OMB Approval Number 2700-0092
Expired 8/31/19

National Aeronautics and Space Administration
Office of STEM Engagement
FY 2020 NASA Cooperative Agreement Notice (CAN)

Established Program to Stimulate Competitive Research (EPSCoR)

Rapid Response Research

Announcement Number: NNH20ZHA001C
Catalog of Federal Domestic Assistance (CFDA) Number: 43.008

Release Date:	**September 27, 2019**
Closing Date	**September 27, 2020**

NASA Headquarters
Office of STEM Engagement
Washington, DC 20546-0001

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Introduction

NASA's Office of STEM Engagement (OSTEM), in collaboration with the Science Mission Directorate (SMD) Planetary Science Division, Earth Science Division; HEOMD Space Biology Division, and the Commercial Space Capabilities Office (CSCO), solicits proposals for the fiscal year 2020 NASA Established Program to Stimulate Competitive Research (EPSCoR) Rapid Response Research (R3) program.

The R3 is a collaborative effort between EPSCoR and the NASA Mission Directorate programs/offices. The goals of R3 are to provide a streamlined method to address research issues important to NASA, and to enable EPSCoR researchers to work with NASA to solve research issues impacting the Agency's programs/missions.

- This solicitation will remain open for one year or for as long as funds are available.
- Amendments will be used to add/close appendices that list research tasks.
- Amendments will be open for 90 days.
- No proposals for the listed research tasks will be accepted after 90 days.
- States may submit one proposal per task (research area), i.e. if there are four tasks, the state may submit four proposals. *Please state which office you are proposing to support.*
- Proposals should be two to three pages and submitted by the State NASA EPSCoR Director through the NASA Solicitation and Proposal Integrated Review and Evaluation System (NSPIRES). EPSCoR only accepts proposals submitted by the State NASA EPSCoR Director.
- Proposers are encouraged to contact the research task point of contact (POC) listed on page 4 for clarification/information on the tasks.

The NASA Authorization Act for Fiscal Year 1993, Public Law 102-588, authorized NASA to initiate NASA EPSCoR to strengthen the research capability of jurisdictions that have not historically participated equably in competitive aerospace research activities. The goal of NASA EPSCoR is to provide seed funding that will enable jurisdictions to develop an academic research enterprise directed toward long-term, self-sustaining, nationally-competitive capabilities in aerospace and aerospace-related research. This capability will, in turn, contribute to the jurisdiction's economic viability and expand the nation's base for aerospace research and development.

Based on the availability of funding, NASA will continue to help jurisdictions achieve these goals through NASA EPSCoR. Funded jurisdictions' proposals shall be selected through a merit-based, peer-review competition, presented for review to the NASA HQ Mission Directorate Review Panel, and accepted by the EPSCoR Project Office.

The following are the specific objectives of NASA EPSCoR:

- Contribute to and promote the development of research capability in NASA EPSCoR jurisdictions in areas of strategic importance to the NASA mission;
- Improve the capabilities of the NASA EPSCoR jurisdictions to gain support from sources outside the NASA EPSCoR program;
- Develop partnerships among NASA research assets, academic institutions, and industry; and
- Contribute to the overall research infrastructure and economic development of the jurisdiction.

Solicitation Availability
This announcement is accessible for a period of one (1) year through the NASA Solicitation and Proposal Integrated Review and Evaluation System (NSPIRES) and through Grants.gov.

To access this announcement through NSPIRES, go to http://nspires.nasaprs.com and click on Solicitations.

To access this announcement through Grants.gov, go to https://www.grants.gov/web/grants/search-grants.html and select the link for NASA.

Eligibility
As stated in NASA EPSCoR legislation, jurisdictions eligible to compete for this opportunity are those jurisdictions eligible to compete in the National Science Foundation (NSF) EPSCoR Research Infrastructure Improvement Grant Program (RII). The NSF eligibility is based on whether the most recent three-year level of NSF research support is equal to or less than 0.75 percent. The most recent eligibility table is located at: https://www.nsf.gov/od/oia/programs/epscor/Eligibility_Tables/FY-2019-Eligibility.pdf

Proposals will be accepted from the resident institution of the NASA EPSCoR Director in each jurisdiction. The 28 jurisdictions that are eligible for this opportunity are: Alabama, Alaska, Arkansas, Delaware, Guam, Hawaii, Idaho, Iowa, Kansas, Kentucky, Louisiana, Maine, Mississippi, Montana, Nebraska, Nevada, New Hampshire, New Mexico, North Dakota, Oklahoma, Puerto Rico, Rhode Island, South Carolina, South Dakota, US Virgin Islands, Vermont, West Virginia, and Wyoming.

Availability of Funds and Period of Performance
NASA's ability to make awards is contingent upon the availability of appropriated funds from which payment can be made.

It is anticipated that approximately five (20) awards for each amendment of up to $100,000 each for a period of performance not to exceed one year each may be made under this CAN pursuant to the authority of Title 2 Code of Federal Regulations (CFR) Parts 200 and the NASA Grant and Cooperative Agreement Manual (GCAM).

Proposal Submission
All information needed to respond to this solicitation is contained in this announcement and in the companion document entitled *Guidebook for Proposers Responding to a NASA Research Announcement (NRA) or Cooperative Agreement Notice (CAN) March, 2018 Edition* (hereafter referred to as the *NASA Guidebook for Proposers*). The latest PDF version is available at: http://www.hq.nasa.gov/office/procurement/nraguidebook

Proposers are cautioned that only the Grants Officer at the NASA Shared Services Center (NSSC) has the authority to make commitments, obligations, or awards on behalf of NASA or authorize the expenditure of cooperative agreement funds. No commitment on the part of NASA should be inferred from technical or budgetary discussions with NASA managers, Mission Directorate employees, or other support staff. An organization that makes financial or personnel commitments in the absence of a grant or cooperative agreement signed by a NASA NSSC Grants Officer does so at its own risk.

Inquiries

Technical and scientific questions about programs in this CAN may be directed to:

EPSCoR Program

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Computational and Information Sciences and Technology Office (CISTO)

James Harrington
Project Manager
Goddard Space Flight Center, MD
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Telephone: (301) 286-4063
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New Frontiers Program (Juno and New Horizons)

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KSC Partnerships Office

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Technology Utilization	Technology Transfer Office
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1.0 Description of Opportunity

1.1 Program Description

The NASA Authorization Act for Fiscal Year 1993, Public Law 102-588, authorized NASA to initiate NASA EPSCoR to strengthen the research capability of jurisdictions that have not historically participated equably in competitive aerospace research activities. The goal of NASA EPSCoR is to provide seed funding that will enable jurisdictions to develop an academic research enterprise directed toward long-term, self-sustaining, nationally-competitive capabilities in aerospace and aerospace-related research. This capability will, in turn, contribute to the jurisdiction's economic viability and expand the nation's base for aerospace research and development.

The NASA EPSCoR is administered through NASA's Office of STEM Engagement (OSTEM). The purpose of NASA EPSCoR is to strengthen the research capability of jurisdictions that have not in the past participated equably in competitive federal research and development activities.

This Cooperative Agreement Notice (CAN) solicits proposals of two (2) to three (3) pages for the FY 2020 NASA EPSCoR Rapid Response Research (R3) program. Each funded NASA EPSCoR proposer shall work closely with a NASA researcher to focus on developing competitive research and technology for the solution of scientific and technical issues of importance to the NASA Mission Directorates as listed in the appendices. The Rapid Response Research (R3) program is an attempt to implement research within NASA and commercial programs to address technical issues. It will allow EPSCoR researchers to work alongside of NASA and commercial partners for up to one year and is intended to strengthen the bonds among EPSCoR jurisdictions, NASA, the commercial partners, and other entities.

1.2 Award Information: Funding and Cost-Sharing

The maximum funding that a jurisdiction can request from NASA is $100,000 per proposal. This amount is to be expended in accordance with the budget details and budget narrative in the approved proposal. Jurisdictions may submit one proposal consisting of two (2) to three (3) pages per NASA Technical Area listed. Multiple awards may be given for a particular task, depending on availability of funds. Proposers may resubmit proposals from previous R3 solicitations or submit proposals for renewal of existing awards.

EPSCoR plans to make approximately 20 awards from this announcement.

The period of performance is one year. Cost-sharing is not required; however, any funds used for voluntary matching or cost-sharing shall be allowable under 2 CFR 200.

1.3 Award Information: Restrictions

All awards made in response to proposals to this solicitation shall comply with the National Environmental Policy Act (NEPA). Thus, proposers are encouraged to plan and budget for any anticipated environmental impacts per instructions in the *NASA Guidebook for Proposers*.

Per the *NASA Guidebook for Proposers, Title 2 CFR* Parts *200 and 1800*, and the *NASA Grant and Cooperative Agreement Manual* (GCAM), the following restrictions govern the use of the NASA-provided EPSCoR funds and are applicable to this CAN:

- Funds shall not be used to fund research carried out by non-U.S. institutions. However, U.S. research award recipients may directly purchase supplies and/or services that do not constitute research from non-U.S. sources. Subject to export control restrictions, a foreign national may receive remuneration through a NASA award for the conduct of research while employed either full or part time by a U.S. institution. For additional guidance on foreign participation, see Section 3.2 of the *NASA Guidebook for Proposers* and the NASA FAR Supplement (NFS) Part 1835.016-70.
- Domestic travel does not have a funding limit. Domestic travel, defined as travel that does not require a passport, shall be appropriate and reasonable to conduct the proposed research.
- NASA EPSCoR funding shall not be used to purchase general purpose equipment, e.g. desktop workstations, office furnishings, reproduction and printing equipment, etc. as a direct charge. Special purpose equipment purchases (i.e., equipment that is used only for research, scientific, and technical activities directly related to the proposed research activities) are allowed and can be reflected as a direct charge as per cost principles cited in GCAM Appendix D, Equipment and Other Property. Per 2 CFR 200.439, special purchase equipment items with a unit cost of $5,000 or more must have the prior written approval of the Federal awarding agency, in this case, the NASA Grants Officer.
- NASA EPSCoR funding shall not be used to support NASA civil service participation (FTE) in a research project. That funding is provided through a funding vehicle between the jurisdiction and NASA Center, such as a Space Act Agreement or other reimbursable agreement. NASA EPSCoR may set aside funding from an award to send to a Center for contractor support (including travel) and/or services as identified by the proposer.
- NASA EPSCoR funds shall be expended on NASA EPSCoR institutions. If a Co-Investigator (Sc-I/Co-I) with an NASA EPSCoR award transfers to a non-EPSCoR institution, the EPSCoR funding amount, or the portion of it that remains unobligated at the time of Sc-I/Co-I transfer, shall not be transferred to the non-EPSCoR institution.
- All proposed funds shall be allowable, allocable and reasonable. Funds may only be used for the EPSCoR project. All activities charged under indirect cost shall be allowed under the cost principles included in 2 CFR 200.
- Non-Federal entities may use one of the methods of procurement as prescribed in 2 CFR 200.320. As defined in 2 CFR 200.67, the micro-purchase threshold for acquisitions of supplies or services made under grant and cooperative agreement awards issued to institutions of higher education, or related or affiliated nonprofit entities, or to nonprofit research organizations or independent research institutes is $10,000; or such higher threshold as determined appropriate by the head of the relevant executive agency and consistent with audit findings under chapter 75 of Title 31, United States Code, internal institutional risk assessment, or State law.
- Unless as otherwise directed in 2 CFR 200, for changes to the negotiated indirect cost rate that occur throughout the project period, the proposer/recipient shall apply the rate

negotiated for that year, whether higher or lower than at the time the budget and application was awarded.

- Proposals shall not include bilateral participation, collaboration, or coordination with China or any Chinese-owned company or entity, whether funded or performed under a no-exchange-of-funds arrangement.
- Cost sharing is not required, however, any funds used for voluntary matching or cost-sharing shall be allowable under 2 CFR 200.

1.4 Access to Research Results

In keeping with the *NASA Plan for Increasing Access to Results of Scientific Research*, found at: https://www.nasa.gov/sites/default/files/atoms/files/206985_2015_nasa_plan-for-web.pdf, new terms and conditions, consistent with the Rights in Data term and conditions (NASA Procedural Requirements (NPR) 7120.8A and GCAM, Appendix D30), information about making manuscripts and data publically accessible may be attached to NASA EPSCoR Research awards. All proposals will be required to provide a Data Management Plan (DMP) or an explanation as to why one is not necessary given the nature of the work proposed. *The DMP shall be submitted by responding to the NSPIRES cover page question about the DMP (limited to 4000 characters)*. Any research project in which a DMP is not necessary shall provide an explanation in the DMP block. Example explanations:

- *This is a development effort for flight technology that will not generate any data that my entity can release, so a DMP is not necessary.*
- *The data that our entity will generate will be ITAR.*
- *Or, your entity may simply explain why your project is not going to generate data.*

The proposal type that requires a DMP is described in the *NASA Plan for Increasing Access to Results of Scientific Research* (see above link). The DMP shall contain the following elements, as appropriate to the project:

- A description of data types, volume, formats, and (where relevant) standards;
- A description of the schedule for data archiving and sharing;
- A description of the intended repositories for archived data, including mechanisms for public access and distribution;
- A discussion of how the plan enables long-term preservation of data; and
- A discussion of roles and responsibilities of team members in accomplishing the DMP. (If funds are required for data management activities, these should be included in the budget and budget justification sections of the proposal.).

Proposers that include a plan to archive data should allocate suitable time for this task. Unless otherwise stated, this requirement supersedes the data sharing plan mentioned in the *NASA Guidebook for Proposers*.

In addition, as part of an award term and conditions, researchers submitting NASA-funded articles in peer-reviewed journals or papers from conferences now shall make their work accessible to the public.

1.5 Foreign National Participation

All recipients shall work with NASA project/program staff to ensure proper credentialing for any individuals who need access to NASA facilities and/or systems. Such individuals include U.S. citizens and lawful permanent residents ("green card" holders). It should be noted that foreign nationals (individuals who are neither U.S. citizens nor permanent residents) are not normally allowed access to NASA facilities. Foreign nationals from "designated" countries or countries designated by the State Department and listed by NASA as being sponsors of terrorism cannot be allowed on any NASA facilities unless they're green card holders.

1.6 Flight Activities

Proposals that include flight activities (not normal passenger travel) such as aircraft or helicopter flight services, including Unmanned Aircraft Systems (UAS)/Drones operations or the acquisition or construction of such flight vehicles, must comply with NASA Policy Directive 7900.4. Questions concerning flight compliance requirements may be addressed to Norman Schweizer at norman.s.schweizer@nasa.gov.

2.0 Eligibility

2.1 Jurisdictions Eligible to Apply

As stated in NASA EPSCoR legislation (NASA Authorization Act for Fiscal Year 1993, Public Law 102-588), jurisdictions eligible to compete for this opportunity are those jurisdictions eligible to compete in the National Science Foundation (NSF) EPSCoR Research Infrastructure Improvement Grant Program (RII). The NSF eligibility is based on whether the most recent three-year level of NSF research support is equal to or less than 0.75 percent. The most recent eligibility table is located at: https://www.nsf.gov/od/oia/programs/epscor/Eligibility_Tables/FY-2019-Eligibility.pdf

Proposals will be accepted from the resident institution of the NASA EPSCoR Director in each jurisdiction. The 28 jurisdictions that are eligible for this opportunity are: Alabama, Alaska, Arkansas, Delaware, Guam, Hawaii, Idaho, Iowa, Kansas, Kentucky, Louisiana, Maine, Mississippi, Montana, Nebraska, Nevada, New Hampshire, New Mexico, North Dakota, Oklahoma, Puerto Rico, Rhode Island, South Carolina, South Dakota, US Virgin Islands, Vermont, West Virginia, and Wyoming.

2.2 Cost Share

There is no cost share requirement to compete for this announcement.

3.0 Proposal Submission Instructions and Due Date/Time

All proposals in response to this announcement shall be submitted electronically via NSPIRES (http://nspires.nasaprs.com). Hard copies of the proposal will not be accepted. Electronic proposals shall be submitted in their entirety by 11:59 p.m., Eastern Time on the proposal due date of **September 27, 2020.**

Respondents without Internet access or that experience difficulty using the NSPIRES proposal site (http://nspires.nasaprs.com) may contact the Help Desk at nspires-help@nasaprs.com or call 202-479-9376 between 8:00 a.m. and 6:00 p.m. (ET), Monday through Friday, except Federal holidays. NSPIRES automatically identifies any proposals that are late. Proposals received after the due date may be returned without review. If a late proposal is returned, it is entirely at the proposer's discretion whether or not to resubmit it in response to a subsequent solicitation.

Note carefully the following requirements for submission of an electronic proposal via NSPIRES

- Every organization that intends to submit a proposal to NASA in response to this CAN shall be registered in NSPIRES. Registration for the proposal data system shall be performed by an organization's electronic business point-of-contact (EBPOC) who holds a valid registration with the System for Award Management (SAM) https://www.sam.gov/portal/public/SAM/
- Each individual team member (e.g., PI, co-investigators, etc.), including all personnel named on the proposal's electronic cover page, shall be individually registered in NSPIRES.

While every effort is made to ensure the reliability and accessibility of the web site and to maintain a help center via e-mail and telephone, difficulty may arise at any point on the internet, including with the user's own equipment. Prospective proposers are strongly urged to familiarize themselves with the NSPIRES site and to submit the required proposal materials well in advance of the proposal submission deadline. Difficulty in registering with or using a proposal submission system (NSPIRES) is not, in and of itself, a sufficient reason for NASA to consider a proposal that is submitted after the proposal due date.

3.1. Proposal Preparation

Required elements of the proposal are described below and shall be submitted as one or more PDF documents that are uploaded for proposal submission. Please refer to Section 3.6 of the *NASA Guidebook for Proposers* which provides guidelines for style formats and Section 3.7 which provides guidelines for proposal content.

Please identify to which Office you are proposing

REQUIRED CONSTITUENT PARTS OF A PROPOSAL (in order of assembly)	**PAGE LIMIT**
Proposal Cover Page	NSPIRES proposal cover page that is available at http://nspires.nasaprs.com/
Proposal Summary (abstract)	4,000 characters including spaces
Data Management Plan	4,000 characters, including spaces
Table of Contents	As needed
Scientific/Technical/Management Plan	2-3*
References and Citations	As needed
Biographical Sketches for:	
the Science Investigator (Sc-I)	2
each Co-Investigator (Co-I)	1
Current and Pending Support	As needed
Statements of Commitment and Letters of Support	As needed

Budget Justification: Narrative and Details • *Includes proposed budget, itemized list detailing expenses within major budget categories, detailed subawards and summary of personnel (User's Guide section 3.18 and Appendix C).* • *For cooperative agreements the table of personnel and work effort should immediately follow the proposal budget and is not included in the budget.*	As needed
Facilities and Equipment	As needed
Special Notifications and/or Certifications	As needed
** includes all illustrations, tables, and figures, where each "n-page" fold-out counts as n-pages and each side of a sheet containing text or an illustration counts as a page.*	

3.2 Announcement of Updates/Amendments to Solicitation

Additional programmatic information for this CAN may be made available before the proposal due date. If so, such information will be added as a formal amendment to this CAN as posted at its homepage on http://nspires.nasaprs.com.

Any clarifications or questions and answers regarding this CAN will be posted at its homepage on http://nspires.nasaprs.com.

Each prospective proposer has the responsibility to regularly check this CAN's homepage for any and all updates.

3.3 Cancellation of Program Announcement

NASA Office of STEM Engagement reserves the right to not make any awards under this CAN and/or to cancel this CAN. NASA assumes no liability (including proposal costs) for cancelling the CAN or for any organization's failure to receive such notice of cancellation.

3.4 Contacts

Inquiries regarding the submission of electronic proposal materials to NSPIRES should be addressed to:

Ms. Althia Harris
NASA Research and Education Support Services (NRESS)
Phone: 202-479-9030 x310
E-mail: aharris@nasaprs.com

All other inquiries about this training cooperative agreement announcement should be addressed to:

Mr. Jeppie Compton
National Project Manager, NASA EPSCoR
Office Phone: 321-867-6988
Cell Phone: 321-360-6443
E-mail: jeppie.r.compton@nasa.gov

4.0 Review and Selection Process

Review of proposals submitted in response to this CAN shall be consistent with the general policies and provisions contained in the *NASA Guidebook for Proposers*, Appendix D. Selection procedures shall be consistent with the provisions of the *NASA Guidebook for Proposers*, Section 5. However, the evaluation criteria described in this CAN under Section 4.0, Proposal Evaluation, takes precedence over the evaluation criteria described in Section 5 of the *NASA Guidebook for Proposers*. The selecting official for this CAN is the EPSCoR Project Manager or their appointed representative. The NASA EPSCoR Grants Officer will conduct a pre-award review of risk associated with the proposer as required by 2 CFR 200.205. For all proposals selected for award, the Grants Officer will review the submitting organization's information available through the Federal Awardee Performance and Integrity Information System (FAPIIS) and the System for Award Management (SAM) to include checks on entity core data, registration expiration date, active exclusions, and delinquent federal debt.

Limited Release of Proposers Confidential Business Information

For proposal evaluation and other administrative processing, NASA may find it necessary to release information submitted by the proposer to individuals not employed by NASA. Business information that would ordinarily be entitled to confidential treatment may be included in the information released to these individuals. Accordingly, by submission of this proposal the proposer hereby consents to a limited release of its confidential business information (CBI).

Except where otherwise provided by law, NASA will permit the limited release of CBI only pursuant to non-disclosure agreements signed by the assisting NASA support contractor or subcontractor, and their individual employees who may require access to the CBI to perform work under the support contract with NASA.

4.1 Selection Announcement

NASA's stated goal is to announce selections as soon as possible. However, NASA does not usually announce new selections until the funds needed for those awards are approved through the Federal budget process. Therefore, a delay in NASA's budget process may result in a delay of the selection date(s). After 180 days past the proposal's submitted date, proposers may contact the NASA EPSCoR Project Manager for a status.

A proposer has the right to be informed of the major factor(s) that led to the acceptance or rejection of the proposal. Debriefings will be available upon request. Again, it is emphasized that non-selected proposers should be aware that proposals of nominally high intrinsic and programmatic merits may be declined for reasons entirely unrelated to any scientific or technical weaknesses.

4.2 Notice of Award

For selected proposals, the NASA Grants Officer will contact the business office of the proposer's institution. The NASA Grants Officer is the only official authorized to obligate the Government. For a grant or cooperative agreement, any costs that the proposer incurs within 90 calendar days before an award are at the recipient's risk in accordance with 2 CFR § 1800.209.

4.3 Administrative and National Policy Requirements

All administrative and national policy requirements may be found at Title 2 CFR Part 200, Title 2 CFR Part 1800, and the NASA GCAM (all available at: http://prod.nais.nasa.gov/pub/pub_library/srba/index.html).

4.4 Award Reporting Requirements

Recipients shall submit a report to the NASA Grants Officer at the NSSC, with copies to Agency-EPSCoR and to the supported organization on the results pertaining to this award no later than 120 days after the project's end date. The reporting requirements for awards made through this CAN will be consistent with the reporting requirements outlined in the GCAM Appendix.

5.0 Proposal Evaluation

Proposals will be evaluated based on the proposed research approach (intrinsic merit) that addresses the research presented in the appendices, management, and budget.

Successful R3 proposals shall provide sound contributions to both immediate and long-term scientific and technical needs of NASA as explicitly expressed in current NASA documents and communications.

Proposals will be evaluated based on the following criteria: Intrinsic Merit, Management, and Budget Justification: Narrative and Details. The bulleted lists after each criterion below should not be construed as any indication of priority or relative weighting. Rather, the bullets are provided for clarity and facilitation of proposal development.

5.1 Intrinsic Merit (65% of score)

- Proposed Research should have clear goals and objectives; address the expectations described in the announcement; and be consistent with the budget, effectively utilize the program management, and demonstrate a high probability for successful implementation.
- Proposals shall provide a narrative of the proposed research activity, including the scientific and/or technical merit of the proposed research, unique and innovative methods, approaches, concepts, or advanced technologies, and the potential impact of the proposed research on its field.
- Existing Research Proposals shall provide baseline information about current research activities in the proposed research area currently funded under NASA EPSCoR R3.

5.2 Management (20% of score)

- The proposal Project Management should: describe the proposed program management structure in reasonable detail.
- Proposals shall describe the use of NASA content, people, or facilities in the execution of the research activities. They should describe current and/or previous interactions, partnerships, and meetings with NASA researchers, engineers, and scientists in the area of the proposed research, and discuss how future partnerships between the institution's researchers and personnel at the Mission Directorates and/or Centers will be fostered. The name(s) and title(s) of NASA

researchers with whom the proposers will partner shall be included. NASA shall consider the utilization of NASA venues for recipients to publish their accomplishments

5.3 Budget (15% of score)

- The proposed budget shall be adequate, appropriate, reasonable, and realistic, and demonstrate the effective use of funds that align with the content and text of the proposed project. Preparation guidelines for the budget can be found in the *NASA Guidebook for Proposers*, Section 3.18 and appendix C.
- The budget will be evaluated based upon the clarity and reasonableness of the funding request. A budget narrative shall be included that discusses relevant budgetary issues such as the extent and level of jurisdiction, industrial, and institutional commitment and financial support, including resources (staff, facilities, laboratories, indirect support, waiver of indirect costs, etc.).

6.0 Certification of Compliance

By submitting the proposal identified in the Cover Sheet/Proposal Summary in response to this Research Announcement, the Authorizing Official of the proposing organization (or the individual Proposer if there is no proposing organization) as identified below—

(a) Certifies that the statements made in this proposal are true and complete to the best of his/her knowledge;

(b) Agrees to accept the obligation to comply with NASA award terms and conditions if an award is made as a result of this proposal; and

(c) Confirms compliance with all applicable terms and conditions, rules, and stipulations set forth in the Certifications, Assurances, and Representations contained in this NRA or CAN. Willful inclusion of false information in this proposal and/or its supporting documents, or in reports required under an ensuing award, is a criminal offense (U.S. Code, Title 18, Section 1001).

The AOR's signature on the Proposal Cover Page automatically certifies that the proposing organization has read and is in compliance with all certifications, assurances, and representations as detailed in GCAM Appendix C, Section C1. The GCAM can be found at the following site: http://naiststl.nais.nasa.gov/pub/pub_library/srba/certs.html.

Note: On February 2, 2019, the System for Award Management (SAM) implemented a new process that allows financial assistance registrants to submit common federal government-wide certifications and representations. The new process will be required effective January 1, 2020. Guidance on the new process and system change can be found at:
https://interact.gsa.gov/blog/certifications-and-representation-improvements-sam

Appendix A: NASA SMD Planetary Division

Below is the SMD Planetary Science request. It is the same as before as they seek additional proposals. Please contact the POC listed in the solicitation for additional information.

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

Specifically for the planet Venus which has important scientific relevance to understanding Earth, the Solar System formation, and Exoplanets. For EPSCoR technology projects Venus highly acidic surface conditions is 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). Further Information on Venus's challenging environment 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/reports/Venus-Technology-Plan-140617.pdf

Two examples of areas of technology development highlighted for an EPSCOR extreme environment call are described below:

A. **High-Temperature Subsystems and Components for Long-Duration (months) Surface Operations:** Advances in high-temperature electronics and power generation would enable long-duration missions on the surface of Venus operating for periods as long as a year, where the sensors and all other components operate at Venus surface ambient temperature. These advances are needed for both the long-duration lander and the lander network. Development of high-temperature electronics, sensors, thermal control, mechanisms, and the power sources designed for operating in the Venus ambient would be enabling for future missions.

    For example, Venus surface landers could investigate a variety of open questions that can be uniquely addressed through in-situ measurements. The Venus Exploration Roadmap describes a need to investigate the structure of Venus's interior and the nature of current activity, and potentially conduct the following measurements: a. Seismology over a large frequency range to constrain interior structure; b. Heat flow to discriminate between models of current heat loss; c. Geodesy to determine core size and state.
    Landers with sample return capability would be of great interest.

B. **Aerial Platforms for Missions to Measure Atmospheric Chemical and Physical Properties:**
More than three decades ago, two small (3.5 m) VEGA balloons launched by the Soviet Union completed two day flights around Venus, measuring wind speeds, temperature, pressure, and cloud particle density. The time is ripe for modern NASA efforts to explore the Venus atmosphere with new technology.

Aerial platforms have a broad impact on science for Venus. Examples of science topics they could investigate include: a. the identity of the unknown UV absorber; b. properties of the cloud particles in general; c. abundances atmospheric gas species (including trace gases and noble gases); d. the presence of lightning; e. properties of the surface mapped aerially. Aerial vehicles able to operate at a variety of high and low altitudes in the middle atmosphere are needed to enable mid-term and far-term Venus missions addressing these issues. A platform able to operate close to the Venusian surface would be able to provide close surface monitoring but would require major development to operate in the hot dense lower atmosphere. Miniaturized guidance and control systems for aerial platform navigation for any altitudes are needed to track probe location and altitude.

Other topics of interest would include high pressure and acidic environments for technology development, which would be of interest to include in the $750K level EPSCoR call.

C. Extreme Environment Aerobot •

- Venus provides an important scientific link to Earth, Solar System formation, and to Exoplanets. This EPSCoR call is made for technology projects, which take into consideration Venus middle atmosphere conditions and its unique extreme environment. The call concentrates on the challenge to develop an aerial platform that would survive the extreme conditions of the Venusian middle atmosphere. Noting that in the middle atmosphere of Venus (79km to 45Km) the conditions are considerably more benign than its surface conditions. This EPSCoR call will focus on Variable Manurable (horizontally and vertically) altitude balloons or hybrid airship, or aerobots (buoyancy + lift). The top technical parameters to consider for the Extreme Environment Aerobot for Venus conditions are (* see references below):
- Altitude: Maintain 79km to 45km Altitude (avoids high temps)
- •Structure: Airframe & Materials compatible with acids (PH -1.3 to 0.5). The cloud pH varies from about 0.5 at the top (65 km) to -1.3 at the base (48 km).
- •Power source: Solar and/or Batteries
- Navigation: provide, Guidance & Control concepts
- Science Instruments: for atmosphere and ground remote sensing
- Lifetime: weeks to months
- Pressure and temperature range: 80mb-1.3bar, with pressure at 65 km (245Kelvin or -28C) from Pioneer Large probe measured 80 mb and at 48 km(385 Kelvin or 112C) is approximately 1.3 bar. At 60 deg. latitude the pressure at 65 km is about 70 mb and temperature is about 222 K (-51C).
- Winds: Vertical shear of horizontal wind, up to 5-10 m/s per km

Reference material:

Further Information on Venus's challenging environment needs, for its exploration, can be found on the Venus Exploration Analysis Group (VEXAG) website:
https://www.lpi.usra.edu/vexag/.

"Aerial Platforms for the Scientific Exploration of Venus" report (JPL) Aug 2018.
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/reports/Venus-Technology-Plan-140617.pdf

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(*) Reference papers:

Counselman C. C., Gourevitch S. A., King R. W., Loriot G. B., and Ginsberg E. S. (1980) Zonal and meridional circulation of the lower atmosphere of Venus determined by radio interferometry. *Journal of Geophysical Research*, 85: 8026-8030.

Kerzhanovich V. V., Aleksandrov Y. N., Andreev R. A., Armand N. A., Bakitko R. V., Blamont J., Bolgoh L., Vorontsov V. A., Vyshlov A. S., Ignatov S. P. et al. (1986) Small-scale turbulence in the Venus middle cloud layer. *Pisma v Astronomicheskii Zhurnal*, 12: 46-51.

Kerzhanovich V. V., and Limaye S. S. (1985) Circulation of the atmosphere from the surface to 100 KM. *Advances in Space Research*, 5: 59-83

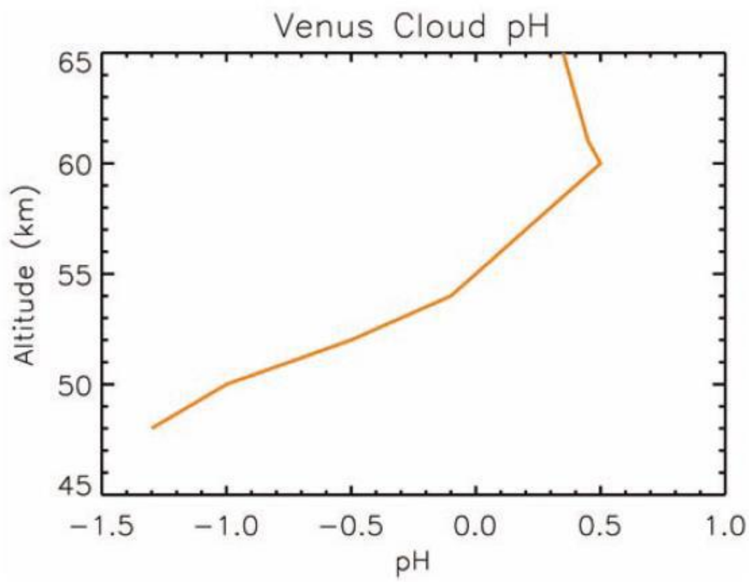

Plate 2. The pH of Venus' clouds as a function of altitude. The relatively water-rich aerosols in the upper cloud have a small range of positive pH, from 0.3 to 0.5. In the lower cloud, with its larger and more water-poor particles, pH can be as low as -1.3. Aerosol H_2SO_4 concentrations were calculated using the cloud model of Bullock and Grinspoon (2001), constrained by PV data. Correction for high activities is from Nordstrum et al. (2000).

Appendix B: Commercial Space Capabilities Office

Commercial Space Research
Research Request Number: CSCO-2020-01

CSCO-2020-01 is to allow consideration to award funded extension ("Renewal" per GCAM Section 5.3.3) to deserving CSCO EPSCOR R3 work that is ongoing from awards made in Fall 2018/2019 Cyle-1. We would evaluate these along with the regular R2 proposals received for CSCO-2020-02

1) Program: Commercial Space Capabilities Office (CSCO)

2) Research Title: Renewal of Previously Selected Cycle 1 CSCO R3

3) Research Overview:

NASA is requesting proposed renewals for continuation of successful currently supported CSCO R3 efforts and as otherwise adhering to *NASA Grant and Cooperative Agreement Manual* section 5.3.3. as follows;

a. Renewals can only be proposed for CSCO selections from Fall 2018 (RAPID RESPONSE RESEARCH – CYCLE 1) selections: 18-EPSCoR R3-0001, 18-EPSCoR R3-0015, 18-EPSCoR R3-0021, 18-EPSCoR R3-0027, and 18-EPSCoR R3-0035.
    i. Proposer may assume that (as applicable) NASA provided materials will be similar to those in predecessor award.
    ii. Proposer shall assume that all special conditions (e.g ITAR) in predecessor award remain in effect.

b. Proposed renewals shall support the same work of the predecessor award, or work that is a natural extension of and closely related to that work, not new projects unrelated to the predecessor award.

c. In addition to normal Proposal contents, the proposer shall provide the following in their renewal proposal:
    i. Brief statements about:
        1. why the work is still relevant, and
        2. how the work satisfies b. above.
        3. why the work should be renewed rather than recompeted
    ii. Show that costs are reasonable and realistic
    iii. State which Co-I/Sci-I personnel and capabilities/facilities would be used to perform the proposed renewal work, and state which (if any) are new. [NOTE: Changes in research personnel supporting the Co-I/Sci-I do not need to be stated]

4) NASA Contact

Name: Warren Ruemmele
Organization: Commercial Space Capabilities Office (CSCO)/UA3
Work Phone: 281-483-3662
Cell Phone: 832-221-1367
Email: warren.p.ruemmele@nasa.gov

NASA Technical Monitor (TM) will be assigned after award, but is anticipated to be the same TM as for the predecessor award.

5) 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

None are required. Proposer shall indicate if any has been arranged for the proposed renewal work.

6) 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.

7) Intellectual property management:

Proposer to indicate any intellectual property considerations in the Proposal.

8) Additional Agreement Clauses applicable to Cooperative Agreements awarded for this Call Area

None additional.

9) 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 4).

NASA CSCO will coordinate support from within NASA as needed.

NASA will make the resulting materials data available in its MAPTIS database https://maptis.nasa.gov/ .

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.

Appendix B: Commercial Space Capabilities Office (continued)

Commercial Space Research
Research Request Number: CSCO-2020-02

1) Program: Commercial Space Capabilities Office (CSCO)

2) Research Title: Landed Sensing of Mars Ice

3) Research Overview:
NASA is requesting research proposals in this area to further Mars exploration and commercialization efforts, by investigating landed sensing capabilities to characterize Mars ice deposits with the goal of better understanding the availability of water ice, including:

- Composition of the ice, including possible mixed in salts, dust, pebbles, and rocks
- Heterogeneity of ice deposits: both for mixed in materials as well as any distinct layering
- Spatial distribution within an area of about 10 km^2 (e.g. localized vs uniform)
- Depth, density, and nature of overburden over the area of interest (e.g. loose sand vs large rocks)

NASA has not identified specific tasks in this area but is seeking proposals that consider the following:

a) Sensing capabilities that would be landed on Mars surface or operate near the surface (not in orbit)
b) Sensing capability would be deployed from a single large vehicle that will soft land at specific mid-latitude location(s) on Mars that have been identified from orbit as likely to have accessible water ice in the subsurface.
    i. Sensing capability shall be scientifically/geologically sound, and ideally with the underlying methodology being proven terrestrially in analogous environment. Methods include, but are not limited to: seismic, drill/melt probe, ground penetrating radar, neutron spectrometer.
    ii. Sensing capability elements may remain on, and/or deploy from, the large vehicle. Elements can be centralized or spread among these.
        i. If deployment, a feasible method needs to be included in this proposal. Methods include, but are not limited to: flying, ejecting/shooting (non-explosive preferred), fully autonomous rover, tethered/cabled, combinations, etc.
    iii. The proposed sensing capability can be of much greater mass/volume than current NASA rovers. NASA telecon to discuss.
    iv. Sensing capability electrical power can be provided by direct connection or cable to the large vehicle. NASA telecon to discuss.
    v. Sensing capability commanding/data can be provided by direct connection, cable, or wireless from/to the large vehicle. Direct-To-Earth is allowed but not recommended. Commanding/data would be from Earth.
    vi. Goal of being able to sense an area ~10 km^2 centered on the large vehicle.
    vii. Goal of being able to operate on/in Mars environments between +35º and +50º latitude, for ~one Mars year.
    viii. Sensing capability shall not require any crew interaction on/near Mars.
c) Sensing capability is intended to provide ground truth to build upon the large amount of prior and ongoing data collection by other Mars systems (landers, rovers, remote sensors) and assessments by the Mars science/engineering community. Proposal should indicate relevance to, alignment with, and usage of these. Some references are:
    i. https://swim.psi.edu/

ii. https://astrogeology.usgs.gov/geology/mars-ice
iii. http://www.antarcticglaciers.org/glacial-geology/glaciers-mars/
iv. https://mepag.jpl.nasa.gov/
    i. https://mepag.jpl.nasa.gov/reports/ICESAG_Report_FINAL.pdf

The proposed work shall include performing the following at minimum:

a) Developing an engineering design concept and, as funding permits, fabricating all or part of the design to prototypic level, that would be suitable for testing in suitable terrestrial analog.
b) Producing a final report and delivery of developed design concept and data.

Proposals for this Research Title must include:

a) Describe proposing Institution's and Co-I/Sci-I's relevant capabilities and prior work. (weblinks preferred. Does not count against the 2-3 page limit.)
b) Identify the underlying scientific principles.
c) Compare and contrast proposed work against prior and existing work.
d) If data is needed from NASA to perform the proposed work, identify what it is needed and a contact/source if known

<u>Proposers can assume that technically knowledgeable NASA engineers and scientists will be reviewing the Proposal – so Proposer should focus on technical/scientific specifics.</u>

4) NASA Contact

Name: Warren Ruemmele
Organization: Commercial Space Capabilities Office (CSCO)/UA3
Work Phone: 281-483-3662
Cell Phone: 832-221-1367
Email: warren.p.ruemmele@nasa.gov

NASA Technical Monitor (TM) will be assigned after award

5) 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 <u>in addition</u> 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

None are required. Proposer shall indicate if any has been arranged for the proposed work.

6) 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.

7) Intellectual property management:

Proposer to indicate any intellectual property considerations in the Proposal.

8) Additional Agreement Clauses applicable to Cooperative Agreements awarded for this Call Area

None additional.

9) 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 4).

NASA CSCO will coordinate support from within NASA as needed.

NASA will make the resulting materials data available in its MAPTIS database https://maptis.nasa.gov/ .

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.

Appendix B: Commercial Space Capabilities Office (continued)

Commercial Space Research
Research Request Number: CSCO-2020-03

1) Program: Commercial Space Capabilities Office (CSCO)

2) Research Title: Improvement of Space Suit State of Art

3) Research Overview:

NASA is requesting research proposals in this area to further future Moon and Mars exploration and commercialization efforts, by investigating improvements to current space suit state of art.

NASA has not identified specific tasks in this area but is seeking proposals that consider the following:

a) Improvement(s) to current space suit design, implementation, and operation. Areas include: soft goods/woven materials and fabrication processes, mobility (spacecraft and surface), ergonomics and crew performance/health/safety, usability (don/doff, pre-breathe), suit life support, suit autonomy aids, availability/maintainability/redundancy (e.g. for repeated surface operations), and produce-ability/cost reduction.
b) Improvement may apply to any space suit flight phase including: launch/landing Intra Vehicular Activity (IVA), surface Extra Vehicular Activity (EVA) operation, and in-space EVA .
c) Improvement should address an identified need and/or shortcoming in current state of art, rather than a "nice to have".
d) Reasonably projected to be applicable to flight designs (so ~TRL7 https://www.nasa.gov/pdf/458490main_TRL_Definitions.pdf) within ~2 years.

The proposed work shall include performing the following at minimum:

a) Developing an engineering design concept and, as funding permits, fabricating all or part of the design to prototypic level, that would be suitable for testing in suitable terrestrial analog. NASA would work with Proposer to identify suitable terrestrial analog facilities and/or sites.
b) Producing a final report and delivery of developed design concept and data.

Proposals for this Research Title must include:

a) Describe proposing Institution's and Co-I/Sci-I's relevant capabilities and prior work. (weblinks preferred. Does not count against the 2-3 page limit.)
b) Provide references/links when presenting need and/or shortcoming in current state of art.
c) Compare and contrast proposed work against prior and existing work.

<u>Proposers can assume that technically knowledgeable NASA engineers and scientists will be reviewing the Proposal – so Proposer should focus on technical/scientific specifics.</u>

4) NASA Contact

Name: Warren Ruemmele
Organization: Commercial Space Capabilities Office (CSCO)/UA3
Work Phone: 281-483-3662
Cell Phone: 832-221-1367
Email: warren.p.ruemmele@nasa.gov

NASA Technical Monitor (TM) will be assigned after award

5) 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
None are required. Proposer shall indicate if any has been arranged for the proposed work.

6) 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.

c. From NASA organization other than EPSCOR
None.

d. From Organization partnering with NASA
None.

7) Intellectual property management:
Proposer to indicate any intellectual property considerations in the Proposal.

8) Additional Agreement Clauses applicable to Cooperative Agreements awarded for this Call Area
None additional.

9) 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 4).

NASA CSCO will coordinate support from within NASA as needed.

NASA will make the resulting materials data available in its MAPTIS database https://maptis.nasa.gov/ .

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.

Appendix C: SMD Earth Sciences Division

NASA SMD Earth Science Division (ESD) Research Topics to Address Earth System response to disasters

SMD requests that EPSCoR include research opportunities focused on understanding the response of the Earth System to disasters. The ESD, in order to address its strategic goals and core near-term objectives, regularly collects data on unforeseen events or events of unique and novel character (scale, extent, complexity or impact) in the Earth system using remote sensing measurements from on-orbit satellites and airborne platforms. Such events may include wild fires, hurricanes and tropical storms, volcanic eruptions, floods, earthquakes, tsunamis, landslides, environmental emissions, pollution and toxic releases, oil spills, harmful algal blooms, coral bleaching events, crop failure, energy and transport disruption, and other large-scale, extraordinary, events. These data are used to address specific science questions in response to the event; improve the understanding related to natural or anthropogenic extreme events or similar unanticipated or unpredictable disasters and cascading impacts; and/or advance application readiness, disaster risk management, and disaster resilience. However, there is vast and untapped potential in science and applications of those data even after the event has long passed, which can significantly advance the understanding of the Earth System, and provide societal benefits.

Proposals seeking to respond to this EPSCOR Research Topic should focus on utilizing existing data (including outputs and predictive capabilities from models associated NASA products) relating to past unforeseen events or events of unique and novel character to further the understanding of such events within the Earth System, advancing the readiness of application science, and/or provide advancements in risk management and disaster resilience. 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/.

Instrument-specific airborne data in addition can be found through the different airborne data sites; examples suitable to this call include:

AVIRIS (Airborne Visible InfraRed Imaging Spectrometer):
https://aviris.jpl.nasa.gov/data/get_aviris_data.html

UAVSAR (Uninhabited Aerial Vehicle Synthetic Aperture Radar):
https://www.asf.alaska.edu/sar-data/uavsar/

G-LiHT (Goddard's LiDAR, Hyperspectral & Thermal Imager): https://gliht.gsfc.nasa.gov/
Please check the above mentioned websites to see if observational data are available for the time period and area of interest.

The proposals should include clear statements as to what the significance and impact of proposed work will be, scientifically and/or to a stakeholder community, and a plan on dissemination and sharing of data, products, and tools where applicable. This research opportunity seeks to take advantage of the large quantities of data that NASA has already collected over the years in response to unforeseen or unpredictable Earth system events. Scientists cannot propose to collect new airborne or satellite observations; we may consider collection of limited and targeted field data on a case by case basis.

Examples of potential topics suitable for the EPSCOR Earth System response to natural disasters include:

1. Oil spills (e.g. improved mitigation strategies; further understanding of oil distribution through time; comparison between spills in similar settings)
2. Hurricanes (e.g. impacts on coastal communities/ecosystems and subsequent recovery; comparison of storm types and ecosystem damage)
3. Wildfires (linkages of various wildfires (type, extent) to climatic conditions; societal impacts; recurrence and ecosystem response)
4. Harmful algal blooms (e.g. impacts on air/water quality; comparison of climatic conditions for different blooms; comparison of blooms across regions)
5. Volcanic eruptions (e.g. atmospheric composition/distribution of plumes of same volcano through time)

Appendix D: NASA Space Life and Physical Sciences and Research Applications

SLSPRA has 11 topics listed below and on the following pages for your consideration and possible involvement.

(1) Program: Physical Sciences Program

(2) Research Title: Dusty Plasmas

(3) Research Overview:

Dusty plasma research uses dusty plasmas – mixtures of electrons, ions, and charged micron-size particles as a model system to understand astronomical phenomena involving dust-laden plasmas, and as a simplified system modelling the behavior of many-body systems in problems of statistical and condensed matter physics. Dusty plasma research also addresses practical questions of dust management in planetary exploration missions.

Proposals are sought for research on dusty plasmas, particularly on the transport of particles in dusty plasmas.

4) NASA Contact

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5) Commercial Entity:

a. Company Name: na
b. Contact Name: na
c. Work Phone: na
d. Cell Phone: na
e Email: na

6) Partner contribution

No NASA Partner contributions

7) Intellectual property management:

No NASA Partner intellectual property concerns

8) Additional Information:

All publications that result from an awarded EPSCOR study shall acknowledge NASA Space Life and Physical Sciences Research and Applications (SLPSRA).

Appendix D: NASA Space Life and Physical Sciences and Research Applications (continued)

1) **Program:** Fluids Physics and Combustion Science

2) **Research Title:** Drop Tower Studies

3) **Research Overview**:

Fundamental discoveries made by NASA researchers over the last 50 years in fluids physics and combustion have helped enable advances in fluids management on spacecraft water recovery and thermal management systems, spacecraft fire safety, and fundamental combustion and fluids physics including low-temperature hydrocarbon oxidation, soot formation and flame stability.

The microgravity environment provides an ideal experimental backdrop for probing many of the questions raised in boiling, capillary effects and combustion research. Because the microgravity environment allows for extended length and/or time scales certain diagnostic techniques, that otherwise prove intractable in 1-g environments, show promise in obtaining new experimental insights. Using well designed experiments the aforementioned research topics can successfully be explored in microgravity and will serve to greatly enhance the developmental pace of a number of important technologies for both terrestrial and extraterrestrial application.

4) **Research Focus**

This Fluids Physics and Combustion Science emphasis requests proposals for hypothesis-driven experiments and/or analysis that that will help address fundamental issues in these fields or will address important issues in spacecraft life-support.

Proposers are encouraged to include the use of NASA GRC drop tower facilities in their proposals. For more information about these facilities, please contact Eric Neumann (eric.s.neumann@nasa.gov; 216-433-2608). These facilities provide either 2.2 or 5.2 seconds of low-gravity.

(5) NASA Contact

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c. Work Phone: 202-358-0693
d. Email: francis.p.chiaramonte@nasa.gov

6) **Commercial entity:**

a. Company Name: na
b. Contact Name: na
c. Work Phone: na
d. Cell Phone: na
e. Email: na

7) **Partner contribution**

No NASA Partner contributions

8) **Intellectual property management:**
No NASA Partner intellectual property concerns

9) **Additional Information:**
All publications that result from an awarded EPSCOR study shall acknowledge NASA Space Life and Physical Sciences Program.

Appendix D: NASA Space Life and Physical Sciences and Research Applications (continued)

1) **Program:** Combustion Science

2) **Research Title:** Transcritical Combustion

3) **Research Overview:**

Fundamental discoveries made by NASA researchers over the last 50 years has helped enable advances in fundamental combustion including low-temperature hydrocarbon oxidation, soot formation and flame stability. One area of fundamental research that NASA wishes to focus on is combustion at supercritical conditions. This study has two major applications: super critical water oxidation (SCWO) and hydrocarbon combustion processes as seen in diesel and jet engines.

The microgravity environment provides an ideal experimental backdrop for probing many of the questions raised in high pressure combustion research. Because the microgravity environment allows for extended length and/or time scales certain diagnostic techniques, that otherwise prove intractable in 1-g environments, show promise in obtaining new experimental insights. Using well designed experiments the aforementioned research topics can successfully be explored in microgravity and will serve to greatly enhance the developmental pace of a number of important technologies for both terrestrial and extraterrestrial application.

4) **Research Focus**

This Combustion Science Emphasis requests proposals for hypothesis-driven experiments and/or analysis that that will help determine: 1) fundamental phase change and transport processes in the injection of a subcritical fluid into an environment in which it is supercritical; 2) ignition and combination of hydrocarbons under these conditions; and 3) how to optimize SCWO systems for waste management in extraterrestrial habitats.

Proposers are encouraged to include the use of drop tower facilities in their proposals. For more information about these facilities, they can contact Eric Neumann (eric.s.neumann@nasa.gov ; 216-433-2608). These facilities provide either 2.2 or 5.2 seconds of low-gravity. The possibility exists that investigators could take advantage of an existing test rig for the 5.2 second drop tower. To learn about its capabilities contact: Daniel Dietrich (Daniel.l.dietrich@nasa.gov; 216-433-8759)

5) **NASA Contact**

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b Organization: NASA Headquarters Space Life and Physical Sciences, Physical Sciences Program
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6) **Commercial entity:**

a. Company Name: na
b. Contact Name: na
c. Work Phone: na
d. Cell Phone: na
e. Email: na

7) **Partner contribution**
No NASA Partner contributions

8) **Intellectual property management:**
No NASA Partner intellectual property concerns

9) **Additional Information:**
All publications that result from an awarded EPSCOR study shall acknowledge NASA Space Life and Physical Sciences Research and Applications Division.

Appendix D: NASA Space Life and Physical Sciences and Research Applications (continued)

1) **Program:** Physical Sciences Program

2) **Research Title:** Quantum Effects

3) **Research Overview:**

Space offers a unique environment for experimental physics in many areas. Current areas of focus for NASA's Fundamental Physics program are cold atom physics, the application of cold atom technologies to research in quantum science and general relativity, and the physics of dusty plasmas.

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 computers, quantum communication networks, and sensor technologies. 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 physics 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, and the creation of exotic quantum matter than cannot exist on Earth.

4) **Research Focus:**

Proposals are sought for ground-based theory and experimental research that may help to develop concepts for future flight experiments. Research in distance effects in quantum superposition and entanglement are of particular interest.

5) **NASA Contact**
   a. Name: Bradley Carpenter, Ph.D.
   b. Organization: NASA Headquarters Space Life and Physical Sciences Research and Applications (SLPSRA)
   c. Work Phone: (202) 358-0826
   d. Email: bcarpenter@nasa.gov

6) **Commercial Entity:**
   a. Company Name: na
   b. Contact Name: na
   c. Work Phone: na
   d. Cell Phone: na

7) **Partner contribution**

   No NASA Partner contributions

8) **Intellectual property management:**

   No NASA Partner intellectual property concerns

9) **Additional Information:**

   All publications that result from an awarded EPSCOR study shall acknowledge NASA Space Life and Physical Sciences Research and Applications (SLPSRA).

Appendix D: NASA Space Life and Physical Sciences and Research Applications (continued)

1) **Program:** Fluid Physics

2) **Research Title:** Flow Boiling in Reduced Gravity

3) **Research Overview:**

Study of two-phase flow instabilities began in the late 1920s, and in the nearly 100 years since, progress has been made in both experimental and theoretical understanding of them. Despite these advances, many key deficiencies remain, solution of which will provide appreciable value for system designers looking to leverage phase change heat transfer technologies in a safe and repeatable manner. There are several types of instabilities that are prevalent in flow boiling applications, but few modeling tools are available to predict operating conditions leading to their occurrence, or methods for mitigating their negative effects on flow boiling. These issues are especially concerning for flow boiling systems employed in space, given the added complexity of reduced gravity environment.

4) **Research Focus:**

The most prevalent and important forms of two-phase instability are (1) ***Density Wave Oscillations*** (DWOs) and (2) ***Parallel Channel Instability*** (PCI), both are *dynamic instability* types. The former is manifest by a liquid surge along a flow boiling channel, and precipitates fluctuations in both flow rate and wall temperature. The latter is encountered in cold plates containing parallel flow channels, where differences in interfacial behavior and void fraction between channels also causes fluctuations in both flow rate and wall temperature. A third important instability topic is ***Two-phase Choking***, which is a *static instability* limit. This phenomenon is the outcome of appreciable changes in specific volumes and enthalpies of liquid and vapor, and is known to both greatly increase pressure drop and/or impose upper limits on flow rate through the boiling channel. This focused flow boiling research emphasis requests ground-based, laboratory proposals for hypothesis-driven experiments and/or analysis to investigate and help determine: 1) Density wave oscillations 2) Parallel Channel Instability and 3) Two phase chocking instability.

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7) Partner contribution

No NASA Partner contributions

8) Intellectual property management:

No NASA Partner intellectual property concerns

9) Additional Information:

All publications that result from an awarded EPSCOR study shall acknowledge NASA Space Life and Physical Sciences Research and Applications Division.

Appendix D: NASA Space Life and Physical Sciences and Research Applications (continued)

1) **Program:** Physical Sciences

2) **Research Title:** Physical Sciences Informatics System

3) **Research Overview:**

This call for proposals is for ground-based research proposals to utilize NASA's Physical Sciences Informatics (PSI) system (https://psi.nasa.gov/) to develop new analyses and scientific insights. The PSI system is designed to be a resource for researchers to data mine information generated from completed reduced-gravity physical sciences experiments performed on the International Space Station (ISS), Space Shuttle flights, Free Flyers, commercial cargo flights to and from the ISS, or from related ground-based studies. Specifically, this call is for the utilization of data from investigations that are currently available in the PSI system.

4) **Research Focus**

The call solicits ground-based research proposals that present a compelling case of how the experimental data from the PSI system (https://psi.nasa.gov/) will be used to promote the advancement of further research. Proposers must show a clear path from the scientific data obtained from the PSI system to the proposed investigation. In addition, the project must address an important problem in the proposed area of research and advance scientific knowledge or technology. The scope of the proposed work is unrestricted except that the use of data in the PSI database must comprise a substantial portion of the research.

This call solicits proposals in the following five research areas: 1) Combustion Science, 2) Complex Fluids, 3) Fluid Physics, 4) Fundamental Physics, and 5) Materials Science. The call specifically solicits proposals that utilize data from investigations listed in the table below. Of the eligible 63 investigations, 47 are from the ISS, eight from the Space Shuttle (Space Transportation System; STS), one from a Free Flyer experiment, three from commercial cargo flights to and from the ISS (Commercial Resupply Services; CRS), and four selected through PSI NRA (denoted with "PSI NRA science" in the table). Proposals that do not utilize data from investigations listed in the table below may be declared without further review.

#	Research Area	Investigation	Carrier / Source
1	Combustion Science	BASS (Burning and Suppression of Solids)	ISS
2	Combustion Science	BASS-II (Burning and Suppression of Solids - II)	ISS
3	Combustion Science	CFI (Cool Flames Investigation)	ISS
4	Combustion Science	DAFT (Dust and Aerosol Measurement Feasibility Test)	ISS

5	Combustion Science	DAFT-2 (Dust and Aerosol Measurement Feasibility Test - 2)	ISS
6	Combustion Science	FLEX (Flame Extinguishment Experiment)	ISS
7	Combustion Science	FLEX-2 (Flame Extinguishment Experiment - 2)	ISS
8	Combustion Science	Quantitative Studies of Cool Flame Transitions at Radiation/Stretch Extinction Using Counterflow Flames (PSI NRA science)	PSI-A
9	Combustion Science	SAFFIRE I (Spacecraft Fire Experiment I)	Cygnus CRS OA-6
10	Combustion Science	SAFFIRE II (Spacecraft Fire Experiment II)	Cygnus CRS OA-5
11	Combustion Science	SAFFIRE III (Spacecraft Fire Experiment III)	Cygnus CRS OA-7
12	Combustion Science	SAME (Smoke Aerosol Measurement Experiment)	ISS
13	Combustion Science	SAME-R (Smoke Aerosol Measurement Experiment - Reflight)	ISS
14	Combustion Science	SLICE (Structure and Liftoff in Combustion Experiment)	ISS
15	Combustion Science	SPICE (Smoke Point in Coflow Experiment)	ISS
16	Complex Fluids	ACE-M1 (Advanced Colloids Experiment - Microscopy 1)	ISS
17	Complex Fluids	ACE-M2 (Advanced Colloids Experiment - Microscopy 2)	ISS
18	Complex Fluids	BCAT-3 (Binary Colloidal Alloy Test - 3)	ISS
19	Complex Fluids	BCAT-4 (Binary Colloidal Alloy Test - 4)	ISS
20	Complex Fluids	BCAT-5 (Binary Colloidal Alloy Test - 5)	ISS
21	Complex Fluids	BCAT-6 (Binary Colloidal Alloy Test - 6)	ISS
22	Complex Fluids	InSPACE (Investigating the Structure of Paramagnetic Aggregates from Colloidal Ellipsoids)	ISS

23	Complex Fluids	InSPACE-2 (Investigating the Structure of Paramagnetic Aggregates from Colloidal Ellipsoids - 2)	ISS
24	Complex Fluids	InSPACE-3 (Investigating the Structure of Paramagnetic Aggregates from Colloidal Ellipsoids - 3)	ISS
25	Complex Fluids	InSPACE-3+ (Investigating the Structure of Paramagnetic Aggregates from Colloidal Ellipsoids - 3+)	ISS
26	Complex Fluids	PCS (Physics of Colloids in Space)	ISS
27	Complex Fluids	PHaSE (Physics of Hard Spheres Experiment)	STS-94
28	Complex Fluids	SHERE (Shear History Extensional Rheology Experiment)	ISS
29	Complex Fluids	SHERE II (Shear History Extensional Rheology Experiment II)	ISS
30	Complex Fluids	SHERE-R (Shear History Extensional Rheology Experiment - Reflight)	ISS
31	Complex Fluids	Structure Evolution During Phase Separation in Colloids Under Microgravity, (PSI NRA science)	PSI-B
32	Fluid Physics	CCF-EU1-CV (Capillary Channel Flow - Experiment Unit 1 - Critical Velocities)	ISS
33	Fluid Physics	CCF-EU2-CV (Capillary Channel Flow - Experiment Unit 2 - Critical Velocities)	ISS
34	Fluid Physics	CCF-EU2-PS (Capillary Channel Flow - Experiment Unit 2 - Phase Separation	ISS
35	Fluid Physics	CFE (Capillary Flow Experiment)	ISS
36	Fluid Physics	CFE-2 (Capillary Flow Experiment – 2)	ISS
37	Fluid Physics	Computational Framework for Capillary Flows, (PSI NRA science)	PSI-A
38	Fluid Physics	CVB (Constrained Vapor Bubble)	ISS
39	Fluid Physics	CVB-2 (Constrained Vapor Bubble – 2)	ISS
40	Fluid Physics	Gravity Scaling of Pool Boiling Heat Transfer: Numerical Simulations and Validation with MABE and NPBX, (PSI NRA science)	PSI-B
41	Fluid Physics	MABE (Microheater Array Heater Boiling Experiment)	ISS
42	Fluid Physics	NPBX (Nucleate Pool Boiling Experiment)	ISS

43	Fluid Physics	PBE (Pool Boiling Experiment)	STS-47, STS-57, STS-60, STS-72, STS-77
44	Fluid Physics	PBRE (Packed Bed Reactor Experiment)	ISS
45	Fluid Physics	STDCE-1 (Surface Tension Driven Convection Experiment) - First United States Microgravity Payload on Columbia (USML-1)	STS-52
46	Fundamental Physics	DECLIC-ALI (Device for the Study of Critical Liquids and Crystallization - Alice Like Insert)	ISS
47	Fundamental Physics	GRADFLEX (Gradient Driven Fluctuation Experiment)	Free Flyer
48	Fundamental Physics	PKE-Nefedov & PK-3+ (Plasma Kristall Experiment; Dusty Plasma)	ISS
49	Materials Science	CSLM (Coarsening in Solid-Liquid Mixtures)	STS-83, STS-94
50	Materials Science	CSLM-2 (Coarsening in Solid-Liquid Mixtures - 2)	ISS
51	Materials Science	CSLM-2R (Coarsening in Solid-Liquid Mixtures - 2 Reflight)	ISS
52	Materials Science	CSLM-3 (Coarsening in Solid-Liquid Mixtures - 3)	ISS
53	Materials Science	CSLM-4 (Coarsening in Solid-Liquid Mixtures - 4)	ISS
54	Materials Science	DECLIC-DSI (Device for the Study of Critical Liquids and Crystallization - Directional Solidification Insert)	ISS
55	Materials Science	IDGE-STS-62 (Isothermal Dendritic Growth Experiment) - Second United States Microgravity Payload on Columbia (USMP-2)	STS-62
56	Materials Science	IDGE-STS-75 (Isothermal Dendritic Growth Experiment) - Third United States Microgravity Payload on Columbia (USMP-3)	STS-75
57	Materials Science	IDGE-STS-87 (Isothermal Dendritic Growth Experiment) - Fourth United States Microgravity Payload on Columbia (USMP-4)	STS-87
58	Materials Science	ISSI (In-Space Soldering Investigation)	ISS

59	Materials Science	MICAST/CSS (Microstructure Formation in Casting of Technical Alloys under Diffusive and Magnetically Controlled Convective Conditions/Comparison of Structure and Segregation in Alloys Directionally Solidified in Terrestrial and Microgravity Environments)	ISS
60	Materials Science	PFMI (Pore Formation and Mobility Investigation)	ISS
61	Materials Science	Strata-1	ISS
62	Materials Science	SUBSA (Solidification Using a Baffle in Sealed Ampoules)	ISS
63	Materials Science	TEMPUS (Tiegelfreies Elektromagnetisches Prozessieren Unter Schwerelosigkeit; Electromagnetic Containerless Processing in Microgravity)	STS-65, STS-83, STS-94

5) **Proposers must review the data in the PSI system before preparing their proposal. The proposal must clearly demonstrate how the PSI data will be used in the project.** Furthermore, prior to the submission of the proposal, it is highly recommended that the proposers take at least one representative sample set of PSI data to perform numerical modeling or sample experiments and present the findings as part of the proposal.

   Research results from proposals selected under this call for proposals will be entered into the PSI system for use by future investigators.

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8) **Partner contribution**
   No NASA Partner contributions

9) **Intellectual property management:**
   No NASA Partner intellectual property concerns

10) **Additional Information:**
   All publications that result from an awarded EPSCOR study shall acknowledge NASA Space Life and Physical Sciences Research and Applications Division.

Appendix D: NASA Space Life and Physical Sciences and Research Applications (continued)

1) **Research Title:**
Bioinformatic Analysis of Space Biology Data in the NASA GeneLab Data System

2) **Research Overview:**
With humans pushing to live further off Earth for longer periods of time, it is increasingly important to understand the changes that occur in biological systems during spaceflight --- whether these be astronauts, their microbial commensals, or their plant-based life support systems.
The NASA GeneLab data system contains decades of genomic, metabolomic, proteomic, transcriptomic, and microbiome profiling data from biological experiments performed in space or exposed to spaceflight-like conditions. Curation and aggregation of this data within GeneLab enables re-use and cross comparison of these rare opportunities for experimentation in space.
NASA is requesting proposals from investigators who wish to perform bioinformatic analyses of the data within GeneLab. These analyses could include single or multiple datasets. Investigators are encouraged to include data from other databases. Investigators are encouraged to utilize pre-processed data provided on GeneLab when possible, but are welcome to suggest improvements to this data to the GeneLab team.
All proposers are required to interact with various GeneLab Analysis Working Groups (AWGs) to receive input on their work and to strengthens these communities with new ideas (https://genelab.nasa.gov/awg/charter).
Proposals must translate the spaceflight derived data in the GeneLab database into new knowledge that addresses the objectives of NASA's Space Biology Program and its principal scientific elements (https://www.nasa.gov/sites/default/files/atoms/files/16-03-23_sb_plan.pdf).

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No NASA partner intellectual property concerns

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NASA welcomes communication with the GeneLab team, as necessary, to discuss approaches to the data analysis. All publications that result from the EPSCOR study shall acknowledge NASA Space Biology Program and GeneLab. Publications using GeneLab data: https://genelab.nasa.gov/publications

Appendix D: NASA Space Life and Physical Sciences and Research Applications (continued)

1) **Program:** Space Biology Program

2) **Research Title:** Biofilms and the Built Environment

3) **Research Overview:**
NASA needs to optimize the design of future human-occupied space craft for exploration to manage the microbial environment for sustained human utilization. Exploration missions include destinations to the moon and Mars as well as enabling a better understanding of continued long duration occupation of the International Space Station. Included in this design are. To identify and understand key factors required to optimize spacecraft and habitat design, an in-depth understanding of how the healthy and disease-causing microbes of this enclosed and sealed space will evolve and interact with the crew and plants over the mission duration is required. Areas for potential biofilm interactions include: life support subsystems, such as water recovery, spacecraft structural materials, and chambers for growing crops for crew food and nutrition. Additional microbiology research is needed to expand our understanding of spaceflight environmental factors that impact microbial growth, physiology, reproduction, evolution, community dynamics, and virulence.

Early studies with microorganisms showed that they reached higher population densities when grown under microgravity conditions than were obtained from cultures grown under similar conditions on the ground. The higher cell densities were likely due to a more homogeneous distribution of cells in the culture medium, as opposed to the crowded and more nutrient– depleted conditions that occurs at 1g as the cells settle (Klaus et al., 1997; PMID 9043122). Additional studies also showed that spaceflight caused some bacterial species to become more resistant to common antibiotics. (Klaus and Howard, 2006: PMID 16460819). Other studies demonstrated that spaceflight or simulated microgravity promoted biofilm formation (Kim et al., 2013; PIMD 23658630, Searles et al., 2011; PMID 21936634). These biofilms have been found to cause significant biofouling of water recovery system fluidic systems and serve as potential agents for biocorrosion of spacecraft materials.

4) **Research Focus**
The goal of this NASA Space Biology Program research emphasis is to build a better understanding of fungal and bacterial biofilm biology, its development, and interactions with spacecraft materials and hardware through hypothesis-driven experiments that will answer basic questions about how individual and mixed microbial biofilms respond to changes in gravity and other environmental factors (e.g., radiation) associated with spaceflight and methods for mitigating their development. Overall, the results of the proposed investigations should contribute to a broader, systems level understanding of biofilm biology in the spaceflight environment and its interaction with the built environment.

For this research emphasis, NASA requests proposals to determine the effect of simulated microgravity on microbial biofilm biology and community dynamics to advance findings and hypotheses derived from spaceflight investigations. Such studies are expected to generate and test specific ground-based hypotheses that will lead to hypotheses testable in spaceflight.

The proposed investigation is expected to simulate elements of the spaceflight conditions, such as microgravity, in ground-based analogs such as clinostats, High Aspect Rotating Vessels (HARVs), or other Low- Shear Model-Microgravity (LSMM) systems. Studies that investigate combine microgravity and radiation are encouraged, but the proposal must adhere to the funding and duration requirements of this EPSCoR CAN. Ground-based investigations should be proposed that will study one or more of the following topics:

a. Develop fundamental knowledge about how simulated microgravity influences biofilm biology. Space Biology studies will determine the effects of this environment on the dynamics of microbes in mono or mixed microbe biofilms with respect to cell processes (including biofilm development, biofilms structural and functional changes, and virulence and antibiotic resistance). The proposed investigation may study fungal- and/or bacterial-based biofilms.
b. Determine how biofilms interact with and affect built environment surfaces in simulated microgravity. The built environment is defined as spacecraft hardware and materials. Space Biology studies will determine the role different material types and surface features play in facilitating or inhibiting biofilm formation (including microbe-to-surface interactions and biocorrosion). The proposed investigation may study fungi, bacteria, or mixed microbe communities. It is encouraged that the studies use materials or hardware subsystems that are representative of those used on ISS and its hardware, such water recovery systems and material surfaces exposed to high humidity.
c. Develop fundamental knowledge to develop methods for mitigating biofilm formation on built surfaces and hardware systems, such as the ISS water recovery system and other fluidics systems. Methods for preventing biofilm formation may consider, but are not limited to, surface coatings, material surface topology, biocides, UV radiation, chemicals, mechanical disruption, bio-based antimicrobial treatments. It is anticipated that the studies will examine individual methods or combination of methods.

Proposers are expected to be familiar with the Decadal Survey Priorities (http://www.nap.edu/catalog/13048.html) and the NASA Space Biology Plan (https://www.nasa.gov/sites/default/files/atoms/files/16-05-11_sb_plan_2.pdf) to understand the specific space bioscience research topics that can be affected by non-space-associated variables.

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7) Partner contribution

No NASA Partner contributions

8) Intellectual property management:

No NASA Partner intellectual property concerns

9) Additional Information:

All publications that result from an awarded EPSCOR study shall acknowledge NASA Space Biology Program. 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 Data System.

Appendix D: NASA Space Life and Physical Sciences and Research Applications (continued)

1) **Program:** Space Biology Program

2) **Research Title:** Plant and Microbial Interactions

3) **Research Overview:**

Fundamental discoveries made by NASA researchers over the last 50 years has helped enable successful growth of plants in space, as is demonstrated through current work being done on the ISS using Veggie and the Advanced Plant Habitat. In spite of these forward advances, and the potential of this work to lead to the creation of space life-support systems, additional fundamental plant biology research is still needed. There still much to learn about how plants respond to the spaceflight environment, and what it will take to support long-duration, multiple generation plant growth and cultivation during extended space exploration missions.

One area of fundamental research that NASA wishes to focus on is the impact of the spaceflight environment on plant and microbial interactions. While the microbial contamination of plants grown in the closed environment of a spacecraft is always a potential concern, the interactions of these plants with beneficial microbes, such as those between leguminous plant and nitrogen fixing bacteria, may also be altered in spaceflight-environment (Foster et. al., 2014: PMID: 25370197). The goal of this NASA Space Biology Program research emphasis is to build a better understanding of the effects of spaceflight on microbial and plant ecosystems found spacecraft such as the ISS, which in turn will help us prepare for future exploration missions to the moon and Mars.

4) **Research Focus**

This Space Biology Research Emphasis requests proposals for hypothesis-driven experiments that will help determine: 1) the effects of the spaceflight-like environment on plant-microbial interactions; 2) the long-term, multigenerational effects of the spaceflight-like environment on plant-microbial population dynamics; and 3) how to optimize plant-microbial systems for growing and sustaining plants in space. Fundamental plant-microbial biology research is needed to specifically identity the driving space environmental factors or combination of factors that impact plant-microbial interactions. Applicants should consider at least one of the following questions in the preparation of their proposal:

- How do space-environmental conditions influence the development and diversity of microbial communities associated with plants? How do microbial population from plant surfaces or plant growth media change over time in a spaceflight-like environment?
- Which plant-microbial interactions effect important processes (e.g., commensalisms, symbioses, nitrogen fixation, biodegradation) and how do the processes change in response to the multiple stimuli encountered in space environments?
- What environmental conditions are needed for optimal plant-microbial interactions in spacecraft (e.g., temperature, humidity, light wavelengths, light intensity, concentration and ratio of gases)? What is the optimal microbial composition for plant growth media needed to sustain plants in space environments?
- Can beneficial microbes in plant growth media be grown successfully through multiple life cycles in a space environment?

Proposers are encouraged to incorporate the use of microgravity analogs that simulate the effects of spaceflight (or partial gravity) on their plant/microbial system in their experimental design, or to use centrifuges to conduct hyper-gravity studies that characterize how their proposed system(s) responds to a downshift in gravity levels from 2g to 1g (as a surrogate for a 1g to 0g downshift). Investigators may also propose studies that characterize the long terms effects of isolation similar to those experience in a closed built environment such as a spacecraft on plant/microbial ecosystems.

Proposers are expected to be familiar with the Decadal Survey Priorities (http://www.nap.edu/catalog/13048.html) and the NASA Space Biology Plan (https://www.nasa.gov/sites/default/files/atoms/files/16-05-11_sb_plan_2.pdf) to understand the specific space bioscience research topics that can be affected by non-space-associated variables.

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7) Partner contribution

No NASA Partner contributions

8) Intellectual property management:

No NASA Partner intellectual property concerns

9) Additional Information:

All publications that result from an awarded EPSCOR study shall acknowledge NASA Space Biology Program. 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 Data System.

Appendix D: NASA Space Life and Physical Sciences and Research Applications (continued)

1) **Program:** Physical Sciences Program

2) **Research Title:** Extraction of Materials from Regolith

3) **Research Overview:**

With NASA's renewed efforts to put astronauts on the moon and to develop a persistent human presence on the moon, the ability to utilize in-situ resources is paramount to the success of these future missions. Extraction of materials (e.g. metals, glasses and water ice) from extra-terrestrial regolith is necessary for NASA to be successful in the long term. The extracted materials could be used as feedstock for additive manufacturing processes, to construct habitats and/or other structures, to build infrastructure, for example, roads, walls, and landing pads, or to fabricate tools or other hardware. The water ice from regolith material could be used to augment life support systems for extended stay missions or produce liquid hydrogen and liquid oxygen for propellant production.

4) **Research Focus**

The goal of this NASA Physical Sciences Program research emphasis is to develop and increase understanding of extraction techniques to generate useful materials (e.g. metals, glasses, water ice) from Lunar or Martian regolith.

Proposed studies are expected to generate and test specific hypotheses to the extent possible in a terrestrial lab or reduced gravity aircraft. Investigations should be proposed that would study one or more of the following topics:

a. Refinement of existing techniques to extract materials from regolith.
b. Development of new techniques for extraction of materials from regolith.
c. Studies of the extracted material to determine its properties or to investigate novel ways of utilizing it to support NASA's exploration goals.

It is expected that regolith simulant will be used for the proposed experiments. Proposals are encouraged to use existing hardware.

More information on NASA's exploration goals can be found in the Decadal Survey (http://www.nap.edu/catalog/13048.html), specifically Translation to Space Exploration Systems (TSES) number 16 (TSES16).

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7) **Partner contribution**
No NASA Partner contributions

8) **Intellectual property management:**
No NASA Partner intellectual property concerns

9) **Additional Information:**
All publications that result from an awarded EPSCOR study shall acknowledge NASA Space Life and Physical S

Appendix D: NASA Space Life and Physical Sciences and Research Applications (continued)

1) Program: Space Biology Program

2) Research Title: In-Situ Food Safety Monitoring

3) Research Overview: (General overview – no more than a couple of paragraphs)
NASA has identified in situ crop production as a technology gap that needs to be filled to enable deep space exploration. Current solutions to this technological gap utilize growing "pick and eat" crops during missions in plant growth chambers that are exposed to the cabin environment and crew interaction. Produce grown in situ is consumed without cooking or other processing techniques, leaving the produce susceptible to contamination during growth or post-harvest handling. Produce grown on ISS is currently cleaned post-harvest with produce sanitizing wipes to minimize crew exposure to potentially harmful pathogens. This procedure of cleaning produce post-harvest on-orbit is time consuming for the crew and requires the use of consumable sanitizing wipes that may be burdensome to stow on long-duration exploration missions.

There are currently no in situ techniques or procedures in place to detect or identify potential pathogens and opportunistic pathogens in crop production systems on spacecraft. This is especially concerning in the microgravity environment, where numerous changes in microbial behavior in response to microgravity are documented, such as findings of higher microbial population densities when grown under microgravity conditions (Klaus et al., 1997; PMID 9043122) and increased virulence in space-grown cultures of the pathogen *Salmonella* enterica serovar Typhimurium (Wilson et al., 2007; PMID 17901201).

There are numerous microbial monitoring programs on ISS that utilize molecular techniques to identify microbial populations on ISS (e.g. Venkateswaran et al., 2014: PMID 25130881). In their current form, none of these techniques are employed as a diagnostic tool for in-situ food safety monitoring of freshly grown produce. Molecular techniques could be employed as a diagnostic tool to detect specific human pathogens on produce prior to crew consumption. Current research at NASA and USDA into hyperspectral and multispectral imaging is advancing the capability to detect plant stress in real-time, which could be useful for identifying potential food safety concerns as plants are cultivated. Additionally, these advanced imaging systems are able to detect microbial growth, though it is still to be determined at what level of sensitivity microbes can be detected (i.e. colony size). It is likely a multi-faceted in-situ food safety monitoring approach may ultimately be deployed in space crop production systems on spacecraft. One where advanced plant health imaging systems are able to detect biofilm growth or changes in plant health that are most conducive to pathogen and opportunistic pathogen establishment, which is then followed up with targeted molecular techniques capable of detecting pathogens to the genus or species levels.

4) Research Focus:
The goal of this NASA Space Biology Program research emphasis is to build a better understanding of non-destructive in situ techniques that can be deployed to advance food safety specific microbial monitoring on spacecraft such as ISS to prepare for future exploration missions far from Earth.

The proposed investigation is expected to simulate elements of spaceflight crop production, to include use of light emitting diode (LED) lighting systems, controlled environmental conditions, and analogous water and nutrient delivery systems. Studies that use simulated microgravity are welcomed but may not be feasible with larger crops and must adhere to the funding and duration requirements of this EPSCoR CAN. Ground-based studies should be proposed that will:

a. Grow a range of "pick and eat" crops similar to those proposed to support future deep space exploration missions, including leafy greens, tomatoes, and peppers, and demonstrate the effectiveness of the proposed In-Situ Food Safety Monitoring technology to detect and measure the amount of microbes associated with these crops. An effective system will provide a visual cue for measurements that exceed a specific user defined quantity, which may be user adjustable based on health requirements.
b. Determine the false positive and false negative rate of the technology for different crop types and measure what other factors, such as gravity environment, humidity levels, ambient lighting, etc, may have on the false detection rates.
c. Determine microbial detection capabilities of food safety monitoring technique. Beyond knowing total microbial levels, differentiating individual strains of pathogens and beneficial microbes can enable targeted reduction of pathogens to ensure Food Safety while minimizing the negative impact of any sanitation techniques on the healthy microbiome of the grow system or potentially beneficial probiotic effect of the produce for the crew.

Proposers are expected to be familiar with the Decadal Survey Priorities (http://www.nap.edu/catalog/13048.html) and the NASA Space Biology Plan (https://www.nasa.gov/sites/default/files/atoms/files/16-05-11_sb_plan_2.pdf) to understand the specific space bioscience research topics that can be affected by non-space-associated variables.

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7) Partner contribution

No NASA Partner contributions

8) Intellectual property management:

No NASA Partner intellectual property concerns

9) Additional Information:

All publications that result from an awarded EPSCOR study shall acknowledge NASA Space Biology Program. 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 Data System.

Appendix E: KSC Partnerships Office

Research Title: Conversion of CO_2 into Fuel

Research Overview: The original research at NASA aimed to investigate and demonstrate the conversion of CO_2 in the presence of H_2O vapor to fuel (i.e. CH_4) using novel photocatalysts in a photocatalytic reactor under Mars and Earth simulated solar spectrums. Results demonstrated production of hydrocarbon fuel, which was likely CH_4, as observed by GC and FTIR data. If peak performance parameters can be isolated and then honed in on, better understanding of the kinetics and mechanisms can aide in making the reaction more efficient for future scale up purposes.

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Related Publications: *Photocatalytic Conversion of CO_2 on Mars*, September 21, 2016.
Carbon Dioxide Methanation for Human Exploration of Mars: A Look at Catalyst Longevity and Activity Using Supported Ruthenium, April 18, 2018, Great Plains Catalysis Society Symposium, Manhattan KS.

Additional Information: The photocatalyst materials tested in the photoreactor were initially generated from the Science Innovation Fund Project "An In-Depth Study of Photocatalytic Charge Transport and Material Development through Synthesis, Characterization, and Photocatalytic Properties for In Situ Resource Utilization and Fuel Production on Mars". Further developments at Kennedy Space Center (KSC) continued during this project where photocatalyst materials were synthesized at KSC and the University of South Florida (USF) for photoreactor testing at KSC. The photocatalyst materials underwent structural/morphology analysis and optical characterization and were believed to have bandgap values in the regime for photocatalytic H_2O splitting and CO_2 conversion. The hydrogen evolution reaction produces available hydrogen that may react with CO_2 in a series of reduction and oxidation (redox) reactions for the production of fuels such as CH_4, which is a necessity for liquid O_2 and liquid CH_4 propulsion systems of deep space, as well as fuels used on earth. The data in this work looked at MoS_2, $(ZnO)_{1-x}(GaN)_x$, $(ZnO)_{1-x}(AlN)_x$ materials in the photoreactor under Earth and Mars conditions.

Appendix E: KSC Partnerships Office (continued)

Research Title: Evaluation of Low Pressure Air Plasma for Passivation of Metal Components

Research Overview: Currently there is no International Space Station capability for disinfecting pick and eat crops, food utensils and production areas, or medical devices. This deficit is extended to projected long duration missions. Small, portable, Cold Plasma (CP) devices would provide an enhanced benefit to crew health and address issues concerning microbial cross contamination. New technology could contribute to the reduction of solid waste since currently crews utilize benzalkonium chloride wet wipes for cleaning surfaces and might use organic acid based wipes for cleaning vegetables.

Previoulsy an innovation was designed to allow for passivation of aerospace components using a low-pressure air plasma system. The system operates as it is designed to (functional operation of low-pressure plasma system) but instead of the normal feed gases (hydrogen, oxygen, or argon) a k-bottle of breathing air is utilized. The compressed air is fed into the plasma system and ionized, allowing for cleaning of all available surfaces within the chamber. Plasma cleaning is a dry, non-thermal process which can provide broad-spectrum antimicrobial activity. It is microgravity compatible since cold plasma uses no liquids and is able to penetrate event eh smallest cracks and crevices. This innovation eliminates hazardous solvents and hazardous waste stream while reducing a multi-step process into single-step process. CP is a technology that could be used in medical facilities in remote areas and third world countries.

Since the cleaning process developed at KSC uses air as the plasma gas, this technology could be used in remote areas for sterilization without any consumables. In Food Science, CP has the potential to be used to disinfect vegetables and reduce considerably the number of foodborne illnesses per year in the world (deaths, medical costs, industry costs) and represents an alternative to the common disinfection method with bleach.

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Related Publications: *Evaluation of Low-Pressure Cold Plasma for Disinfection of ISS Grown Produce and Metallic Instrumentation*, July 16, 2017, 47th International Conference on Environmental Systems, Charleston, SC.

Additional Information: Aerospace components undergo a passivation process to ensure contaminants are removed from the surface of the metals/alloys and to form an inert, protective oxide layer to enhance the corrosion resistance of the material. Current methods require the use of hazardous chemicals, involve multiple steps, and produce hazardous waste streams that must be disposed of. Currently, passivation of corrosion-resistant steels for aerospace applications follows an SAE International Standard, AMS2700, where parts are submerged in either a nitric acid or nitric acid/sodium dichromate bath at predetermined temperatures and contact times. These baths require constant testing to ensure effective treatment, use corrosive and carcinogenic chemicals, and produce hazardous waste.

Appendix F: GSFC Computational and Information Sciences and Technology Office (CISTO)

Program: Computational and Information Sciences and Technology Office (CISTO)

Research Title: Computational and Technological Advances for Scientific Discovery

Research Overview:
SMD requests that EPSCoR include research opportunities in areas of a) Artificial Intelligence and Machine Learning (AI/ML), b) High Performance Computing, c) Augmented Reality/Virtual Reality/Mixed Reality (AR/VR/MR), and d) Citizen Science to enable and accelerate scientific discovery and technological innovations for NASA's scientific missions. NASA's scientific lines of business include Earth Sciences, Planetary Sciences, Astrophysics, and Heliophysics.

a) Artificial Intelligence and Machine Learning (AI/ML)
Advent of new technologies such as Clouds and GPUs for storing and processing massive data sets has significantly increased adoption of AI in the past decade even though many of the AI technologies originated in 1950s. Similarly, in recent years AR/VR consumer-friendly software and hardware tools have become available at affordable prices. Internet tools and technologies have also enabled ordinary citizens to participate in the scientific process via various Citizen Science applications and games. At the same time, NASA scientists are faced with large volumes of data from various missions on a daily basis. This makes it essential to take advantage of the latest technological and computational advances, as outlined in this call, for their analysis and scientific discovery.

Recent advances in AI infrastructure and tools calls for development of AI algorithms for various, yet unexplored, scientific data *classification, search, prediction, feature selection, and modeling* problems in different NASA scientific areas. Some past work includes classification of supernova to better measure cosmic distances and understand expansion of universe, classification of Planets to better predict probability of life, finding craters on moon, search for gravitational waves, and search for exoplanets. Similar techniques can be applied for finding different phenomena (e.g. feature detection for identifying safe landing sites, finding faint moving objects, etc.), environmental feature recognition (forest patches, water bodies, agriculture fields, etc.), or to other fields such as Earth Science and Heliophysics data. Another topic of interest is to apply AI/ML techniques to NASA data in time domain, or time-series analysis (e.g. when studying solar winds or various Earth observations).

While these techniques are often applied on the ground, there are compelling reasons for benefitting from AI capabilities onboard the spacecraft in deep space. Drivers for onboard AI capabilities include data transmission and downlink limitations, the desire to have near real time results (e.g. for spacecraft safety, planetary defense, etc.), or the nature of mission itself (e.g. in interferometry missions an image cube is constructed from data of multiple satellites via complex image registration and reconstruction algorithms).

b) High Performance Computing; Evolving Applications to Exascale
High Performance Computing (HPC) applications across NASA have seen a significant increase in computational capability over the past decade using cluster systems with traditional CPU-only based capabilities. The architectures being deployed across the US and abroad to reach the next milestone of computing, Exascale, have a significantly different architecture based on accelerated computing using Graphical Processing Units (GPUs). NASA applications, such as atmospheric models, will require Exascale computational capabilities over the next decade. Research investigations addressing the porting and scaling of HPC applications on accelerated based HPC are encouraged. Furthermore, the use of

Domain Specific Languages (DSLs), such as Kokkos or GridTools, to create portable and optimized applications for different architectures is of high interest.

In addition to scaling applications using accelerator based computing platforms, NASA is interested in replacing model components and augmenting models with artificial intelligence. In General Circulation Models of the atmosphere, components are written based on physical models and algorithms are then written to compute those physics or chemistry based models. In some cases, the computational requirements for these physical based algorithms take too many resources for current HPC platforms. Replacing these model components with trained algorithms has the potential to dramatically reduce the computational requirements for these models while not reducing accuracy beyond acceptable limits. Research investigations addressing the replacement of model components with trained models for use in HPC applications is of high interest as well.

c) Augmented Reality/Virtual Reality/Mixed Reality (AR/VR/MR)

AR/VR applications allow scientists to experience being in environments that are hard, impossible, or too costly in person. For example, existing NASA AR/VR applications enable immersive exploration of places deep in the ocean, to distant planetary surfaces and galaxies or to experiment with various robotic or spacecraft assembly and integration processes in AR/VR before taking high risks on the actual expensive hardware.

d) Citizen Science

Various NASA projects have used Internet tools and technologies not only as a public outreach and education tool but as a means to engage ordinary citizens in their projects and most importantly to contribute to their scientific discoveries. Examples of such NASA citizen science projects are GLOBE Observer (https://observer.globe.gov), Planet Hunters (www.planethunters.org), Backyard Worlds: Planet 9 (www.backyardworlds.org), Moon Zoo (www.moonzoo.org) and Galaxy Zoo (www.galaxyzoo.org).

Research investigations addressing more than one of the above-mentioned areas (hybrid solutions) are encouraged. Examples include: onboard HPC AI/ML data processing and volume reduction algorithms; Citizen Science applications for generating labeled training data as input to AI/ML software, or to validate AI/ML output results.

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Intellectual property management:

Additional Information:
NASA GSFC CISTO will provide NCCS support as needed.

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