Appendix D

IMPORTANT Notice: *Submit proposals by February 22, 2019*. The second selections will be made from proposals submitted on that date. A new solicitation will be released for FY 2020 within the following 6 months if the pilot is approved by the jurisdictions as worthy of continuing. In addition to the new task added below, the SMD Planetary Science Division invites proposers to submit their own ideas on the Extreme Environment mission. We encourage you to call to discuss these with the below listed POCs beforehand to make sure it fits the Venus Explorer requirements.

I. SMD Planetary Science NV has already submitted proposals

1. We continue to seek proposals for Planetary Science tasks listed in Appendix A. Proposals submitted to Planetary Science for the first cycle will be considered for this cycle.
2. PI's who submitted proposals for Planetary Science tasks listed in Appendix A do not need to replace their proposals or provide up-to-date costing and/or alter their methodology.
3. The following new task is being added.

New Planetary Science Task
NV is soliciting letters of interest for the following new task.

EPSCoR Extreme Environment Aerobot solicitation details.

- 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.

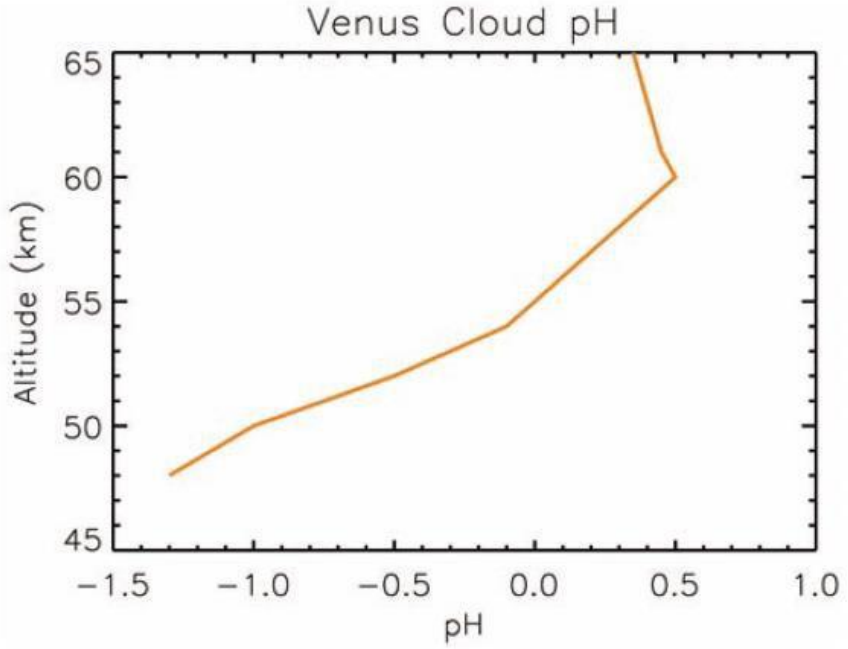

Plate 2. The pH of Venus' clouds as a function of altitude. The relatively water-rich aerosols in the upper cloud have a small range of positive pH, from 0.3 to 0.5. In the lower cloud, with its larger and more water-poor particles, pH can be as low as -1.3. Aerosol H_2SO_4 concentrations were calculated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

II. Commercial Programs NV has already submitted proposals

1. We no longer seek proposals for tasks CSCO-2017-01, -02, -03, -04, -05, and -06 listed in Appendix B. Proposals submitted to CSCO-2017-01, -02, -03, -04, -05, and -06 for the first cycle will be considered for this cycle.
2. PI's who submitted proposals for CSCO-2017-01, -02, -03, -04, -05, and -06 do not need to replace their proposals or provide up-to-date costing and/or alter their methodology.
3. The below tasks are new and we seek proposals against these tasks.

New Commercial Crew Tasks

NV is soliciting letters of interest for the following new tasks.

Commercial Space Research Request
NASA/HEOMD/CSDD
Date: November 27, 2018
Research Request Number: CSCO-2019-01

1) **Program:** Commercial Space Capabilities Office (CSCO)
2) **Research Title:** Additive Component Internal Feature Surface Roughness Reduction
3) **Research Overview:**

NASA is evaluating additive manufacturing technology for fabrication of components in a variety of propulsion and power conversion applications. One of the materials being evaluated using the selective laser melting (SLM) additive process is GRCop42 (Cu-Cr-Nb) for heat exchanger applications, including combustion chambers and nozzles. Nickle and cobalt based alloys are also being explored for higher temperature heat exchangers. The additive processes provides the ability to fabricate small and complex internal features in a single component, but the inability to post-process those internal features is currently limiting. This is because such internal features in the SLM as-built condition can adversely impact performance compared to traditionally manufactured components in certain operating environments. NASA has not identified specific tasks in this area but is seeking proposals that consider the following:

A. NASA has identified that this work will be ITAR/Export Controlled so Proposals will need to meet the appropriate U.S. export control laws and regulations. NASA will provide additional information about this Research Request to appropriately approved Proposers.
B. Development of techniques for reducing the roughness of internal features of additive manufactured metallic components. Such techniques may include; chemical polishing, electrical polishing, abrasive media polishing (such as extrude hone), a combination of or alternate techniques may also be proposed. These features typically have internal dimensions of 0.25" or less, and wall thickness that cannot tolerate large differential pressures (e.g. 100's of psi). The proposed overall technique must consider any final cleaning steps so that no residues are left in the internal features that would be detrimental to the component's subsequent use with typical rocket propellants (Oxygen, Hydrogen, Methane, Rocket Propellant-1).
C. The intent of this task is to establish feasibility of one of these techniques or a comparison of several to determine a suitable path forward.
D. NASA will provide samples with representative internal channel geometry to EPSCOR awardee. Proposal shall identify the samples necessary to perform the work.

The proposed work shall include performing the following at minimum:

1. Determine an appropriate method and complete development to reduce as-built SLM surface finish to less than or equal to 63 micro-inches.
    a. Method shall consider minimal material removal
    b. Process shall be developed to protect areas where removal is not desired (ie. such as channel inlets and outlets with sharp turns)
    c. Straight forward methods should be emphasized to enable easier access to technology
2. Complete characterization of surface that may include optical microscopy, profilometry, cross sections, and other analytical methods.
3. Mechanical testing* may be considered to understand effect on fatigue properties using new method.

4. Flow testing or lab testing* may be considered to help establish benchmark with new method during or following development.
5. Provide recommendations during process development, interim and final reports.

Proposals should provide a novel approach beyond the minimum requirements being requested above.

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

5) Commercial entity:

Not applicable at this time

6) Partner contribution

No NASA Partner contributions. Proposer to indicate any contributions in its proposal.

7) Intellectual property management:

No NASA Partner intellectual property considerations. Proposer to indicate any intellectual property considerations in its proposal.

8) Additional Information:

* Test to ASTM or identify alternate established standard in Proposal

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.

NASA CSCO will coordinate support from within NASA as needed.

NASA anticipates that the results of this work may be ITAR/Export Controlled, so Proposal response shall indicate Proposer's controls.

NASA will make the resulting data available in its MAPTIS database https://maptis.nasa.gov/ . NASA welcomes opportunities to co-publish results proposed by EPSCoR awardee.

Commercial Space Research Request
NASA/HEOMD/CSDD
Date: November 27, 2018
Research Request Number: CSCO-2019-02

1) Program: Commercial Space Capabilities Office (CSCO)

2) Research Title: Investigate Potential Mars or Lunar Resources

3) Research Overview:

NASA is requesting research proposals in this area to further autonomy from Earth resources for space exploration and commercialization efforts, by enabling extending surface stays and/or supporting off-Earth/Moon/Mars economies and/or efficiencies. NASA has not identified specific tasks in this area but is seeking proposals that consider the following:

A. Investigate potential for resources that are of interest to: produce propellants, support human life support and environmental controls, create structures, provide energy, or are of other economic value. This includes accessible near surface, Lunar or Martian ice with high H2O concentration and economically appreciable quantity.
    a. NASA recognizes that given the level of funding this work would likely only be able to identify potentials and not establish ground truth measurement.
    b. The high level challenges that might be associated with eventually extracting/collecting/concentrating the resources for use, such as process energy consumption, and physical access.

B. Feasible methods by which existing/scheduled sensing capabilities and/or other available data/observations (historical, meteorites, recent craters, etc) that can be used to identify resources of interest.
    a. Identify the underlying scientific principles.
    b. Describe proposed data analysis approach and identify if/how it leverages existing software tools.
    c. Compare and contrast proposed work against prior and existing work that may be going on for relevancy and benefit. Identify knowledge gaps.
    d. Describe proposing Institution's relevant capabilities and prior work

C. Use of existing data and scheduled sensing capabilities (e.g. SHARAD, THEMIS, ESA- TGO). Consider NASA exploration plans (e.g. current and future planned rovers/orbiters) to see if those instruments can help inform the work and/or quantify the proposed work results.
    a. If data is needed from NASA to perform the work, identify what it is needed and the specific sensing system (e.g. from NASA or NASA International Partner systems). It is expected that Proposer would help NASA CSCO develop the appropriate sensor data requests.
    b. If NASA plans do not already include an appropriate sensor then briefly describe what sensor would be recommended. NOTE: outcome of this work may recommend future sensors, but this call is <u>not</u> for new sensor proposals.

D. Describe how proposer would incorporate results of work into appropriate database to enable mapping of estimated resources, and including information about resource availability/prevalence (depth from surface, quantity, purity, type of overburden, physical/chemical form, etc).

The proposed work shall include performing the following at minimum:

1. Implementing the proposed method by which existing/scheduled sensing capabilities and/or other available data/observations are used to identify and estimate quantities of the proposed resource of interest.

2. Producing a final report and delivery of developed data

4) NASA Contact

Name: Warren Ruemmele
Organization: Commercial Space Capabilities Office (CSCO)/UA3
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Email: warren.p.ruemmele@nasa.gov

5) Commercial entity:

Not applicable at this time

6) Partner contribution

No NASA Partner contributions. Proposer to indicate any contributions in its proposal.

7) Intellectual property management:

No NASA Partner intellectual property considerations. Proposer to indicate any intellectual property considerations in its proposal.

8) 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.

NASA CSCO will coordinate support from within NASA and with USGS Astrogeology Science Center if needed.

If there are any ITAR or Proprietary considerations identify these in proposal. NASA goal is for widest possible eventual dissemination of the results from this work.

Some related references:

https://astrogeology.usgs.gov/

https://www.lpi.usra.edu/leag/

https://mepag.jpl.nasa.gov/
https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20160005963.pdf

III. Space Biology

The following are rapid response research projects submitted by NASA Space Life and Physical Sciences and Research Applications for Space Biology

New Space Biology Tasks

NV is soliciting letters of interest for the following new tasks.

NASA Space Life and Physical Sciences and Research
Applications Space Biology Research Request 1

1) **Program:** Space Biology Program
2) **Research Title:** GeneLab Data Analysis and Bioinformatics Tool Development
3) **Research Overview:**

Bioinformatics has enabled NASA Space Biology to incorporate system biology into its approach to identify and characterize molecular pathways and mechanisms that underlie the higher order physiological changes caused by the space environment. In addition, the data and findings from these systems biology studies may be used for cross comparisons between diverse species and Earth-based studies to understand if the physiological changes seen in space are truly representative of human disease and aging on Earth. Therefore, Space Biology research that uses state-of-the-art molecular tools of the 21st century characterizes biological responses to spaceflight at the genomic, metabolomic, proteomic, and transcriptomic levels is of great interest to NASA. Because such omics experiments generate large data sets, NASA has created a special omics data archive, known as the GeneLab Data System (GLDS; genelab.nasa.gov) where such data are deposited to ensure that spaceflight biological data, as well as data from ground-based spaceflight simulations, can be compared across, as well as within, species. This data repository enables researchers to share and understand complex information across experiments to enhance the biological science derived from both spaceflight and ground-based experiments.

NASA is requesting proposals from investigators who wish to develop new experimental hypotheses based on the analysis of the data in the GLDS. Investigators may include data bases from other sources. 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) missions and contributes new data and information to GeneLab.

4) **NASA Contact**
   a. Name: David Tomko, Ph.D.
   b. Organization: NASA Headquarters Space Life and Physical Sciences Space Biology Program
   c. Work Phone: 202-358-2211
   d. Email: dtomko@nasa.gov

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:
NASA welcomes communication with the GeneLab team, as necessary, to discuss approaches to the data analysis. Please see genelab.nasa.gov for information about the GeneLab points of contact. All publications that result from the EPSCOR study shall acknowledge NASA Space Biology Program and GeneLab. Also, the keyword list shall include GeneLab.

NASA Space Life and Physical Sciences and Research Applications Space Biology Research Request 2

1) Program: Space Biology Program
2) Research Title: Microbiome of the Built Environment
3) Research Overview:

For the purposes of this Appendix, the term Microbiome of the Built Environment (MoBE) means the study of the formation and function of microbial communities in built environments, especially as it applies to 1) spacecraft hardware and materials and 2) crop plant nutrition and viability. NASA needs to optimize the design of future human-occupied space exploration vehicles to manage the habitat microbial environment over the multiple years it is needed for a mission carrying humans. Included in this design are chambers for growing crops for crew food and nutrition. To do so requires 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. For this reason, additional microbiology research is needed to expand our understanding of spaceflight environmental factors that impact microbial growth, physiology, reproduction, evolution, community dynamics, and virulence.

Some examples of findings pointing out the need for research in this area include but are not limited to the following. 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).

More recent experiments have shown that space-grown cultures of the pathogen *Salmonella* enterica serovar Typhimurium were significantly more virulent than comparable cultures

grown on the ground (Wilson et al., 2007: PMID 17901201). RNA microarray analyses revealed changes in the gene expression of over 160 gene transcripts, one of which was a cross-species conserved RNA-binding regulator protein, Hfq, which is involved in RNA transcription and has been found to play a role in microbial virulence of several pathogenic bacteria. Recent spaceflight experiments are generating a microbial census on the ISS using state-of-the-art molecular biological tools. Studies have provided a mechanistic understanding of changes that can occur in the space environment (Venkateswaran et al., 2014: PMID 24695826). Data are available at: https://genelab-data.ndc.nasa.gov/genelab/accession/GLDS-26/.

Research Focus

The goal of this NASA Space Biology Program research emphasis is to build a better understanding of the effects of spaceflight on microbial ecosystems of spacecraft such as the ISS to prepare for future exploration missions far from Earth. This Space Biology Research Emphasis, therefore, requests proposals for hypothesis-driven experiments that will answer basic questions about how microorganisms and microbial communities respond to changes in gravity and other environmental factors (e.g., radiation) associated with spaceflight. Overall, the results of proposed investigations should contribute to a broader, systems level understanding of physiological changes and potential interaction with the environment and other organisms due to spaceflight-associated factors.

For this research emphasis, NASA requests proposals to determine the effect of simulated microgravity on microbial life, processes, and community dynamics to advance findings and hypotheses derived from spaceflight investigations. Such studies are expected to generate and test specific 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 welcomed, but the proposal must adhere to the funding and duration requirements of this EPSCoR CAN. Ground-based studies should be proposed that will:

a. Conduct long-term, multigenerational studies of microbes to study and understand the population and community dynamics of the microbes that inhabit this unique gravity environment. The proposed investigation may include characterizing microbial re-adaptation to gravity after long term exposure to simulated microgravity.
b. Determine the influence of simulated microgravity on defined microbial populations and communities. Space Biology studies will determine the effects of this environment on dynamics of microbes in mono or mixed cultures with respect to cell processes (including virulence and antibiotic resistance, evolution, biofilm formation, and community development). The proposed investigation may include materials used for spacecraft-built environment and environmental systems

c. Develop fundamental knowledge of interactions among microbes and other organisms such as plants, animals and humans that effect important processes (e.g., commensalisms, symbioses, nitrogen fixation, biodegradation, and prevention of crew dysbiosis).

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.

4) **NASA Contact**
   a. Name: David Tomko, Ph.D.
   b. Organization: NASA Headquarters Space Life and Physical Sciences Space Biology Program
   c. Work Phone: 202-358-2211
   d. Email: dtomko@nasa.gov

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 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.

NASA Space Life and Physical Sciences and Research Applications
Space Biology Research Request 3

1) **Program:** Space Biology Program
2) **Research Title:** Operational and Hardware Variables Impact to Science
3) **Research Overview:**

Gravity (g; 9.8 m/s^2) is a fundamental force of nature on Earth. Since the first organisms developed on Earth, gravity has been the one constant force influencing biological development and function. When humans leave Earth on spaceflight missions, the amount of gravity reduces to approximately 10^{-6} x g (microgravity). In association with this reduction in gravity, many different changes to physiology are observed, such as net loss of bone and muscle mass, reduction in immune functions, vestibular malfunction, changes in microorganism behavior, and environment-associated stress. Also, plant physiologic functions associated with gravisensing appear to be affected by this environment. Therefore, it has been postulated that the loss of normal gravity is responsible for the observed physiological changes. This postulate is based on the fact that the loss of gravity results in changing how many gravity-dependent physical processes, including loading by force, convection, sedimentation, and hydrostatic pressure, act on an organism. The influence can be due to directly loss of gravity, changes in any one or more physical processes, or combined effects. Due to the potential for multiple natural variables acting on the biology, a major challenge to space biology scientists studying live in space is understanding and eliminating the non-space-associated factors that may influence the results of the study.

In conducting space biology investigations, it is critical to understand if the physiological target being studied is being exposed to non-spaceflight-associated factors, such as experiment design/hardware-induced variables. These variables can confound data interpretation and make cross-experiment comparisons impossible. By unknowingly adding these types of variables (e.g. hardware-induced vibration or elevated CO_2 levels), to a study, the data returned may be scientifically compromised and incorrectly interpreted. Using state of the art bioinformatics, scientists have identified biological changes that were related to increased CO_2 and specimen freezing method. Therefore, it is important that these variables are identified and characterized to facilitate science requirements definition, hardware and experiment design, and capture of appropriate meta data to mitigate risk to the science return.

Research Focus

The goal of this NASA Space Biology Program research emphasis is to identify and characterize non-space-associated variables that affect organism physiology. Ground-based studies should be proposed to:

d. Conduct bioinformatics analysis using the GeneLab Data System (genelab.nasa.gov) to identify biological changes that are induced by non-space-associated influences, such as mechanical loading, hypoxia, and shear fluid flow, etc.
e. Conduct studies to identify and characterize cage effects to rodents, such as enrichment, CO_2 build up, and features of caging that could induce full or partial mechanical unloading.
f. Conduct studies to identify and characterize non-microgravity effects of ground-based microgravity analogs such as clinostats, High Aspect Rotating Vessels (HARVs), or other Low- Shear Model-Microgravity (LSMM) systems.
g. Conduct studies using ISS experiment hardware or simulated hardware to characterize the

environment within these hardware and effects to biology, similar to (b). Proposed studies that require ISS experiment hardware must adhere to the requirements of this ESPCoR CAN. In addition, a letter of support from the hardware developer confirming use of the hardware must accompany the proposal.

Spaceflight and associated ground control specimens are available from the Ames Research Center Life Sciences Data Archive (lsda.jsc.nasa.gov), which may be used for the studies.

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.

4) NASA Contact

e. Name: David Tomko, Ph.D.
f. Organization: NASA Headquarters Space Life and Physical Sciences Space Biology Program
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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 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.