diversity enables life to thrive in space. Applicants may propose to use any plant or microbial model system for their studies, but animal models will be limited to cell cultures or invertebrates (excluding cephalopods), and applicants will be expected to include their rationale and justification for their choice of model system, and space-relevant variables to be tested in their proposal.

Additional Information: While the Space Biology Program can be contacted at SpaceBiology@nasaprs.com for general questions about this RFA, the program itself is not able to foster collaborations between applicants and NASA scientists or NASA-funded scientists. If potential applicants are seeking to establish such collaborations for their project, then we recommend that they consult the NASA Task Book (at https://taskbook.nasaprs.com/) to identify potential collaborators. The NASA Task Book is a database that contains information about all the projects that the NASA Space Biology Program has funded since 2004. Here applicants will also find the names of investigators that have been funded by our program as well as their contact information.

All publications that result from an awarded EPSCOR study shall acknowledge the Space Biology Program within NASA's Biological and Physical Science (BPS) Division. If the NASA GeneLab Data Systems (genelab.nasa.gov) is used, GeneLab shall be referenced in the resulting publication and included in the keyword list. All omics data obtained from this study shall be uploaded to the NASA GeneLab (https://genelab.nasa.gov).

Research Focus Area: Commercially Enabled Rapid Space Science Project (CERISS)
Research Identifier**: RFA-028**
POC: Koniges, Ursula M. (HQ-DP000) <ursula.m.koniges@nasa.gov>

Research Overview: The Commercially Enabled Rapid Space Science initiative (CERISS) will develop transformative research capabilities with commercial space industry to dramatically increase the pace of research. Long-range goals include conducting scientist astronaut missions on the International Space Station and commercial low-earth orbit (LEO) destinations and develop automated hardware for experiments beyond low Earth orbit, such as to the lunar surface.

The benefits will include a 10-to-100-fold faster pace of research for a wide range of research sponsored by Biological and Physical Sciences Division, the NASA Human Research Program, other government agencies, and industry. Another benefit will be the increased demand for research and development in low earth orbit, facilitating growth of the commercial space industry.

Research Focus: Advancement of capabilities in the following areas are of particular interest:

Sample preparation; characterization of materials (e.g. differential scanning calorimetry, x-ray diffraction, fourier transform infrared spectroscopy, etc.); and analysis of samples (e.g. fluorescent activated cell sorting, protein and -omics, imaging, etc.)

Additional Information: All publications that result from an awarded EPSCOR study shall acknowledge NASA Biological and Physical Sciences (BPS). Further information on CERISS is available at: https://science.nasa.gov/biological-physical/commercial.

3.8 Commercial Space Capabilities (CSC)

Space Operations Mission Directorate (SOMD)
NASA Johnson Space Center

The Commercial Space Capabilities (CSC) Research Interest area supports the Commercial Low Earth Orbit Development Program of NASA's Space Operations Mission Directorate (SOMD). This area's purpose is to harness the capabilities of the U.S. research community to advance research and perform initial proofs / validations, that improve technologies of interest to the U.S. commercial spaceflight industry. The intent is to address the commercially riskiest portion of implementing new and improved technologies ("Innovation Valley of Death") to advance science and technologies from TRL1 through to TRL3. U.S. commercial spaceflight industry can then assess such technologies and determine implementation.

The overall goal of this area is to encourage and facilitate a robust and competitive U.S. low Earth orbit economy. Efforts that primarily benefit near-Earth commercial activities but that might also be extensible Moon and/or Mars are also in scope.

Research Focus Area: In-Space Welding

Research Identifier**: RFA-029**
POC: Warren Ruemmele warren.p.ruemmele@nasa.gov

Research Overview: Research and initially demonstrate (in 1g) metal welding suitable for being directly exposed to space vacuum/0g. Metals of interest are those typically used for spacecraft structures and plumbing. (Extensibility to being used while exposed to Moon vac/g, and/or Mars atm/g environments could be a secondary interest.) Potential applications include the in-space assembly of very large structures that are too bulky or heavy to launch in one piece, and *in situ* repair or modifications. Consider weld processes suitable for incorporation into a robotic or EVA crew tool. A related secondary interest is for a metal cutting operation suitable for incorporation into a robotic or EVA crew tool. For cutting operations consider debris generation and how to control.

Research Focus Area: Materials and Processes Improvements for Chemical Propulsion State of Art (SoA)

Research Identifier**: RFA-030**
POC: Warren Ruemmele warren.p.ruemmele@nasa.gov

Research Overview: Propose and demonstrate improvements for launch, entry, and/or in-space chemical propulsion (of any type), to improve performance, reduce cost, enable new capabilities, and/or improve/simplify manufacturing. For this topic, when a current SoA exists, identify the shortcoming in the current SoA that the improvement addresses. NASA is specifically interested in proposed work in these subtopics:

Research Focus Area: Materials and Processes Improvements for Electric Propulsion State of Art (SoA)

Research Identifier: **RFA-031**
POC: Warren Ruemmele warren.p.ruemmele@nasa.gov

Research Overview: Propose and demonstrate improvements for solar powered electric propulsion suitable for cislunar application, to improve performance, reduce cost, enable new capabilities, and/or improve/simplify manufacturing. For this topic;

i) Proposer may contact NASA to schedule a pre-proposal telecon to discuss approach and understand details.

ii) ii) Proposer must describe the existing personnel skill and expertise, and facility capabilities to perform the work such as material finishing/processing, testing, inspection, and failure analysis.

NASA is specifically interested in proposed work to any of these three subtopics:

1) Material Properties: An evaluation of the bulk mechanical, thermal, and electrical properties of several common commercially available grades of material in environments relevant to thruster designs.
   a. Specific grades and in some cases samples can be provided by NASA and may include graphite, ceramics, refractories, aluminum, titanium, stainless steel, Inconel, Kovar, and other materials commonly used in thruster designs.
   b. Properties of interest include mechanical strength (flexural and compressive), low cycle fatigue, high cycle fatigue, toughness, slow crack growth, elastic modulus, Poisson's ratio, thermal conductivity, electrical conductivity, emissivity, thermal expansion, and outgas properties.
   c. Environments of interest include ambient temperature, low temperature (-40ºC), thruster temperature (600ºC), and cathode temperature (1100ºC).
   d. This work is intended to help fill gaps in open literature for common properties and materials used by the electric propulsion community to aid in design and analysis.

2) Material Deposition: An evaluation of material deposition resulting from ion beam sputtering of commonly used EP materials onto common spacecraft materials. Data shall include the following:
   a. Phase of the material deposited
   b. Whether the deposits are conductive or insulating
   c. Deposition rate compared to sputter yield based predictions,
   d. When/if spalling of the deposition occur.

3) Krypton Sputter Erosion: An evaluation of the sputter erosion of common thruster, spacecraft, and related materials from Krypton ion bombardment. The materials will be exposed to Krypton ion beams and the following will be determined:
   a. The dependence of the total yield with ion energies in the general range of tens to volts up to 1 kV

b. Dependence of the total yield with ion incidence angles from normal to near grazing, and/or
c. Differential yield profiles at various energies and incidence angles.

Materials of interest include graphite, ceramics, coverglass, kapton, composites, and/or anodized coatings. This effort may be combined with the Material Deposition effort as appropriation including possibly measurement of sticking coefficients of the sputtered products

Research Focus Area: Improvements to Space Solar Power State of Art (SoA)

Research Identifier: **RFA-032**
POC: Warren Ruemmele warren.p.ruemmele@nasa.gov

Research Overview: Propose and demonstrate improvements for solar power generation (of any type) suitable for cis-lunar in-space application (e.g. space stations, satellites, power beaming), to improve performance, reduce cost, enable new capabilities, and/or improve/simplify manufacturing. NASA is especially interested in these two subtopics:

1) Improvements for in-space photovoltaics compared to current spaceflight solar array SoA.
2) Engineering trade studies of other solar power production methods (e.g. concentrators, thermodynamic cycles, etc.) compared to current SoA space photovoltaic systems. Considerations would include: Technology readiness and gaps, launch volume and mass with respect to current US launch vehicles, peak/steady state power and characteristics, efficiency, operational considerations, in-space lifetime/performance degradation, energy storage, orbit and distance, and identifying break points and sweet spots.

Research Focus Area: Small Reentry Systems Research Identifier:
Research Identifier: **RFA-033**
POC: Warren Ruemmele warren.p.ruemmele@nasa.gov

Research Overview: Design and demonstrate reentry systems that can be deployed from low Earth orbit to perform a self-guided intact reentry to return small cargo contained inside them intact to Earth. Cargo might include science samples, space-manufactured items, etc. An alternate use is to recover flight data recorders from destructively reentering technology demonstrators to allow retrieving large amounts of telemetry without the use of communications satellites.

Passively guided systems are preferred. Such reentry systems might need to be safely storable inside crewed in-space platforms so preference is to not use hazardous materials. Hazards for people/property on the Earth resulting from reentry must be considered. Landing on ground is preferred to simplify and expedite recovery.

Research Focus Area: Low Consumable Environmental Control and Crew Systems

Research Identifier: **RFA-034**
POC: Warren Ruemmele warren.p.ruemmele@nasa.gov

Research Overview: Design and demonstrate Environmental Control and Crew Systems technologies suitable for use on U.S. commercial Low Earth Orbit (LEO) space stations, and/or for the spacecraft that would transport crew to and from such space stations in LEO. These would be new space stations – **not** the current International Space Station (ISS). This can be end-to-end systems or major subsystems.

The systems areas are:

1) Crew atmosphere (oxygen, carbon dioxide, trace contaminant control, humidity)
2) Crew potable water
3) Crew hygiene (body washing, human waste)
4) Crew clothes cleaning

The overall goals are:

a) To improve current state of art by: notably reducing cost, reducing size/weight/power, minimizing on-orbit maintenance time, and reducing consumables and trash to reduce the need for resupply from/to Earth.
b) Approaches may include recycling and/or repurposing waste products to perform needed space station/space craft functions.

Research Focus Area: Other Commercial
Research Identifier: **RFA-035**
POC: Warren Ruemmele warren.p.ruemmele@nasa.gov

NASA is receptive to topics in this Research Interest Area that it may not have already identified if a strong case can be made for these. The Proposer may therefore propose other topics as follows:

1) The proposed Topic must be consistent with the Intent and goal of this CSC Area.
2) The proposal must include a strong letter of support from a U.S. commercial company that describes the company's need for the work and any arrangements with the Proposer.
3) Before submitting the proposal for such a topic, the Proposer must discuss with NASA per CSC NASA Contact listed in the following page.

Additional Instructions for Proposals in this CSC Interest Area (RFA-029 through RFA-035):

A. Content

1. Proposals should discuss how the effort is anticipated to align with U.S. commercial spaceflight company interest(s). Proposers are encouraged to contact U.S.commercial spaceflight companies to understand current research challenges.
2. Proposals should identify the estimated starting and end point of the currently proposed effort in terms of Technology Readiness Level (TRL) https://www.nasa.gov/pdf/458490main_TRL_Definitions.pdf), and what subsequent work might be anticipated to achieve TRL5.
3. If there is an existing SoA, state how proposed work would address an identified need/shortcoming (not just a "nice to have").
4. Describe proposing Institution's and Co-I/Sci-I's relevant capabilities and prior work. Compare and contrast proposed work against prior and existing work by others.

(Weblinks preferred. Does not count against the Technical page limit.)

5. Work must produce a final report and delivery of developed design concept and data (as applicable).
6. Proposers can assume that technically knowledgeable NASA engineers and scientists will be reviewing the Proposal – so Proposer should focus on technical/scientific specifics.
7. NASA anticipates that depending on the specifics of the proposed work, the Proposer *may* need to implement Export Controls (e.g. EAR or ITAR). Proposer should identify in their proposal whether they believe Export Controls would apply, and identify (e.g. weblink) institutional export control methods/policy in the proposal's Data Management Plan. Proposer may contact NASA PoC to discuss prior to submitting proposal.

B. Contributions to Proposed Work other than NASA EPSCoR

Proposer-coordinated contributions from Jurisdiction, or Organizations (especially US commercial entities) that would partner with the Jurisdiction, are welcomed but not required. If there are such contributions then the Proposer must state what has been arranged, include funding or other in-kind contributions such as materials or services and indicate the estimated value of these.

C. Intellectual Property

Proposer to indicate any intellectual property considerations in the Proposal.

D. Publishing of Results

NASA welcomes opportunities to co-publish results as proposed by EPSCoR awardee, and its goal is for widest possible eventual dissemination of the results of the Researcher(s) work, to the extent other restrictions (e.g. Export Control) allow. For results that must be controlled, NASA will work with Researcher to present accordingly, and make data available in access controlled databases such as MAPTIS database https://maptis.nasa.gov/.

E. NASA Contact

The CSC NASA Contact will support a telecon with the Proposer prior to the submission of their Proposal, to answer questions and discuss anticipated approach towards this Research Request. NASA Contact will coordinate support from within NASA as needed to provide subject matter expertise/limited consultation in event of award. (If Proposer has already discussed with and NASA or JPL personnel please identify so they might be able to support telecon.)

3.9 NASA Digital Transformation (DT)

Science Mission Directorate (SMD)

Jill Marlow, NASA Digital Transformation Officer
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NASA DIGITAL TRANSFORMATION

NASA Digital Transformation is an agency strategic initiative that aims to accelerate our efforts to modernize and transform NASA using digital advances — by synchronizing DT investments across NASA and catalyzing DT progress by attacking cross-cutting barriers to technology readiness & adoption.

Since 1958, NASA's enduring purpose centers around a mission to discover, explore, innovate, and advance solutions to the problems of flight, within and outside the Earth's atmosphere, for the benefit of humankind. With each new technological revolution, our agency continued to deliver on this mission. Now, the wide-scale adoption of numerous digital advances—cloud computing, data analytics, artificial intelligence, augmented/virtual reality, and others—calls for us to rise to the occasion yet again.

It is vital for us to undergo fundamental digital transformation in order to thrive in a more competitive digital workplace, become more efficient with our resources, and ensure safety from increasing digital threats. In late 2020, NASA established an Enterprise Digital Transformation (DT) agency-level strategic initiative to carry out such an endeavor.
NASA's DT Strategic Framework and Implementation Plan outlines the DT initiative's approach for digitally transforming NASA. By transforming Engineering, Discovery, Operations and Decision Making, we will reach outcomes ensuring continued mission success well into the future. Our world is changing—and so must NASA.

Research Focus Area: Zero Trust, Cybersecurity Mesh Architecture, and Leveraging Artificial Intelligence for Realtime Cyber Defense

Research Identifier**: RFA-036**

NASA Digital Transformation – Zero Trust Foundations; Strategy and Architecture Office (SAO)
NASA Langley Research Center
POC: Mark Stanley, mark.a.stanley-1@nasa.gov

Cybersecurity Engineering Office (CSE)
NASA Headquarters
POC: Dennis daCruz dennis.m.dacruz@nasa.gov

Research Overview: The National Institute of Standards and Technology (NIST), in its Special Publication (SP) 800-207, "Zero Trust Architecture," refers to the increasingly complex enterprise which has "led to the development of a new model for cybersecurity known as "zero trust" (ZT). A ZT approach is primarily focused on data and service protection but can and should be expanded to include all enterprise assets (devices, infrastructure components, applications, virtual and cloud components) and subjects (end users, applications and other nonhuman entities that request information from resources)." While the Zero Trust Framework evolved from its roots in the original Cybersecurity and Infrastructure Security Agency (CISA) Maturity Model to the latest Forrester Research-defined Zero Trust eXtended Framework, another construct emerged; namely, Cybersecurity Mesh Architecture (CSMA). Gartner defines CSMA as "a composable and scalable approach to extending security controls, even to widely distributed assets. Its flexibility is especially suitable for increasingly modular approaches consistent with hybrid multi-cloud architectures. CSMA enables a more composable, flexible and resilient security ecosystem. Rather than every security tool running in a silo, a cybersecurity mesh enables tools to interoperate through several supportive layers, such as consolidated policy management, security intelligence and identity fabric." With a move to an ever more integrated cybersecurity ecosystem, the volume of information, in both mass and speed, that could be leveraged to properly secure and defend the information environment will exceed the human capacity to be effective.

Research Focus: Conduct research on how to optimize a representative Zero Trust information environment to morph into a CSMA and benchmark the potential network operations and cybersecurity telemetry needed to identity, protect, detect, respond, and recover in the event of adversary activity. Then, research the best way in which artificial intelligence, to include machine learning and robotic process automation, could be leveraged to secure and defend the information environment in real time.

Research Focus Area: Applied AI Ethics
Research Identifier**: RFA-037**

NASA Digital Transformation – AI/ML Foundation
NASA Langley Research Center
POC: Ed McLarney, edward.l.mclarney@nasa.gov

Research Overview: There is limited research on trustworthy, responsible, ethical Artificial Intelligence (AI) among a wide variety of government, industry, academic, and international organizations.

Research Focus: Conduct benchmarking research regarding trustworthy, responsible, ethical AI among a wide variety of government, industry, academic, and international organizations. Provide a summary of key AI ethics principles relevant specifically to NASA but also generalizable to other government research, development & scientific organizations. Include the topic of beginning to measure AI ethics characteristics, leveraging existing metrics best practices, and including direct & indirect, subjective and objective measures. Beyond principles and metrics, provide recommendations for behaviors and mechanisms to make application of AI ethics concrete for AI practitioners. NASA will provide documentation of NASA approaches to AI ethics, AI governance, etc. as partial data for this research.

Research Focus Area: Scaled Video ML Object Detection and Alerts
Research Identifier: **RFA-038**

NASA Digital Transformation – AI/ML Foundation
NASA Langley Research Center , JSC, KSC
POC: Ed McLarney edward.l.mclarney@nasa.gov
Martin Garcia martin.garcia@nasa.gov
Mark Page mark.page@nasa.gov

Research Overview: There is limited research in mechanisms for optimizing video stream data flow for ML image analysis, reduction of full-system image recognition latencies to 3-5 seconds or less, training mechanisms to recognize additional conditions / images, robustness against inclement weather, aggregation & visualization of key information, human factors considerations for consuming the outputs, ability to train / correct ML object recognition algorithms, and ability to archive results for post-launch analysis.

Research Focus: Conduct research into mechanisms to scale machine learning object recognition and alerts to hundreds of video streams. Possible use case: monitoring video streams for space launch facilities to warn of people in danger areas or anomalies in countdown sequences. Current practices include human monitoring of key launch video streams, or small numbers of ML-assisted video streams. Research would include mechanisms for optimizing video stream data flow for ML image analysis, reduction of full-system image recognition latencies to 3-5 seconds or less, training mechanisms to recognize additional conditions / images, robustness against inclement weather, aggregation & visualization of key information, human factors considerations for consuming the outputs, ability to train / correct ML object recognition algorithms, and ability to archive results for post-launch analysis. NASA will provide guidance for the research and representative launch videos. Note: this project is not about individual ML video stream object recognition; rather it is about scaling ML video object recognition to hundreds of streams.

Research Focus Area: Verification of AI/ML algorithms for Spacecraft.
Research Identifier: **RFA-039**

NASA Digital Transformation – AI/ML Foundation
NASA MSFC
POC: Scott Tashakkor scott.b.tashakkor@nasa.gov

Research Overview: AI/ML algorithms are non-deterministic by nature, they are statistical algorithms that take inputs and run through multiple nodes for output. Without the determinism and/or guarantee that the algorithm will respond in certain ways, AI/ML will be limited to only supplementary functions in Spacecraft (or aircraft). This is due to the safety of humans and space assets as well as the costs associated with these. Scientists would/could miss significant data or spacecraft can be lost.

Research Focus: Therefore, techniques for V&V of AI/ML algorithms needs to be researched and developed. AI/ML training in space assets suffers similar restrictions, and the hardware that is radiation tolerant (beyond LEO) is not developed yet. Conduct research into techniques for V&V of AI/ML algorithms, training in space assets suffers similar restrictions, and the hardware that is radiation tolerant.

Research Focus Area: Augmenting and Analyzing Requirements with Natural Language Processors.
Research Identifier**: RFA-040**

NASA Digital Transformation – AI/ML Foundation
NASA MSFC

POC: Scott Tashakkor scott.b.tashakkor@nasa.gov

Research Overview: Requirements are the basis to every project; Natural Language Process (NLP) solutions can help remove the ambiguity in requirements or help people identify which requirements need to be focused on. Determining techniques to identify missing requirements needs to be studied as well. Creating higher quality requirements can be augmented with NLP to identify better language to be used and with generative AI methods can write some of the basic requirements.

Research Focus: Conduct research into creation and understanding the quality of requirements augmented with NLP to identify better language to be used and with generative AI methods.

Research Focus Area: AI/ML algorithms to obtain and improve 3-dimentional remote sensing of the Earth's aerosols, clouds, oceans and lands using advanced lidar and polarimeter data.
Research Identifier**: RFA-041**

NASA Digital Transformation – AI/ML Foundation
NASA LaRC
POC: Snorre Stamnes snorre.a.stamnes@nasa.gov
Shan Zeng shan.zeng@nasa.gov
Yongxiang Hu yongxiang.hu-1@nasa.gov

Research Overview: High-spectral-resolution lidars, such as the NASA High-Spectral-Resolution Lidar (HSRL-1 and HSRL-2 and HALO), and multiangle, multispectral polarimeters, such as the NASA Research Scanning Polarimeter, the PolCube polarimeter, and SPEXone and HARP2 onboard the NASA PACE mission, can provide unprecedented 3-D information about the Earth's aerosols, clouds, oceans and lands.

Research Focus: Conduct research in AI/ML remote sensing algorithms to rapidly and accurately process high-spectral-resolution lidars. AI/ML algorithms are sought that can quantitatively retrieve aerosol/cloud optical and microphysical properties including aerosol/cloud optical depth (AOD), absorbing aerosols (aerosol single-scattering albedo), aerosol/cloud size (effective radius) and size distribution width (effective variance). In addition to aerosol/cloud properties, AI/ML algorithms for cloud detection, ocean and land feature detection, water-leaving radiance, surface reflectance, and albedo are also sought. An emphasis is placed on AI/ML algorithms that can make use of combined lidar and polarimeter data, or combined polarimeter and hyperspectral data. Synergistic analysis of such combined data with AI/ML algorithms can provide additional information that is difficult to retrieve using traditional methods, such as for example aerosol/cloud number concentration or PM2.5. Also, AI/ML techniques can take advantage of combined passive and active sensors to fill observation gaps between the horizontal sparsity of active sensors and the vertical sparsity of passive sensors, to improve real-time 3-D monitoring and modeling of the Earth's surface and atmosphere. AI/ML algorithms that can improve climate models, regional dynamical models, or air quality forecasting models, by learning to optimize location, time and frequency of aerosol and cloud property observations, are also sought.

Research Focus Area: ICAN-C-Obscured Vision Enhancement
Research Identifier**: RFA-042**

NASA Digital Transformation – AI/ML Foundation
NASA MSFC
POC: Kelsey Buckles kelsey.d.buckles@nasa.gov

Research Overview: AI/ML can be used to see through dust and debris, and image processing, providing instantaneous clarity of ambient environment capability.

Research Focus: Conduct research to create a software/hardware capability to reduce visual noise. Primary objective is to reduce visual noise of blowing regolith during lunar landing.

Research Focus Area: Lox Methane HS Video Analysis.
Research Identifier**: RFA-043**

NASA Digital Transformation – AI/ML Foundation
NASA MSFC
POC: Kelsey Buckles kelsey.d.buckles@nasa.gov

Research Overview: There is limited research in utilizing AI/ML software to identifies small scale motion detection in order to analyze a blast and characterize vapor cloud shape/position vs. time in space.

Research Focus: Conduct research to create AI/ML software that identifies small scale motion detection in order to analyze a blast and characterize vapor cloud shape/position vs. time in space. Primary function is to provide verification for Consolidated Operations, Management, Engineering and Test (COMET), Lightning Mapping Array (LMA), and Computational Fluid Dynamics (CFD). Other potential uses include structural health monitoring, foreign objects and debris clearing, and military asset recovery.

Research Focus Area: Motion Mag in the Dark.
Research Identifier**: RFA-044**

NASA Digital Transformation – AI/ML Foundation
NASA MSFC
POC: Kelsey Buckles kelsey.d.buckles@nasa.gov

Research Overview: There is limited research in determining the feasibility of using motion magnification, in place of the Integrated Modal Test (IMT).

Research Focus: Conduct research to determine the feasibility of using motion magnification, in place of the Integrated Modal Test (IMT). Primary objective is the potential replacement of IMT on Artemis II, using custom Long Wave Infrared (LWIR) cameras and lenses to encompass the entire stack.

Research Focus Area: Foreign Object Debris (FOD) Detection Using Computer Vision.
Research Identifier: **RFA-045**

NASA Digital Transformation – AI/ML Foundation
NASA MSFC
POC: Kelsey Buckles kelsey.d.buckles@nasa.gov

Research Overview: There is limited research with software/hardware capabilities to detect and record the location and shape of Foreign Object Debris (FOD).

Research Focus: Conduct research to create a software/hardware capability to detect and record the location and shape of FOD. Primary function would be to use in place of a FOD walk, provide debris location data for analysis, monitor airfields and launch complexes. Using a drone equipped with custom Long Wave Infrared (LWIR) cameras and lenses, with onboard image recognition software.

Research Focus Area: Using Multispectral Neural Radiance Fields (NeRFs) for Ground Detection & Characterization of Lunar Micro Cold Traps
Research Identifier**: RFA-046**

NASA Digital Transformation – AI/ML Foundation
NASA Ames
POC: Ignacio López-Francos ignacio.lopez-francos@nasa.gov
Caleb Adams caleb.a.adams@nasa.gov
Ariel Deutsch ariel.deutsch@nasa.gov

Research Overview: High-resolution, near-real-time modeling is crucial for lunar science and exploration missions, particularly in identifying icy targets. Our proposal aims to generate intricate models of micro-cold-trap topography, temperatures, and water content to streamline target identification in dynamic, low-light polar environments. By applying Neural Radiance Fields (NeRFs) to data acquired from Artemis III and VIPER missions, we plan to enhance 3D mapping techniques, supporting science operations in future NASA expeditions. Micro cold traps, small and cold regions where ice remains thermally stable, are believed to contain approximately 20% of the Moon's water ice. These traps are scattered across the lunar landscape and are safer and more accessible than permanently shadowed regions (PSRs). Despite their importance for lunar exploration, we lack prior knowledge of their locations and compositions due to their minute size.

Research Focus: Conduct research to remedy this by potentially employing custom-built NeRFs on multi-spectral ground-based data during mission operations. This research advancement would revolutionize surface science operations by facilitating the measurement and integration of micro-cold trap topography, temperature, and water content into augmented reality systems, thus assisting in identifying scientific targets.

Unlike traditional methods, NeRFs can maintain the full spectral range and resolution during scene optimization, potentially retaining spectral context throughout the 3D reconstruction process. By utilizing intelligent priors and leveraging knowledge about light sources and sparse point clouds of target regions, the optimization in the NeRF could be constrained. This would result in accurate 3D reconstructions across various wavelengths, especially those diagnostic of water ice. Our proposed NeRFs will be rigorously tested using the SSERVI Lunar Regolith Testbeds at NASA Ames.

Note: NASA Ames is in collaboration with UC Berkeley, with potential NSF funding being directed to Professor Angjoo Kanazawa of the department of Electrical Engineering and Computer Sciences (EECS). Her pioneering research in 3D vision, specifically related to neural volumetric rendering and Neural Radiance Fields, will be instrumental in driving this project forward.

Research Focus Area: High-Resolution 3D Mapping of Lunar Shadowed Regions Using Neural Radiance Fields (NeRFs)
Research Identifier: RFA- **RFA-047**

NASA Digital Transformation – AI/ML Foundation
NASA Ames
POC: Ignacio López-Francos ignacio.lopez-francos@nasa.gov
Caleb Adams caleb.a.adams@nasa.gov
Ariel Deutsch ariel.deutsch@nasa.gov

Research Overview: With upcoming missions like Artemis and Commercial Lunar Payload Services (CLPS) aiming to study these lunar polar regions, designing safe traverses into, within, and out of permanently shadowed regions (PSRs) for robots and astronauts poses a primary challenge due to the lack of high-resolution and high signal-to-noise Digital Terrain Models (DTMs) of these areas.

Research Focus: Conduct research to overcome this, and determine if utilizing Neural Radiance Fields (NeRFs) will generate high-resolution 3D models of PSRs for efficient mission planning, safe operations, and maximizing scientific returns.
NeRFs, a novel technique in 3D reconstruction, outperform traditional methods like Multi-View Stereo (MVS) in handling complex lighting conditions typical of lunar polar regions. Recent developments in NeRF pipelines, including Sat-NERF, RAWNeRF, StructNeRF, and DS-NeRF, present promising opportunities for our applications. We intend to leverage these advancements in neural 3D reconstruction as well ray tracing techniques to simulate secondary illumination in PSRs to develop an hybrid MVS/NeRF-based mapping method for PSR reconstruction.

Note: NASA Ames is in collaboration with UC Berkeley, with potential NSF funding being directed to Professor Angjoo Kanazawa of the department of Electrical Engineering and Computer Sciences (EECS). Her pioneering research in 3D vision, specifically related to neural volumetric rendering and Neural Radiance Fields, will be instrumental in driving this project forward.

Research Focus Area: Study the deployment of Large Language Models (LLMs) for Systems Engineering and Project Management at NASA
Research Identifier: RFA- **RFA-048**

NASA Digital Transformation – AI/ML Foundation
NASA Ames

POC: Ignacio López-Francos ignacio.lopez-francos@nasa.gov
Caleb Adams caleb.a.adams@nasa.gov
Ariel Deutsch ariel.deutsch@nasa.gov

Research Overview: As the complexity of projects at NASA increases, more sophisticated tools are required for efficient systems engineering and project management. Large Language Models (LLMs) can offer potential advantages in these domains. However, due to their statistical nature, reliability and transparency concerns may hinder their adoption. Thorough verification and validation processes are vital to ensure their trustworthy and robust implementation in mission-critical planning and execution.

Research Focus: Conduct research on LLMs focuses on: (1) Identifying potential applications and benefits of LLMs in enhancing systems engineering and project management processes. (2) Establishing robust techniques for the verification and validation of LLMs within these contexts. (3) Recognizing and mitigating potential risks and limitations, addressing transparency and bias issues inherent in LLMs. The objective is to enable the integration of LLMs into NASA's operations to improve project management efficiency, reduce planning complexities, and facilitate more effective communication and information processing, paving the way for the next generation of space mission planning and execution.

Research Focus Area: Collaborative platforms for capturing data analytics workflows.
Research Identifier: **RFA-049**

NASA Digital Transformation – AI/ML Foundation
NASA Ames
POC: Nikunj Oza nikunj.c.oza@nasa.gov

Research Overview: Platforms are needed that allow for individuals and groups to perform the many steps needed to transform raw data into domain-relevant insights and publications and capture these steps into workflows that can be shared, revised, and compared. Users must be able to use the tools that they are accustomed to using, such as Jupyter notebooks, MATLAB, Python libraries, various databases, and/or others. However, the various steps that users take need to be captured in a form to where they can be readily re-run, individual steps can be changed, the resulting new workflows can be re-run, and the results compared to the previous workflows. Such workflow capture systems and Machine Learning can be used as the basis for a recommender system for new users to recommend key steps in new workflows that they create. Such systems can also be used to flag publications that may need to be revised because earlier data processing or analytics steps have been revised. Such a system can also serve as an "honest broker" that can instantly make a record of who produced a given result so that others may use that result immediately, without waiting for a publication, and while automatically giving the creator due credit.

Research Focus: Conduct research to properly understand how experts in different domains perform data analytics and develop components of a workflow capture system that will work as described above while using the tools of those domains as much as possible and not impeding the experts' work. Research is also needed to identify interface standards that are general enough to allow the tool interoperability described here and demonstrate whether productivity is improved due to the components and systems developed.

Research Focus Area: Uses of generative AI to dynamically create Photo realistic 3D content in real-time for use in XR applications.
Research Identifier: **RFA-050**

NASA Digital Transformation – AI/ML Foundation
NASA Ames/JSC
POC: Jules Casuga jules.casuga@nasa.gov
Frank Delgado francisco.j.delgado@nasa.gov

Research Overview: XR environments (virtual reality, augmented reality, and mixed reality) are being used to train crew, support operations, augment collaboration, improve the planning process, support complex data visualization, and support public and education outreach activities. One of the biggest challenges developing these applications is having access to high fidelity, realistic 3D models that are combined to create realistic and immersive applications. An active area of research is to use generative A.I. to, in real-time, create and insert 3D models into a virtual scene dynamically using a simple and intuitive user interface.

Emerging AI generative technologies currently being researched in this field include Neural Radiance Fields (NeRFs) and GANS to support the creation of 3D assets. An investigation into a Language Models (LLM) to generate natural language description of 3D assets can potentially be used in combination with NeRFs to speed up the process of 3D asset generation for XR applications.

Research Focus: Conduct research the feasibility of creating high fidelity 3D models dynamically (using a simple interface to define their properties) and insert them into a live XR session within acceptable timeframes, so that the user does not experience a degradation in frame rate that detracts from the immersive experience? Best validation methods to assure the assets created are representative of what would be expected. Optimum way(s) to interact with the system (voice, keyboard, other)?

Research Focus Area: Use of a Brain Computer Interface (BCI) system as a novel computer interface

Research Identifier: **RFA-051**

NASA Digital Transformation – AI/ML Foundation
NASA Ames/JSC
POC: Jules Casuga jules.casuga@nasa.gov
Frank Delgado francisco.j.delgado@nasa.gov

Research Overview: The mantel of human to computer interaction for decades has been the keyboard and mouse. Recently technologies such as voice recognition and body/limb/finger tracking have also been used to provide inputs to computers. Of course, the ultimate computer input device would allow a person to interface their mind directly with a computer. The idea that people's thoughts could be read and manipulated has been a theme in science fiction for decades. Conceptually, the brain would be communicating with a computer the same way it communicates with other parts of the body, but instead of using eyes, hands and fingers directly, a person would just have to think what they want the computer to carry out.

Research Focus: Conduct research the feasibility of creating a functional BCI system and the level of interactions/commands that a brain computer interface can provide; What biometric devices are best suited for this type of application. Best methods to incorporate this type of system into an XR environment?

Research Focus Area: Cognitive State Determination System to Support Training, Education, and Real-Time Operations in an XR environment.

Research Identifier**: RFA-052**

NASA Digital Transformation – AI/ML Foundation
NASA Ames/JSC

POC: Jules Casuga jules.casuga@nasa.gov
Frank Delgado francisco.j.delgado@nasa.gov

Research Overview: There is limited research on how we can use advanced computer science methods to develop correlation algorithms that use autonomic responses in the vision system (pupil dilation), autonomic response related to the conductance of the skin (galvanic skin response), the vascular system (heart rate and heart rate variability), electrochemical patterns in the brain (using EEG), hemoglobin-concentration changes in the brain (using Functional Near-Infrared Spectroscopy - FNIR), Electrical activity in the muscles (EMG), and vocal biomarkers. The system could use all of the biometric modalities mentioned above, or just a subset to carry a determination of a person's mental state. The states of primary interest include: cognitive underload, adequate cognitive workload, high cognitive workload, and cognitive overload. The system should also provide a confidence level for each prediction. A Cognitive State Determination System (CSDS) can significantly improve applications related to education, training, medicine, marketing, aeronautics, transportation, etc. For initial wide range usage, this type of system would require the use of non-intrusive sensors that are easy to use.

Note: An example of a CSDS system for training and education could allow for the educator/trainer to modulate the information being provided based on the trainee's cognitive state. If the trainee is bored, then additional elements to make the tasks more engaging could be added. If the person is getting close to cognitive overload, easier elements could be incorporated. Another example is the usage of a CSDS system to support real-time operations. Providing cognitive state information to support personnel or to the individual themselves would be valuable. This system can be used to support a wide range of activities from operating a spacecraft, flying an airplane, to driving a car. Coupling a cognitive state determination system with an AI/ML system would allow for the creation of an adaptable human interface that can modulate the information being provided to a user based on their cognitive state.

Research Focus: Conduct research on the feasibility to create a system that can accurately determine a person mental state. Specially its' ability to determine when a person is experiencing cognitive underload, adequate cognitive workload, high cognitive workload, and cognitive overload; Variability and performance differences between individuals; Study into the optimum set of biometric sensors needed for this type of system.

Research Focus Area: Automatic XR friendly procedure creation using videos
Research Identifier: **RFA-053**

NASA Digital Transformation – AI/ML Foundation
NASA Ames/JSC

POC: Jules Casuga jules.casuga@nasa.gov
Frank Delgado francisco.j.delgado@nasa.gov

Research Overview: NASA and many other organizations use procedures to support a wide variety of applications that range from maintaining a simple system, to carrying complex operations in dangerous environments. Depending on the use-case, developing procedures can require significant resource investments by many people with different skill bases. These individuals are scarce and always in demand. The desire is to have the ability to create XR friendly procedures automatically by capturing and analyzing training videos of specific tasks. Additionally, capturing and analyzing context specific to NASA's (or other companies) terms/vocabulary from the video voice or written instructional documentation is a challenging, but necessary component to create accurate and useable procedure content. Finally, in order for the virtual procedure assistance to serve its purpose to its full extent, it must be able to adapt to the user's expertise by presenting the information to them in a user customized manner. Another area of research is how to best incorporate this capability in an immersive XR system.

Research Focus: Conduct research to determine the feasibility of creating a system that can automatically develop accurate procedures using video.; Optimum ways to interact with such a system; Ability for a system to customize procedure content to meet an individual's expertise.

Research Focus Area: Video based mocap system
Research Identifier: **RFA-054**

NASA Digital Transformation – AI/ML Foundation
NASA Ames/JSC

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Research Overview: VR Motion Capture (Mocap) Systems are an important part of an XR system. Technology specific challenges that would be researched include the overall performance and viability of a video based Mocap system. In the near-term, R&D will benefit from automation of analytical workflows for engineering design and contribute toward research and the evaluation of options for in-flight crew data collections on the ISS. Comparing how an astronaut is ambulating over time, when carrying out an activity, can be used to determine changes in the musculoskeletal system that may be caused by fatigue or injury. Identifying and looking for ways to mitigate these types of changes is important to assure that astronauts are always performing in an optimum state.

Furthermore, contactless mocap system can support the development of a personal coach that can instruct a person when they are not performing exercises correctly. This could be done by using a pre-trained A.I. system that knows the positions of a person's limbs, torso and head while exercising and comparing them to optimum positions for the activity. Investigating ways that the system can interact with a person is another research area.

Research Focus: Conduct research to determine the feasibility of creating a system that can automatically determine a person's pose based on video. Performance metrics and limitations of such a system.

Research Focus Area: Retrieval Augmented Dialog LLM
Research Identifier: **RFA-055**

NASA Digital Transformation – AI/ML Foundation
NASA HQ
POCs: David Meza david.meza-1@nasa.gov

Research Overview: NASA policy, strategic documents, SOPs, and other important information are split across many diverse and disparate documents. Currently it is highly time consuming and difficult for NASA employees to determine the correct policy or SOP relevant to their situation. NASA employees lack a simple tool for them to quickly get answers to their questions in a seamless, natural way. Large Language Models (LLMs) provide a potential simple interface for employees to get answers, but current models require NASA questions and information to be provided to a 3rd party as part of the Generative AI process threatening the security of NASA's information. Existing Generative AI tools also suffer from hallucinations where they provide highly convincing, but inaccurate responses.

Research Focus: By deploying an LLM on the NASA network, NASA employees will be able to ask questions in natural language without risking their data leaving NASA systems. This will ensure their privacy and the protection of NASA information. By breaking NASA documents into small chunks of relevant information and storing those documents as semantic embeddings in a vector database, the relevant pieces of NASA policy can be retrieved to answer each question as it is asked. Through prompt engineering and fine-tuning, the LLM can be guided to answer the questions with the additional information "injected" from the NASA official policies and documents. This ensures the models provide true information and do not hallucinate answers to questions not available in their public training data. This project will pilot creating this tool on NASA infrastructure and determine how the tools and interface must be customized for the NASA environment and use cases. This project will explore, document, and propose a technical path forward to scale the pilot system to a production NASA tool. This solution could be replicated at any Agency or organization.

3.10 Earth Science

Science Mission Directorate (SMD)
NASA SMD Earth Science Division (ESD)

POC: Laura Lorenzoni, laura.lorenzoni@nasa.gov
Dr. Kelsey Bisson kelsey.bisson@nasa.gov
Dr. David Grinspoon david.grinspoon@nasa.gov

Research Focus Area: Impacts of human activity on coastal physical, geomorphological and ecological variability
Research Identifier**: RFA-056**

Research Focus Area: Sea level rise, coastal erosion/retreat, and salt-water intrusion, and their impacts on ecosystems;
Research Identifier**: RFA-057**

Research Focus Area: Linkages between aquatic dynamics and land subsidence and its impacts on aquatic ecosystems
Research Identifier**: RFA-058**

Research Focus Area: The role of urban development on land subsidence and aquatic ecosystems; biophysical coupling and feedbacks within the aquatic-land interface
Research Identifier**: RFA-059**

Research Focus Area: Impacts of hazards related to climate extremes, such as storms and heat waves, on biogeophysical aspects of the coast; etc.
Research Identifier**: RFA-060**

Research Focus Area: Impacts of upstream activities on coastal communities
Research Identifier**: RFA-061**

Research Focus Area: Integration of existing and upcoming observational and modeling assets into a conceptual or (better) digital aquatic-land framework that enables the dynamical coupling of key processes within the aquatic-land interface.
Research Identifier**: RFA-062**

Research Focus Area: Exposure and vulnerability to geohazards (e.g., infrastructure and flooding, landslides, etc.), land cover/use change and their impacts on water
Research Identifier**: RFA-063**

Research Overview: NASA SMD Earth Science Division (ESD) seeks topics to address coastal and ecosystem resilience, and equity and environmental justice.

This research focus area seeks to expand and build on the recently-established Coastal Resilience program, selected under ROSES22, and the work solicited under ROSES21 equity and environmental justice and ROSES22 IDS environmental and climate justice. Climate change impacts all aspects of the Earth and human systems, and highly populated coastal communities (adjacent to inland water bodies and the ocean) are among those experiencing its most disruptive consequences. Extreme weather events on land (droughts/floods), erosion, loss of marshes and wetlands, rising oceans and other direct human-induced changes threaten coastal communities, ecosystems, national and global economies. Furthermore, land changes from human activities such as groundwater/hydrocarbon extraction/injection, levee construction, river/sediment management, and urban development can have compounding effects with the naturally occurring land processes such as tectonics, sediment compaction, erosion, etc., with each process modifying the land surface elevation and coastal geomorphology. Combined, these complex and interconnected aquatic-land processes impact biogeochemistry and ecology, affect ecosystem structure and function, and threaten biodiversity.

NASA ESD recognizes a need to develop and learn from relationships with environmental justice (EJ) and climate justice (CJ) and underserved communities, as well as organizations familiar with working alongside these communities. EJ and CJ refer to communities in geographic locations around the globe with significant representation of minoritized populations, low-income persons, and/or indigenous persons or members of Tribal nations, where such individuals experience, or are at risk of experiencing, more adverse human health, environmental, and/or climate change impacts.

NASA Earth Science and satellite-based Earth observations can play an important role in addressing questions at the intersection of Earth observations and EJ/CJ, and are critical to understanding and predicting land/aquatic interface environments that undergo natural and human-induced changes. Understanding both direct and indirect human-induced changes is equally important in informing studies of coastal resilience and addressing high priority EJ/CJ needs.

Proposals seeking to respond to this EPSCoR Research Topic must address research that contributes to furthering support priorities related to coastal resilience and EJ/CJ, and will provide the foundational information and evidence-based knowledge that will help inform solutions to increase resilience of coastal communities and high priority needs as exemplified below. NASA is specifically interested in proposals that make significant use of remote sensing data to advance our understanding of key physical, biological, biogeochemical, geological, and hydrological coastal processes and their interactions within the interface of the aquatic-land-human system, and to enhance our understanding of how these processes will be compounded in rapidly changing coastal environments.
Examples of potential topics suitable for the EPSCoR research on coastal resilience include the exploration of the underlying physical, biological, and/or geological mechanisms within the aquatic-land framework and potential feedback processes and impacts on coastal ecosystems and underserved communities. Examples of coupled coastal processes may include but are not limited to:

1. Impacts of human activity on coastal physical, geomorphological and ecological variability;
2. Sea level rise, coastal erosion/retreat, and salt-water intrusion, and their impacts on

ecosystems;

3. Linkages between aquatic dynamics and land subsidence and its impacts on aquatic ecosystems;
4. The role of urban development on land subsidence and aquatic ecosystems; biophysical coupling and feedbacks within the aquatic-land interface;
5. Impacts of hazards related to climate extremes, such as storms and heat waves, on biogeophysical aspects of the coast; etc.
6. Impacts of upstream activities on coastal communities
7. Integration of existing and upcoming observational and modeling assets into a conceptual or (better) digital aquatic-land framework that enables the dynamical coupling of key processes within the aquatic-land interface.
8. Exposure and vulnerability to geohazards (e.g., infrastructure and flooding, landslides, etc.), land cover/use change and their impacts on water

The proposed investigations should be of regional (beyond local, 1,000+ km) focus, preferably in areas of high potential population growth, e.g. U.S. East, West, or Gulf coasts, Island Nations, and other low-lying regions across the globe that are impacted by climate change and/or socio-economic disadvantages. Proposals must provide a rationale for their region of choice. Proposals targeting the EJ/CJ topics are encouraged to integrate socio-economic data in their proposal.

Proposed investigations must utilize remotely sensed observations (e.g., MODIS, Landsat, etc.) for data analysis and as a primary research tool; however, other NASA data products from airborne campaigns, ground-based stations, or model output may be used for the proposed research. Proposers are also encouraged to use data acquired via the NASA Commercial SmallSat Data Acquisition Program (CSDAP). A description of NASA's fleet of Earth observing satellites and sensors can be found at https://science.nasa.gov/missions-page/, with more details about related airborne missions at https://airbornescience.nasa.gov/. Information about data access and discovery can be found at https://earthdata.nasa.gov/.

This research opportunity will not fund the acquisition of new in situ data, but seeks to further leverage the large quantities of remotely sensed and/or in situ data that NASA has already collected over the years.

Research Focus Area: Ocean Worlds Research: observational and modeling synergies between ice, ocean and surficial processes on Earth and other ocean environments in our solar system

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Research Identifier**: RFA-064**

Earth's ocean sustains an extraordinary diversity of life. At the base of the marine food web are phytoplankton, which are unicellular protists that perform photosynthesis at rates equivalent to all plants on land, through the absorption of atmospheric CO2 and sunlight where oxygen and biomass are byproducts for consumption by the wider ecosystem. Phytoplankton use and alter the incoming light field to such a large extent that ecosystem changes are visible from space. On Earth, satellite observations are the only way to observe synoptic change at the time scales relevant for ecosystems, from daily to decadal and from kilometers to the whole globe.

But Earth isn't the only ocean world in our solar system. Water exists in diverse forms on other planets, moons, dwarf planets, and comets. Given the essential role of water as a solvent for "life as we know it," ice, clouds, water vapor in the atmosphere, and oceans on other worlds offer clues in the quest to discover life beyond our home planet. Coordination and collaboration between the Earth ocean sciences and planetary science communities will be critical for next generation studies of ocean world habitability, and – ultimately – building a framework for detecting life. Earth ocean scientists understand how life covaries with environmental conditions and processes, while planetary scientists can translate those underlying concepts to alien environments and present day and future spacecraft measurements. No perfect analog for life on ocean worlds exists on Earth, but there are several environments with similar attributes (e.g., polar ice/ocean interactions, hydrothermal vents) that can be used to generate insights. Extraterrestrial environments may also conceivably present analogs for past terrestrial environments which no longer exist today but which are relevant for understanding the evolution of life on Earth. Synergistic activities concerning how these various planetary layers of ice and atmosphere affect our observations is important because the ice shell and atmosphere are the only window through which we will, for now, observe ocean world systems. This topic seeks projects that further advance the understanding of the workings of ocean worlds, including Earth, by further exploring processes that occur on ocean worlds across the solar system. For example, how do organisms alter ice properties and can these alterations be produced abiotically as well? What surface ice observations indicate underlying ocean processes? Are there places on Earth from which an abiotic baseline (and accompanying observations) can be determined? How do seafloor heating and rotation drive ocean currents, and how do currents distribute biosignatures, heat, salt, nutrients and other components? What are the timescales for equilibrium of volatile organic compounds from different environments? What life forms are found on Earth along the temperature, salinity, pressure spectrum, and can these be used to develop biotic intuitions for other ocean worlds?

Terrestrial and extraterrestrial ocean scientists must work collaboratively to measure and model spatial and temporal dynamics, determine essential parameters that govern interface processes, and evaluate new and existing technologies to access and study dynamics of habitable worlds. Synergy between studies of ice, ocean and geothermal processes on Earth, in targeted ways, and models of how these processes may manifest on ocean worlds benefits both communities. Moreover, the technological needs for exploring, especially at the poles, are often synergistic.

3.11 Entry Systems Modeling Project

Space Technology Mission Directorate (STMD)

Entry Systems Modeling Project
Space Technology Mission Directorate (STMD)

Research Focus Area: Deposition of Ablation/Pyrolysis Products on Optical Windows
Research Identifier**: RFA-065**
POC: Aaron Brandis aaron.m.brandis@nasa.gov
Research Overview: Provide experimental data to characterize the deposition of ablation/pyrolysis products on radiometer/spectrometer windows that reduce transmissivity.
Research Focus: Mars 2020 carried a radiometer on the backshell of the entry vehicle as part of the MEDLI2 instrumentation suite. Pyrolysis and ablation products can be deposited on the radiometer window during entry, and reduce the transmissivity. This reduction in transmissivity is a function of spectral wavelength, and can reduce the signal level reaching the radiometer sensing element. Such a test could be conducted in an ArcJet or Plasma torch either with a scaled approximate model of Mars 2020, or a simplified geometry (e.g. a wedge, backward facing step). Relevant materials for testing include PICA, RTV and SLA 561V. After products have been deposited on the window during a test, these products need to be characterized and the transmissivity of the window measured. These post-test results could either be measured as part of the proposal, or the post-test models sent back to NASA for characterization.

Research Focus Area: Plume Surface Interaction Predictive Capability
Research Identifier**: RFA-066**
POC: Aaron Brandis aaron.m.brandis@nasa.gov

Research Overview: Both model improvements and validation data are needed to further develop a multi-physics capability for simulating the interaction of rocket plumes and surface ejecta.
Research Focus: During propulsive spacecraft landings on surfaces with significant surface regolith (or other potential ejecta particles), such as found on the Moon or Mars, improved modeling of the interactions between rocket exhaust plumes and the surface upon which the vehicle is landing is needed. This complicated, multi-physics coupled particle-laden flow produces several phenomena of interest: plume-flow physics, surface erosion, and ejecta dynamics. All of these phenomena can lead to potential risks to a successful mission, including to nearby infrastructure, instrumentation, the vehicle, and in the future, crew. Current models exist for predictive modeling capabilities with varying levels of fidelity. These models largely use computational fluid dynamics (CFD). However, well characterized, relevant data for use in validation or for model inputs is often lacking. Therefore, this topic seeks data utilizing either intrusive or non-intrusive experimental approaches for plume-surface interaction studies that can be used to further the fidelity of predictive models by either improving model input parameters, providing a validation dataset, or informing the design of future ground and flight tests.

Research Focus Area: Computational Methods For Propagating Uncertainty in Hypersonic Flow Simulations
Research Identifier**:** **RFA-067**
POC: Aaron Brandis aaron.m.brandis@nasa.gov

Research Overview: Develop and implement novel methods to propagate uncertainty distributions for hypersonic computational fluid dynamic simulations.
Research Focus: Hypersonic flow simulations involve many models and database inputs for which each has a large number of either experimentally or fundamentally derived parameters. The impact of uncertainty in these parameters on quantities of interest has often been dealt with in the past via Monte Carlo style calculations, and frequently using a significantly reduced set of parameters. Therefore, a detailed and robust approach for characterizing the uncertainty on quantities of interest in non-equilibrium real gas hypersonic computational fluid dynamic simulations (CFD) is desired. The method should be able evaluate the sensitivity for defined quantities of interest (e.g. heat flux, or shear stress) to the large number of model and design parameters used as CFD inputs, which can be highly non-linear. An important aspect of the numerical approach detailed is to optimize computational efficiency (time, compute resources) in accurately capturing the sensitivity to this large number of input parameters. The ultimate goal being to use such a methodology to quantitatively assess the reliability of an aeroshell thermal protection system (TPS) during entry.

Research Focus Area: Nitrogen/Methane Plasma Experiments Relevant to Titan Entry
Research Identifier**:** **RFA-068**

POC: Aaron Brandis aaron.m.brandis@nasa.gov

Research Overview: Provide experimental data to characterize TPS material response under simulated Titan entry conditions.

Research Focus: Research Focus: Data is needed to validate models for the material response of thermal protection system (TPS) materials under simulated Titan entry conditions, with the atmosphere being predominately nitrogen (N2) and a small amount of methane (CH4). The conditions should be traceable to conditions relevant to the upcoming Dragonfly mission. Furthermore, an understanding of how coatings, e.g. NuSil, are impacted (or not) by the presence of methane and in a non-oxidizing environment is of interest. Relevant facilities for such measurements could include ArcJets or Plasma Torches. Data of interest would include thermocouples imbedded in TPS materials (e.g. PICA, SLA) and non-intrusive surface temperature measurements. Characterization of the post-test materials is also of interest. Understanding the material response of NuSil/PICA in a Titan atmosphere is important to maximize the science return for the DrEAM instrumentation suite.

Research Focus Area: Predictive Modeling of Plasma Physics Relevant to High Enthalpy Facilities
Research Identifier**: RFA-069**

POC: Aaron Brandis aaron.m.brandis@nasa.gov

Research Overview: Develop predictive models for arc and plasma processes used in the generation of high enthalpy flows in shock tube and arcjet facilities at NASA.
Research Focus: This proposal seeks predictive modeling of processes occurring in facilities that generate high enthalpy flows at NASA, including Arcs and Plasma Torches. The objectives may differ depending on facilities being modeled. For instance, the Electric Arc Shock tube uses an Arc to produce a high velocity shock waves. Acoustic modes in the arc driver may determine velocity profiles in the tube while ionization processes produce radiating species that may heat driven freestream gases. In plasma torches, studies of recombination of Nitrogen and Air plasma flows have relevance for predicted backshell radiation modeling. Modeling in arc jets may improve estimates of enthalpy profile uniformity and mixing of arc gas with add air.

Research Focus Area: Mechanical Properties of Ablative TPS Materials during Char Formation
Research Identifier**: RFA-070**

POC: Aaron Brandis aaron.m.brandis@nasa.gov

Research Overview: Provide mechanical property data to enable models that couple pyrolysis and char formation with thermostructural analysis for predicting the stress state of ablative TPS materials of interest to Entry Descent and Landing projects and missions at NASA.
Research Focus: This proposal seeks mechanical and/or strength measurements of ablative, porous thermal protection system (TPS) materials. The properties should be determined as a function of char conversion, with the char conversion occurring under controllable, repeatable conditions. Both degree and rate of char formation on the final properties would be desirable. The data would be made available to the TPS materials modeling groups at NASA to improve coupled ablative and thermostructural models.

3.12 Office of Chief Health and Medical Officer (OCHMO)

Space Operations Mission Directorate (SOMD)
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Dr. James D. Polk, james.d.polk@nasa.gov

Research Focus Area: Development and elaboration of Functional aids and testing paradigms to measure activity for use by parastronauts during spaceflight
Research Identifier**: RFA-071**
POC: Victor S. Schneider vschneider@nasa.gov

Research Overview: Development and elaboration of Functional aids and testing paradigms to measure activity for use by parastronauts during spaceflight. This may include egressing and exiting space capsules and donning and doffing spacesuits and other aids for parastronauts. The European Space Agency is establishing a parastronaut feasibility project. Since NASA offers its international partners access to NASA supported spacecraft and the International Space Station, NASA wants to establish appropriate functional testing measures to determine the time it takes fit astronaut-like subjects compared to fit parastronaut subjects to egress and exit simulated space capsules and simulated donning and doffing spacesuit. Research proposals are sought to establish appropriate functional testing.

Research Focus Area: Evaluation space capsule and spacesuit activity in stable and fit lower or upper extremity amputees and compare their responses to non-amputee fit individuals
Research Identifier**: RFA-072**
POC: Victor S. Schneider vschneider@nasa.gov

Research Overview: Evaluation space capsule and spacesuit activity in stable and fit lower or upper extremity amputees and compare their responses to non-amputee fit individuals. The European Space Agency is establishing a parastronaut feasibility project. Since NASA offers its international partners access to NASA supported spacecraft and the International Space Station, NASA wants to obtain research data measuring the time it takes fit astronaut-like subjects compared to fit parastronaut subject to egress and exit simulated space capsules and simulated donning and doffing spacesuit. Research proposals are sought to obtain data measuring the functional testing indicated.

3.13 Human Research Program

Human Exploration and Operations (HEO) Mission Directorate (HEOMD)

Dr. Kristin Fabre kristin.m.fabre@nasa.gov

Human Research Program

The NASA Human Research Program (HRP) drives advances in scientific and technological research to enable human space exploration. It is a human-focused Program dedicated to providing solutions and mitigation strategies beyond low-earth orbit by reducing the risks to human health & performance through focused translational, applied, and operational research. HRP's primary deliverables include:

- Human health, performance, and habitability standards
- Countermeasures and other risk mitigation solutions
- Advanced habitability and medical support technologies

Recently, HRP has developed a strategy to deliver critical components for an evolvable Crew Health and Performance System by 2032. This will be central to how HRP characterizes spaceflight risks and produces mitigation strategies that enable optimal crew health and performance during exploration missions. HRP will demonstrate and mature this system in ground analogs, in LEO, and on and around the moon to support a 2039 Mars mission. The Human Research Roadmap (https://humanresearchroadmap.nasa.gov) is a web-based version of an HRP Integrated Research Plan that allows users to search HRP risks, gaps, and tasks.

The HRP is organized into several research Elements:

- Human Health Countermeasures
- Human Factors and Behavioral Performance
- Exploration Medical Capability
- Space Radiation

Each of the HRP Elements addresses a subset of the risks. Proposals should address specific gaps listed in the Human Research Roadmap (https://humanresearchroadmap.nasa.gov/Gaps/).

Researchers from proposals selected for this R3 opportunity should consider attending the Human Research Program Investigators' Workshop (HRP IWS) in Galveston, TX (February 2025).

Human Research Program

Human Exploration and Operations (HEO) Mission Directorate (HEOMD)

<u>Precision Health Initiative</u>

Research Focus Area: Pilot studies to adopt terrestrial precision health solutions for astronauts
Research Identifier**: RFA-073**

POC: Corey Theriot corey.theriot@nasa.gov , 281-244-7331

The term "precision health" (similar to precision or personalized medicine in clinical settings) refers to the strategy of collecting and analyzing an individual's unique health status along with environmental and lifestyle data to identify key factors that can ultimately improve the health and performance of each crewmember in an individualized manner.

The Precision Health Initiative seeks to identify innovative methods to maintain an individual astronaut's health and optimal mission performance, requiring in-depth understanding of individual molecular profiles and how they relate to health and performance. The practice of Precision Health encompasses the use of detailed phenotyping of an individual, using both clinical and molecular measures, along with the integrated analyses of those data to draw conclusions about an individual's response to the environment, diet, medications, exercise regimen, etc. This topic seeks proposals for preliminary pilot studies that identify vetted and approved precision health techniques from terrestrial settings that can be applied with little to no modification to crewmembers that will be exposed to the stressors of spaceflight: space radiation, altered gravity, isolation/confinement, distance from Earth, and hostile/closed environments. For this solicitation, the term "technique" encompasses any clinical practice, strategy, test, or process that provides a clinically actionable medical outcome or unique knowledge of an individual's health status.

Research Focus: While most terrestrial precision medicine techniques focus on diagnosis and treatment of disease states, NASA is most interested in preventive measures that maintain crew health and performance during exposure to spaceflight stressors resulting in human health and performance risks as described in the Human Research Roadmap (https://humanresearchroadmap.nasa.gov). Proposed precision health techniques should have compelling evidence of efficacy for the crew population and be approved for terrestrial clinical practice by appropriate governing bodies, and proposals should address incorporation into the existing NASA operations, workflow, and infrastructure. Any proposed precision health techniques using genetic information must comply with the Genetic Information Nondiscrimination Act of 2008 (GINA) rules that preclude use of genetic information in employment decisions, which for NASA means that genetic data cannot be used to inform or influence crew selection or crew mission assignments.

Research Focus Area: Use of human-based tissue engineered models for characterization of space stressor and/or hazard effects.

Research Identifier**: RFA-074**

POC: Janapriya Saha janapriya.saha@nasa.gov

Complex *in vitro* models that mimic component of human physiology continue to evolve and show promise for various research. These tissue-engineered models, including organoids and tissue chips, could be ideal in better understanding space flight stressors and hazards such as chronic effects of low-dose radiation exposure to the human, microgravity, etc.. *Research proposals are sought to establish translational value of human-based tissue models for characterization of space flight hazards and/or stressor, and countermeasure studies. Such research should include models relevant to cancer, cardiovascular health, neurocognitive health, bone, immune, retinal etc. (For additional information concerning areas of interest please visit* https://humanresearchroadmap.nasa.gov/Risks/) Selected stressor and or hazard levels should be relevant to space exploration missions.

Respondents can propose the following types of activities:

1. Conduct research on HUMAN tissue models and compare to existing human data on vascular, cancer, cardiovascular health, neurocognitive health, bone, immune, retinal etc.. Structural and functional sturdies should be included, in addition to cell/molecular biomarker readouts. Selected stressor and or hazard levels should be relevant to space exploration missions.
2. Conduct research on ANIMAL tissue models and compare to existing in vivo data on vascular, cancer, cardiovascular health, neurocognitive health, bone, immune, retinal etc.. Structural and functional sturdies should be included, in addition to cell/molecular biomarker readouts. Selected stressor and or hazard levels should be relevant to space exploration missions
3. Obtain relevant preliminary data from either activities 1 or 2 that can be used in a future HRP OMNIBUS or FLAGSHIP grant application

Research Focus Area: Remote-controlled robotic operation

Research Identifier**: RFA-075**

POC: Honglu Wu honglu.wu-1@nasa.gov

Research Overview: This research focus area seeks proposals to develop technologies that enable performing tasks with a robot on the Space Station, the Moon or Mars. The robot will be controlled by humans on Earth, and should strive to be able to perform tasks remotely such as surgeries on humans. Other tasks include, but are not limited to, manufacturing new materials in the microgravity environment and preclinical experiments for investigating biological changes and health risks in space, using advanced tissue culture and/or animal models. The intent of such technologies is to allow for highly trained and experienced personnel to remotely perform tasks in space, to not only minimize the involvement of the crew, but also potentially improve the experimental environment and animal welfare with reduced hands-on activities.

Space Radiation

Space radiation exposure is one of numerous hazards astronauts encounter during spaceflight that impact human health. High priority health outcomes associated with space radiation exposure are carcinogenesis, cardiovascular disease (CVD), and central nervous system (CNS) changes that impact astronaut health and performance.

Research Focus Area: Tissue and Data sharing for space radiation risk and mitigation strategies
Research Identifier**: RFA-076**
POC: Janice Zawaski janice.zawaski@nasa.gov

Research Overview: Research proposals are sought to accelerate risk characterization for high priority radiation health risks and inform mitigation strategies the NASA Human Research Program (HRP) Space Radiation Element (SRE) by sharing animal tissue samples and data. The proposed work should focus is on translational studies that support priority risk characterization (cancer, CVD, CNS), development of relative biological effectiveness (RBE) values, identification of actionable biomarkers, and evaluation of dose thresholds for relevant radiation-associated disease endpoints. Cross-species comparative analyses of rodent data/samples with higher order species (including human archival data and tissue banks) are highly encouraged.

- Data can include but is not limited to behavioral tasks, tumor data, physiological measurements, imaging, omics', etc. that has already been, or is in the process of being, collected.
- Tissue samples can include, but are not limited to, samples that have already been, or are in the process of, being collected and stored as well as tissues from other external archived banks (e.g., http://janus.northwestern.edu/janus2/index.php).
- Relevant tissue samples and data from other externally funded (e.g., non-NASA) programs and tissue repositories/archives for comparison with high linear energy transfer (LET), medical proton, neutron and other exposures can be proposed.
- A more detailed list of samples and tissues available from SRE can be found at our tissue sharing websites:
  - https://lsda.jsc.nasa.gov/Document/doc_detail/Doc13726
  - https://lsda.jsc.nasa.gov/Document/doc_detail/Doc13766
  - https://lsda.jsc.nasa.gov/Biospecimen by searching "NASA Space Radiation Laboratory (NSRL)" in the payloads field.
  - Instructions for accessing the tissue sharing information are posted at: https://spaceradiation.jsc.nasa.gov/tissue-sharing/.

Research Focus Area: Compound screening techniques to assess efficacy in modulating responses to radiation exposure.
Research Identifier**: RFA-077**

POC: Janice Zawaski janice.zawaski@nasa.gov

Research Overview: Research proposals are sought to establish innovative screening techniques for compound-based countermeasures to assess their efficacy in modulating biological responses to radiation exposure relevant to the high priority health risks of cancer, CVD, and/or CNS. Techniques that can be translated into high-throughput screening protocols are highly desired, however high-content protocols will also be considered responsive.

Research Focus Area: Inflammasome role in radiation-associated health impacts
Research Identifier**: RFA-078**

POC: Janapriya Saha janapriya.saha@nasa.gov

Research Overview: Research proposals are sought to evaluate the role of the inflammasome in the pathogenesis of radiation-associated cardiovascular disease (CVD), carcinogenesis, and/or central nervous system changes that impact behavioral and cognitive function. Although innate inflammatory immune responses are necessary for survival from infections and injury, dysregulated and persistent inflammation is thought to contribute to the pathogenesis of various acute and chronic conditions in humans, including CVD. A main contributor to the development of inflammatory diseases involves activation of inflammasomes. Recently, inflammasome activation has been increasingly linked to an increased risk and greater severity of CVD. Characterization of the role of inflammasome-mediated pathogenesis of disease after space-like chronic radiation exposure can provide evidence to better quantify space radiation risks as well as identify high value for countermeasure development.

Research Focus Area: Aging related effects of space radiation
Research Identifier**: RFA-079**
POC: Gregory Nelson gregory.a.nelson@nasa.gov or Janice Zawaski janice.zawaski@nasa.gov

Normal aging processes have been shown to include many cellular processes that are shared with the pathogenesis of late degenerative diseases. Aging involves a progressive loss of physiological integrity and impaired function and is considered a primary risk factor for cancer, diabetes, cardiovascular disorders, and neurodegenerative diseases. Recently aging processes have been organized into a unified framework called the Hallmarks of Aging (e.g. López-Otin 2013, http://dx.doi.org/10.1016/j.cell.2013.05.039). The nine identified hallmarks of aging are: genomic instability, telomere length reduction, epigenetic changes, altered protein homeostasis, deregulated nutrient sensing, mitochondrial dysfunction, cellular senescence, stem cell depletion, and altered intercellular communication. Many of these processes have been investigated in detail in the context of low LET radiation exposure and "accelerated aging" has been proposed as a conceptual framework for radiation effects. However, much less understood about the effects of high LET space-like radiation exposure, especially at low doses and dose rates. These processes underly impairments to human risk imposed by space radiation exposure and an understanding of their responses is required for astronaut risk estimation, health management and countermeasure development. *Research proposals are sought to explore the pathogenic processes* *associated with aging and late degenerative diseases that are also elicited by charged particle radiation of composition and dose corresponding to spaceflight exposures. Such research should include models relevant to, but not limited to, cancer, cardiovascular and central nervous system health.*

Respondents can propose the following types of activities:

1. Conduct research on adult animals (sexually and immunologically mature) exposed to space-like radiation that characterize pathogenic processes common to aging and radiation injury. Outcome measures that relate to altered protein homeostasis, mitochondrial dysfunction, cellular senescence, and inflammation are of particular interest as well as those that can be used as predictive biomarkers for translation to humans. Use of both wild type and transgenic animals of both sexes is appropriate. Selected radiation doses, dose rates and sources should be relevant to space exploration missions.
2. Conduct research comparing human and animal tissue models using engineered tissue and organoid models. Structural and functional studies should be included, in addition to cell/molecular biomarker readouts. Selected radiation doses and sources should be relevant to space exploration missions.

Research Focus Area: Effects of space radiation on microvasculature
Research Identifier**: RFA-080**
POC: Gregory Nelson gregory.a.nelson@nasa.gov or Janice Zawaski janice.zawaski@nasa.gov

The microvasculature is responsible for perfusion, nutrient delivery, waste removal and endocrine communication for all cells and tissues and regulates these functions according to real-time tissue demands. It forms the interface between the blood, immune system and parenchyma and plays critical roles in wound healing (e.g., angiogenesis and coagulation). Its structure is adapted to different tissues and organs and can organize to isolate compartments such as blood-brain barrier or portal circulations such as in the liver. Microvascular injury is a prominent feature of normal tissue radiation injury and plays a critical role in both acute (inflammatory) and chronic (fibrotic) radiation responses. It has been hypothesized that damage to vascular endothelium plays the primary role in the development of late radiation-induced tissue injury and many years of investigation using low LET radiation support this idea (e.g. Lyubimova, N. and Hopewell, J.W., 2004 for late CNS effects). However, our knowledge of the effects of high LET space-like radiation on the microvasculature is very incomplete. Limited *in vivo* and *in vitro* experiments have demonstrated altered brain vessel network structure, adhesive properties, blood-brain and blood-retina barrier dysfunction, angiogenesis and other cellular changes. *Research proposals are sought to explore the structural and functional responses of the microvasculature to charged particle radiation of composition and dose corresponding to spaceflight exposures. Such research should include models relevant to, but not limited to, cardiovascular and central nervous system health and may include in vitro and in vivo studies. For purposes of this solicitation, microvasculature or microvessels refers to capillaries and associated small arterioles and venules as well as lymphatics.*

Respondents can propose the following types of activities:

1. Conduct research on adult animals exposed to space-like radiation that characterize functional and structural changes to microvessels in one or more tissue. Biochemical changes, cell signaling, interactions of endothelial cells with immune system components, measures of perfusion, etc. as they relate to tissue and organ function and overall health are all appropriate. Tumor vasculature models are not of interest. Selected radiation doses and sources should be relevant to space exploration missions. (Computational models of circulation?)
2. Conduct research comparing human and animal tissue models using engineered tissue and organoid models. Structural and functional studies should be included, in addition to cell/molecular biomarker readouts. Selected radiation doses and sources should be relevant to space exploration missions.

Research Focus Area: Use of human-based tissue engineered models for characterization of space stressor and/or hazard effects.

Research Identifier**: RFA-081**

POC: Janapriya Saha janapriya.saha@nasa.gov

Complex *in vitro* models that mimic component of human physiology continue to evolve and show promise for various research. These tissue-engineered models, including organoids and tissue chips, could be ideal in better understanding space flight stressors and hazards such as chronic effects of low-dose radiation exposure to the human, microgravity, etc.. *Research proposals are sought to establish translational value of human-based tissue models for characterization of space flight hazards and/or stressor, and countermeasure studies. Such research should include models relevant to cancer, cardiovascular health, neurocognitive health, bone, immune, retinal etc. (For additional information concerning areas of interest please visit* https://humanresearchroadmap.nasa.gov/Risks/) Selected stressor and or hazard levels should be relevant to space exploration missions.

Respondents can propose the following types of activities:

4. Conduct research on HUMAN tissue models and compare to existing human data on vascular, cancer, cardiovascular health, neurocognitive health, bone, immune, retinal etc.. Structural and functional sturdies should be included, in addition to cell/molecular biomarker readouts. Selected stressor and or hazard levels should be relevant to space exploration missions.
5. Conduct research on ANIMAL tissue models and compare to existing in vivo data on vascular, cancer, cardiovascular health, neurocognitive health, bone, immune, retinal etc.. Structural and functional sturdies should be included, in addition to cell/molecular biomarker readouts. Selected stressor and or hazard levels should be relevant to space exploration missions

6. Obtain relevant preliminary data from either activities 1 or 2 that can be used in a future HRP OMNIBUS or FLAGSHIP grant application

3.14 Planetary Division

Science Mission Directorate (SMD)

SMD requests that EPSCoR includes research opportunities in the area of Extreme Environments applicable to Venus, Io, Earth volcanoes. and deep-sea vents.

Venus has important scientific relevance to understanding Earth, the Solar System formation, and Exoplanets. For EPSCoR technology projects, Venus' highly acidic surface conditions are also a unique extreme environment with temperatures (~900F or 500C at the surface) and pressures (90 earth atmospheres or equivalent to pressures at a depth of 1 km in Earth's oceans). Furthermore, information on Venus' challenging environmental needs for its exploration can be found on the Venus Exploration Analysis Group (VEXAG) website: https://www.lpi.usra.edu/vexag/.

In particular, the technology requirements and challenges related to Venus exploration are discussed in the Venus Technology Roadmap at:

https://www.lpi.usra.edu/vexag/documents/reports/VEXAG_Venus_Techplan_2019.pdf

Research Focus Area: In-situ Astrobiology Instruments
Research Identifier: **RFA-082**

POC: Montbach, Erica N. (GRC-MA00) erica.n.montbach@nasa.gov
Michael Lienhard michael.a.lienhard@nasa.gov

Research Overview: The determination of whether other bodies in our solar system are, or were habitable, are important science questions identified in "An Astrobiology Strategy for the Search for Life in the Universe" at https://nap.nationalacademies.org/catalog/25252/. Additional information on promising destination in the solar system towards the search for conditions suitable for life can be found in "Origins, Worlds, and Life: A Decadal Strategy for Planetary Science and Astrobiology 2023-2032 (2022)" at https://nap.nationalacademies.org/catalog/26522/.

NASA may employ instruments similar to those used on Earth to detect biomarkers and/or to determine evidence of habitability in the solar system. The concentration of organic material at destinations of interest may be very low, necessitating innovative sample handling and processing techniques to perform sample analysis. Maintaining positive and negative controls, ensuring that samples are not destroyed or contaminated, and reading highly dilute and/or small samples are also technology challenges in this area. This topic seeks the development of innovative technologies that significantly improve instrument measurement capabilities for future planetary science missions that will look for bio habitability in the search for life.

Research Focus Area: Advanced Mobility for Subsurface Access
Research Identifier**: RFA-083**

POC: Montbach, Erica N. (GRC-MA00) erica.n.montbach@nasa.gov, Michael Lienhard michael.a.lienhard@nasa.gov

Research Overview: Subsurface access and drilling have applications in several priority future Planetary Science missions to locations including; the Moon, Mars, small bodies, and ocean worlds. Exploration of these locations requires access to pristine/unmodified materials and have scientific relevance to understanding the Earth, the Solar System formation, support in the search for life and could be key for in situ resource utilization. Technologies include drills, melt probes, tethers, submersibles, emplaced communication nodes, telemetry from the probe/drill tip, and materials capable of meeting stringent planetary protection requirements.

As highlighted in the Origins, Worlds and Life (OWL) Decadal Survey and community documents, certain high-priority science objectives, including subsurface ice composition, detailed organics characterization to search for modern biosignatures, and in situ stable and radiogenic isotopic measurements of rocks will benefit from further technology development. In situ laboratories on rovers at carefully selected sites, and measurements of a dynamic surface and atmosphere that link the past and the present and inform investigation of a planetary body's subsurface.

For EPSCoR technology projects, subsurface access technology has important scientific relevance to understanding how the interiors of planetary bodies evolve, and how this evolution is recorded in a body's physical and chemical properties, also how solid surfaces are shaped by subsurface, surface, and external processes. In addition, supporting the search for life by enabling new observations and measurements to understand the evolution of the planetary body surfaces, interiors, atmosphere, and transport of volatiles from surface to subsurface, and of the potential for past life, or potentially still extant subsurface life. Strong geophysical evidence exists for subsurface water oceans in the Jovian satellites Europa, Ganymede and Callisto and the Saturnian satellites Enceladus and Titan, therefore, the ability to drill into the icy layer on these icy worlds is also highly needed.

Drill systems with capability on the locations identified would be of great interest.

3.15 Planetary Protection

Science Mission Directorate (SMD)
Exploration Systems Development Mission Directorate (ESDMD)

Office of Safety & Mission Assurance

Research Focus Area: Addressing Knowledge Gaps in Planetary Protection for Crewed Mars Mission Concepts - Microbial and Human Health Monitoring

Research Identifier**: RFA-084**

POC: J Nick Benardini James.N.Benardini@nasa.gov

Research Overview: Planetary Protection is the practice of protecting solar system bodies from contamination by Earth life and protecting Earth from possible life forms that may be returned from other solar system bodies. NASA's Office of Planetary Protection (OPP) promotes the responsible exploration of the solar system by implementing and developing efforts that protect the integrity of scientific discovery, the explored environments, and the Earth.

As NASA expands its exploration portfolio to include crewed missions beyond low Earth orbit, including planning for the first crewed Mars mission, a new paradigm for planetary protection is needed. Together with COSPAR, the Committee on Space Research, NASA has been working with the scientific and engineering communities to identify gaps in knowledge that need to be addressed before an end-to-end planetary protection implementation can be developed for a future crewed Mars mission[1].

For this EPSCoR Rapid Research Response Topic, NASA is interested in proposals that will address identified knowledge gaps in planetary protection for crewed Mars mission concepts, facilitating a knowledge-based transition from current robotic exploration-focused planetary protection practice to a new paradigm for crewed missions.

Research Focus: The capability to detect, monitor and then (if needed) mitigate the effects of adverse microbial-based events, whether terrestrial or Martian in origin, is critical in the ability to safely complete a crewed return mission to and from the red planet.

OPP is interested in proposals that would be the first steps on a path to develop -omics based approaches (including downstream bioinformatic analyses) for planetary protection decision making, with a particular emphasis on assessing perturbations in the spacecraft microbiome as indicators of key events such as exposure to the Mars environment, or changes in crew or spacecraft health.

Additionally, OPP is interested in technologies and approaches for mitigation of microbial growth in space exploration settings. This includes remediation of microbial contamination (removal, disinfection, sterilization) in spacecraft environments in partial or microgravity as well as on

[1] Further information on the COSPAR meeting series on planetary protection knowledge gaps for crewed Mars missions can be found in the Conference Documents section of the OSMA Planetary Protection web site, in particular the report of the 2018 meeting at: https://sma.nasa.gov/docs/default-source/sma-disciplines-and-programs/planetary-protection/cospar-2019-2nd-workshop-on-refining-planetary-protection-requirements-for-human-missions-and-work-meeting-on-developing-payload-requirements-for-addressing-planetary-protection-gaps-on-nat.pdf?sfvrsn=507ff8f8_8

planetary surfaces.

Research Focus Area: Addressing Knowledge Gaps in Planetary Protection for Crewed Mars Mission Concepts - Natural Transport of Contamination on Mars

Research Identifier**: RFA-085**

POC: J Nick Benardini James.N.Benardini@nasa.gov

Research Overview: The threat of harmful biological contamination at Mars is a balance between the release and spread of terrestrial biota resulting from the spacecraft surface operations, and the lethality of the Martian environment to these organisms. To understand and manage the risk of such contamination, the OPP is interested in studies of the following:

- Modeling and experimentation to describe the surface/atmospheric transport of terrestrial microorganisms as they would be released from spacecraft hardware at the Martian surface.
- Modeling and experimentation to describe the subsurface transport of terrestrial microorganisms as they would be released from spacecraft hardware onto the Martian surface.
- Modeling and experimentation to describe the lethality of the Mars environment to terrestrial organisms as they would be released from spacecraft hardware at the Martian surface.

Proposed research could focus in individual (indicator) organisms or populations of organisms. Of particular interest is the resistance of terrestrial organisms to the Martian UV environment under conditions relevant to release from crewed spacecraft (in clumps, attached to dust particles, or as part of a biofilm matrix).

Additional Information: All publications that result from an awarded EPSCoR study shall acknowledge NASA OSMA. If the NASA GeneLab Data Systems (genelab.nasa.gov) is used, GeneLab shall be referenced in the resulting publication and included in the keyword list. All -omics data obtained from these studies shall be uploaded to the NASA GeneLab.

3.16 Space Geodesy Program

Science Mission Directorate (SMD)
NASA Goddard Space Flight Center

Research Focus Area: Space Geodesy, Earth Science
Research Identifier**: RFA-086**
POC: Stephen Merkowitz stephen.m.merkowitz@nasa.gov

NASA develops and operates a global ground network of Space Geodesy systems, including Satellite Laser Ranging, Very Long Baseline Interferometry, and Global Navigation Satellite System stations. Data from these stations are used for the realizations of the Terrestrial and Celestial Reference Frames, measurements of the Earth Orientation Parameters, and satellite Precision Orbit Determination. The data also supports a wide variety of important scientific investigations, including studies of the Earth's surface and interior and fundamental tests of gravity. See https://space-geodesy.nasa.gov for more details.

Proposal research opportunities include science applications of the space geodesy, technology development for the next generation NASA systems, geodetic data analysis, and development of algorithms for geodetic analysis tools.

Research Focus Area: Lunar Laser Ranging, Planetary Science
Research Identifier**: RFA-087**
POC: Stephen Merkowitz stephen.m.merkowitz@nasa.gov

Data from NASA's and the other international Lunar Laser Ranging stations are used to support a wide variety of important scientific investigations, including studies of the Moon's interior structure and fundamental tests of gravity. The measurements also contribute to the realizations of lunar reference frames, interplanetary spacecraft navigation, and positioning and navigation on and around the Moon. NASA is preparing to deploy several new lunar retroreflectors on the lunar surface that will improve the geometric coverage and enable better measurements of the lunar orientation.

Proposal research opportunities include science applications of Lunar Laser Ranging, technology development for improved Lunar Laser Ranging capabilities, Lunar Laser Ranging data analysis, and development of algorithms for Lunar Laser Ranging analysis tools.

FY 2025 Section 4: Contacts/Inquiries

For inquiries regarding technical and scientific aspects of NASA's Research Focus Areas in this NOFO, please contact:

Research Focus Area/Point of Contact (POC)
Electrified Vertical Takeoff and Landing (eVTOL), Material Characterization and Modeling Aeronautic Research Mission Directorate (ARMD) Timothy Krantz, timothy.l.krantz@nasa.gov NASA Glenn Research Center (GRC) Michael Hurrell, michael.j.hurrell@nasa.gov NASA GRC Robert Goldberg robert.goldberg@nasa.gov NASA GRC Justin Littell justin.d.littell@nasa.gov NASA Langley Research Center (LaRC) Mike Pereira mike.pereira@nasa.gov NASA GRC Trenton M. Ricks, PhD trenton.m.ricks@nasa.gov NASA GRC Steven M. Arnold steven.m.arnold@nasa.gov NASA GRC

Research Focus Area	Point of Contact	Id
Research contributing to partial-discharge free motors for aviation propulsion having a continuous power rating in the range 50 – 400 kW.	Timothy Krantz, timothy.l.krantz@nasa.gov Michael Hurrell michael.j.hurrell@nasa.gov	**RFA-001**
Lubrication and cooling technologies specifically optimized for long life and highly efficient eVTOL motors, including interest in single-fluid approaches for combined cooling and lubrication of inverters, motors, and gearboxes.	Timothy Krantz, timothy.l.krantz@nasa.gov Michael Hurrell michael.j.hurrell@nasa.gov	**RFA-002**
Development of Characterization Techniques to Determine Rate and Temperature Dependent Composite Material Properties for the LS-DYNA MAT213 Model	Robert Goldberg robert.goldberg@nasa.gov Justin Littell justin.d.littell@nasa.gov Mike Pereira mike.pereira@nasa.gov	**RFA-003**
Multiscale Modeling of Heterogeneous Materials with NASMAT	Trenton M. Ricks trenton.m.ricks@nasa.gov Steven M. Arnold steven.m.arnold@nasa.gov	**RFA-004**

Research Focus Area/Point of Contact (POC)		
Clean Energy, Climate Change and Orbital Debris Space Technology Mission Directorate (STMD) Jeffrey Sweterlitsch, PhD jeffrey.j.sweterlitsch@nasa.gov NASA JSC Bo Naasz, PhD Bo.j.naasz@nasa.gov NASA Goddard Space Flight Center (GSFC)		
Research Focus Area	**Point of Contact**	**Id**
Earth-observing capabilities to support breakthrough science and National efforts to reduce greenhouse gas emissions (including CO2, CH4, N2O, HFCs).	Sweterlitsch, Jeffrey, Ph.D. jeffrey.j.sweterlitsch@nasa.gov	**RFA-005**
U.S. Climate Change Research Program focusing on carbon capture and Utilization.	Sweterlitsch, Jeffrey, Ph.D. jeffrey.j.sweterlitsch@nasa.gov	**RFA-006**
Addressing Orbital Debris: Control the long-term growth of debris population	Bo Naasz, PhD. Bo.j.naasz@nasa.gov	**RFA-007**
Space Technology / Aeronautic Research Space Technology Mission Directorate (STMD) Aeronautics Research Mission Directorate (ARMD) Dr. Ronald Noebe ronald.d.noebe@nasa.gov NASA Glenn Research Center (GRC)		
Research Focus Area	**Point of Contact**	**Id**
Development of advanced soft magnetic materials for high-power electronic systems.	Dr. Ronald Noebe ronald.d.noebe@nasa.gov	**RFA-008**
Development of high-temperature structural refractory alloys and silicides and environmental coatings for refractory alloys.	Dr. Ronald Noebe ronald.d.noebe@nasa.gov	**RFA-009**
In Space Manufacturing /On Demand Manufacturing of Electronics (ODME) Space Operations Mission Directorate (SOMD) Exploration Systems Development Mission Directorate (ESDMD) Space Technology Mission Directorate (STMD) Jessica Koehne, Ph.D.Jessica.E.Koehne@nasa.gov NASA Ames Research Center (ARC) Curtis Hill curtis.w.hill@nasa.gov NASA Marshall Space Flight Center (MSFC)		
Research Focus Area	**Point of Contact**	**Id**

Research Focus Area/Point of Contact (POC)		
Advanced Manufacturing of Sensors and Electronics	Jessica Koehne, Ph.D. Jessica.E.Koehne@nasa.gov	**RFA-010**
Additive manufacturing and additive manufacturing of electronics	Curtis Hill curtis.w.hill@nasa.gov	**RFA-011**
LEO manufacturing support (additive, advanced materials, thin layer processing)	Curtis Hill curtis.w.hill@nasa.gov	**RFA-012**
Lunar manufacturing of solar cells and sensors	Curtis Hill curtis.w.hill@nasa.gov	**RFA-013**
Materials development for additive manufacturing	Curtis Hill curtis.w.hill@nasa.gov	**RFA-014**
Technology maturation through commercial (sub)orbital flight testing	Curtis Hill curtis.w.hill@nasa.gov	**RFA-015**

Center for Design and Space Architecture
Exploration Systems Development Mission Directorate (ESDMD)
Space Technology Mission Directorate (STMD)

Robert L. Howard, Jr., Ph.D. robert.l.howard@nasa.gov NASA Johnson Space Center (JSC)

Research Focus Area	Point of Contact	Id
Crew-worn restraints and mobility aids for microgravity spacecraft cabin environments	Robert L. Howard, Jr., Ph.D. robert.l.howard@nasa.gov	**RFA-016**
Crew quarters internal architectures compatible with both microgravity and fractional gravity domains	Robert L. Howard, Jr., Ph.D. robert.l.howard@nasa.gov	**RFA-017**
Repair, Manufacturing, And Fabrication (RMAF) Facility for the Common Habitat Architecture	Robert L. Howard, Jr., Ph.D. robert.l.howard@nasa.gov	**RFA-018**

Astrophysics
Science Mission Directorate (SMD)

Dr. Hashima Hasan, hhasan@nasa.gov NASA Headquarters (HQ)
Dr. Mario Perez, mario.perez@nasa.gov NASA HQ

Research Focus Area	Point of Contact	Id
Astrophysics Technology Development	Dr. Hashima Hasan hhasan@nasa.gov Dr. Mario Perez mario.perez@nasa.gov	**RFA-019**

Research Focus Area/Point of Contact (POC)		
NASA Biological and Physical Sciences (BPS) Science Mission Directorate (SMD) NASA Headquarters Biological and Physical Sciences Division NASA Marshall Space Flight Center (MSFC) / EM41 Diane Malarik Diane.C.Malarik@nasa.gov NASA Headquarters (HQ) Brad Carpenter bcarpenter@nasa.gov NASA HQ Mike Robinson michael.p.robinson@nasa.gov NASA HQ Sharmila Bhattacharya SpaceBiology@nasaprs.com NASA HQ Dr. Lisa Carnell; lisa.a.scottcarnell@nasa.gov NASA HQ		
Fundamental Physics	Mike Robinson; michael.p.robinson@nasa.gov	**RFA-020**
Soft Matter Physics	Mike Robinson; michael.p.robinson@nasa.gov	**RFA-021**
Fluid Physics	Brad Carpenter bcarpenter@nasa.gov	**RFA-022**
Combustion Science	Brad Carpenter bcarpenter@nasa.gov	**RFA-023**
Materials Science	Brad Carpenter bcarpenter@nasa.gov	**RFA-024**
Growth of plants in inhospitable "deep space-relevant" Earth soils or conditions	Sharmila Bhattacharya SpaceBiology@nasaprs.com	**RFA-025**
The impact of space-associated stressors on energy metabolism and oxidative stress.	Sharmila Bhattacharya SpaceBiology@nasaprs.com	**RFA-026**
The role of genetic diversity in enabling life to thrive in space.	Sharmila Bhattacharya SpaceBiology@nasaprs.com	**RFA-027**
Commercially Enabled Rapid Space Science Project (CERISS)	Ursula M. Koniges ursula.m.koniges@nasa.gov	**RFA-028**
Commercial Space Capabilities (CSC) Space Operations Mission Directorate (SOMD) Marc Timm, Program Executive marc.g.timm@nasa.gov NASA Headquarters (HQ) Warren Ruemmele, Project Executive warren.p.ruemmele@nasa.gov NASA Johnson Space Center (JSC)		
Research Focus Area	**Point of Contact**	**Id**
In-Space Welding	Warren Ruemmele warren.p.ruemmele@nasa.gov	**RFA-029**

Research Focus Area/Point of Contact (POC)		
Materials and Processes Improvements for Chemical Propulsion State of Art (SoA)	Warren Ruemmele warren.p.ruemmele@nasa.gov	**RFA-030**
Materials and Processes Improvements for Electric Propulsion State of Art (SoA)	Warren Ruemmele warren.p.ruemmele@nasa.gov	**RFA-031**
Improvements to Space Solar Power State of Art (SoA)	Warren Ruemmele warren.p.ruemmele@nasa.gov	**RFA-032**
Small Reentry Systems	Warren Ruemmele warren.p.ruemmele@nasa.gov	**RFA-033**
Low Consumable Environmental Control and Crew Systems	Warren Ruemmele warren.p.ruemmele@nasa.gov	**RFA-034**
Other Commercial Space Topic	Warren Ruemmele warren.p.ruemmele@nasa.gov	**RFA-035**

Research Focus Area/Point of Contact (POC)
ASA Digital Transformation (DT) Science Mission Directorate (SMD) **NASA Digital Transformation Officer** **Jill Marlowe** jill.marlowe@nasa.gov NASA Headquarters (HQ) **NASA Digital Transformation – Portfolio Integration** **Patrick Murphy** patrick.murphy@nasa.gov NASA HQ NASA Digital Transformation – Zero Trust Foundations; Strategy and Architecture Office (SAO) Mark Stanley mark.a.stanley-1@nasa.gov NASA Langley Research Center (LaRC) Cybersecurity Engineering Office (CSE) Dennis daCruz dennis.m.dacruz@nasa.gov NASA HQ NASA Digital Transformation – AI/ML Foundation Ed McLarney edward.l.mclarney@nasa.gov NASA LaRC Martin Garcia martin.garcia@nasa.gov NASA Johnson Space Center (JSC) Mark Page mark.page@nasa.gov NASA Kennedy Space Center (KSC) Scott Tashakkor scott.b.tashakkor@nasa.gov NASA Marshall Space Flight Center (MSFC) Snorre Stamnes snorre.a.stamnes@nasa.gov NASA LaRC Shan Zeng shan.zeng@nasa.gov NASA LaRC Yongxiang Hu yongxiang.hu-1@nasa.gov NASA LaRC Kelsey Buckles kelsey.d.buckles@nasa.gov NASA MSFC Ignacio López-Francos ignacio.lopez-francos@nasa.gov NASA Ames Caleb Adams caleb.a.adams@nasa.gov NASA Ames Research Center (ARC) Ariel Deutsch ariel.deutsch@nasa.gov NASA ARC Nikunj Oza nikunj.c.oza@nasa.gov NASA ARC Jules Casuga jules.casuga@nasa.gov NASA ARC Frank Delgado francisco.j.delgado@nasa.gov NASA JSC David Meza david.meza-1@nasa.gov NASA HQ

Research Focus Area	Point of Contact	Id
Zero Trust, Cybersecurity Mesh Architecture, and Leveraging Artificial Intelligence for Realtime Cyber Defense	Mark Stanley mark.a.stanley-1@nasa.gov	**RFA-036**
Applied AI Ethics	Ed McLarney edward.l.mclarney@nasa.gov	**RFA-037**

Research Focus Area/Point of Contact (POC)		
Scaled Video ML Object Detection and Alerts	Ed McLarney edward.l.mclarney@nasa.gov Martin Garcia martin.garcia@nasa.gov Mark Page mark.page@nasa.gov	**RFA-038**
Verification of AI/ML algorithms for Spacecraft	Scott Tashakkor scott.b.tashakkor@nasa.gov	**RFA-039**
Augmenting and Analyzing Requirements with Natural Language Processors	Scott Tashakkor scott.b.tashakkor@nasa.gov	**RFA-040**
AI/ML algorithms to obtain and improve 3-dimentional remote sensing of the Earth's aerosols, clouds, oceans and lands using advanced lidar and polarimeter data	Snorre Stamnes snorre.a.stamnes@nasa.gov Shan Zeng shan.zeng@nasa.gov Yongxiang Hu yongxiang.hu-1@nasa.gov	**RFA-041**
ICAN-C-Obscured Vision Enhancement	Kelsey Buckles kelsey.d.buckles@nasa.gov	**RFA-042**
Lox Methane HS Video Analysis	Kelsey Buckles kelsey.d.buckles@nasa.gov	**RFA-043**
Motion Mag in the Dark	Kelsey Buckles kelsey.d.buckles@nasa.gov	**RFA-044**
Foreign Object Debris (FOD) Detection Using Computer Vision	Kelsey Buckles kelsey.d.buckles@nasa.gov	**RFA-045**
Using Multispectral Neural Radiance Fields (NeRFs) for Ground Detection & Characterization of Lunar Micro Cold Traps	Ignacio López-Francos ignacio.lopez-francos@nasa.gov Caleb Adams caleb.a.adams@nasa.gov Ariel Deutsch ariel.deutsch@nasa.gov	**RFA-046**
High-Resolution 3D Mapping of Lunar Shadowed Regions Using Neural Radiance Fields (NeRFs)	Ignacio López-Francos ignacio.lopez-francos@nasa.gov Caleb Adams caleb.a.adams@nasa.gov Ariel Deutsch ariel.deutsch@nasa.gov	**RFA-047**

Research Focus Area/Point of Contact (POC)		
Study the deployment of Large Language Models (LLMs) for Systems Engineering and Project Management at NASA	Ignacio López-Francos ignacio.lopez-francos@nasa.gov Caleb Adams caleb.a.adams@nasa.gov Ariel Deutsch ariel.deutsch@nasa.gov	**RFA-048**
Collaborative platforms for capturing data analytics workflows	Nikunj Oza nikunj.c.oza@nasa.gov	**RFA-049**
Uses of generative AI to dynamically create Photo realistic 3D content in real-time for use in XR applications	Jules Casuga jules.casuga@nasa.gov Frank Delgado francisco.j.delgado@nasa.gov	**RFA-050**
Use of a Brain Computer Interface (BCI) system as a novel computer interface	Jules Casuga jules.casuga@nasa.gov Frank Delgado francisco.j.delgado@nasa.gov	**RFA-051**
Cognitive State Determination System to Support Training, Education, and Real-Time Operations in an XR environment	Jules Casuga jules.casuga@nasa.gov Frank Delgado francisco.j.delgado@nasa.gov	**RFA-052**
Automatic XR friendly procedure creation using videos	Jules Casuga jules.casuga@nasa.gov Frank Delgado francisco.j.delgado@nasa.gov	**RFA-053**
Video based mocap system	Jules Casuga jules.casuga@nasa.gov Frank Delgado francisco.j.delgado@nasa.gov	**RFA-054**
Retrieval Augmented Dialog LLM	David Meza david.meza-1@nasa.gov	**RFA-055**
Earth Science Science Mission Directorate (SMD) NASA SMD Earth Science Division (ESD) Earth Science Remote Sensing Dr. Laura Lorenzoni, laura.lorenzoni@nasa.gov Dr. Kelsey Bisson kelsey.bisson@nasa.gov Dr. David Grinspoon david.grinspoon@nasa.gov		
Research Focus Area	**Point of Contact**	**Id**

Research Focus Area/Point of Contact (POC)		
Impacts of human activity on coastal physical, geomorphological and ecological variability	Dr. Laura Lorenzoni, laura.lorenzoni@nasa.gov Dr. Kelsey Bisson kelsey.bisson@nasa.gov Dr. David Grinspoon david.grinspoon@nasa.gov	**RFA-056**
Sea level rise, coastal erosion/retreat, and salt-water intrusion, and their impacts on ecosystems	Dr. Laura Lorenzoni, laura.lorenzoni@nasa.gov Dr. Kelsey Bisson kelsey.bisson@nasa.gov Dr. David Grinspoon david.grinspoon@nasa.gov	**RFA-057**
Linkages between aquatic dynamics and land subsidence and its impacts on aquatic ecosystems	Dr. Laura Lorenzoni, laura.lorenzoni@nasa.gov Dr. Kelsey Bisson kelsey.bisson@nasa.gov Dr. David Grinspoon david.grinspoon@nasa.gov	**RFA-058**
The role of urban development on land subsidence and aquatic ecosystems; biophysical coupling and feedbacks within the aquatic-land interface	Dr. Laura Lorenzoni, laura.lorenzoni@nasa.gov Dr. Kelsey Bisson kelsey.bisson@nasa.gov Dr. David Grinspoon david.grinspoon@nasa.gov	**RFA-059**
Impacts of hazards related to climate extremes, such as storms and heat waves, on biogeophysical aspects of the coast	Dr. Laura Lorenzoni, laura.lorenzoni@nasa.gov Dr. Kelsey Bisson kelsey.bisson@nasa.gov Dr. David Grinspoon david.grinspoon@nasa.gov	**RFA-060**
Impacts of upstream activities on coastal communities	Dr. Laura Lorenzoni, laura.lorenzoni@nasa.gov Dr. Kelsey Bisson kelsey.bisson@nasa.gov Dr. David Grinspoon david.grinspoon@nasa.gov	**RFA-061**
Integration of existing and upcoming observational and modeling assets into a conceptual or (better) digital aquatic-land framework that enables the dynamical coupling of key processes within the aquatic-land interface	Dr. Laura Lorenzoni, laura.lorenzoni@nasa.gov Dr. Kelsey Bisson kelsey.bisson@nasa.gov Dr. David Grinspoon david.grinspoon@nasa.gov	**RFA-062**

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Exposure and vulnerability to geohazards (e.g., infrastructure and flooding, landslides, etc.), land cover/use change and their impacts on water	Dr. Laura Lorenzoni, laura.lorenzoni@nasa.gov Dr. Kelsey Bisson kelsey.bisson@nasa.gov Dr. David Grinspoon david.grinspoon@nasa.gov	**RFA-063**
Ocean Worlds Research: observational and modeling synergies between ice, ocean and surficial processes on Earth and other ocean environments in our solar system	Dr. Laura Lorenzoni, laura.lorenzoni@nasa.gov Dr. Kelsey Bisson kelsey.bisson@nasa.gov Dr. David Grinspoon david.grinspoon@nasa.gov	**RFA-064**
Entry Systems Modeling Project Space Technology Mission Directorate (STMD) Aaron Brandis aaron.m.brandis@nasa.gov NASA Ames Research Center (ARC)		
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Deposition of Ablation/Pyrolysis Products on Optical Windows	Aaron Brandis aaron.m.brandis@nasa.gov	**RFA-065**
Plume Surface Interaction Predictive Capability	Aaron Brandis aaron.m.brandis@nasa.gov	**RFA-066**
Computational Methods For Propagating Uncertainty in Hypersonic Flow Simulations	Aaron Brandis aaron.m.brandis@nasa.gov	**RFA-067**
Nitrogen/Methane Plasma Experiments Relevant to Titan Entry	Aaron Brandis aaron.m.brandis@nasa.gov	**RFA-068**
Predictive Modeling of Plasma Physics Relevant to High Enthalpy Facilities	Aaron Brandis aaron.m.brandis@nasa.gov	**RFA-069**
Mechanical Properties of Ablative TPS Materials during Char Formation	Aaron Brandis aaron.m.brandis@nasa.gov	**RFA-070**
Office of Chief Health and Medical Officer (OCHMO) Space Operations Mission Directorate (SOMD) Victor S. Schneider vschneider@nasa.gov NASA Headquarters (HQ)		
Research Focus Area	**Point of Contact**	**Id**
Development and elaboration of Functional aids and testing paradigms to measure activity for use by parastronauts during spaceflight	Victor S. Schneider vschneider@nasa.gov	**RFA-071**

<table>
<tr><th colspan="3">Research Focus Area/Point of Contact (POC)</th></tr>
<tr><td>Evaluation space capsule and spacesuit activity in stable and fit lower or upper extremity amputees and compare their responses to non-amputee fit individuals</td><td>Victor S. Schneider
vschneider@nasa.gov</td><td>RFA-072</td></tr>
<tr><td colspan="3">Human Research Program
Human Exploration and Operations (HEO) Mission Directorate (HEOMD)

Space Radiation
Precision Health Initiative
Systems Biology Translation

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Robin Elgart shona.elgart@nasa.gov NASA JSC
Janice Zawaski janice.zawaski@nasa.gov NASA JSC</td></tr>
<tr><td>Pilot studies to adopt terrestrial precision health solutions for astronauts</td><td>Corey Theriot
corey.theriot@nasa.gov</td><td>RFA-073</td></tr>
<tr><td>Use of human-based tissue engineered models for characterization of space stressor and/or hazard effects.</td><td>Janapriya Saha
janapriya.saha@nasa.gov</td><td>RFA-074</td></tr>
<tr><td>Remote-controlled robotic operation</td><td>Honglu Wu
honglu.wu-1@nasa.gov</td><td>RFA-075</td></tr>
<tr><td>Tissue and Data sharing for space radiation risk and mitigation strategies</td><td>Janice Zawaski
janice.zawaski@nasa.gov</td><td>RFA-076</td></tr>
<tr><td>Compound screening techniques to assess efficacy in modulating responses to radiation exposure</td><td>Janice Zawaski
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<tr><td>Inflammasome role in radiation-associated health impacts</td><td>Janapriya Saha
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<tr><td>Aging related effects of space radiation</td><td>Gregory Nelson
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Janice Zawaski
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<tr><td>Effects of space radiation on microvasculature</td><td>Gregory Nelson
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<tr><td>Use of human-based tissue engineered models for characterization of space stressor and/or hazard effects</td><td>Janapriya Saha
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</table>

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In-situ Astrobiology Instruments	Erica Montbach erica.n.montbach@nasa.gov Michael Lienhard michael.a.lienhard@nasa.gov	**RFA-082**
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Addressing Knowledge Gaps in Planetary Protection for Crewed Mars Mission Concepts	J Nick Benardini James.N.Benardini@nasa.gov	**RFA-084**
Natural Transport of Contamination on Mars	J Nick Benardini James.N.Benardini@nasa.gov	**RFA-085**
Space Geodesy Program Science Mission Directorate (SMD) NASA Goddard Space Flight Center Stephen Merkowitz stephen.m.merkowitz@nasa.gov		

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Lunar Laser Ranging, Planetary Science	Stephen Merkowitz stephen.m.merkowitz@nasa.gov	**RFA-087**