NASA SBIR 2020 Phase I Solicitation

H3.02 Microbial Monitoring for Spacecraft Cabins

Lead Center: JPL

Participating Center(s): GRC, JSC, KSC, MSFC

Technology Area: TA6 Human Health, Life Support and Habitation Systems

Scope Title

Spacecraft Microbial Monitoring for Long Duration Human Missions

Scope Description

With the advent of molecular methods, emphasis is now being placed on nucleic acids to rapidly detect microorganisms. However, the sensitivity of current gene-based microbial detection systems is low (~100 gene copies per reaction), requires elaborate sample processing steps, involves destructive analyses, and requires fluids to be transferred and detection systems are relatively large size. Recent advancements in the metabolomics field have potential to substitute (or augment) current gene-based microbial detection technologies that are multi-stepped, destructive and labor intensive (e.g. significant crew time). NASA is soliciting non-gene based microbial detection technologies and systems that target microbial metabolites and that quantify the microbial burden of surfaces, air and water inside future long-duration deep space habitats.

Potable Water:
A simple integrated, microbial sensor system that enables sample collection, processing and detection of microbes or microbial activity in the crew potable water supply is sought. A system that is fully-automated and can be in-line in an Environmental Control and Life Support Systems (ECLSS)-like water system is preferred.

Habitat Surfaces:
Future crewed habitats in cis-lunar space will be crew-tended and thus unoccupied for many months at a time. When crew reoccupies the habitat they will want to quickly, efficiently, and accurately assess the microbial status of the habitat surfaces. A microbial assessment / monitoring system or hand-held device that requires little to no consumables is sought.

Airborne Contamination:
Future human spacecraft, such as Gateway and Mars vehicles, may be required to be dormant while crew is absent from the vehicle, for periods that could last from 1 to 3 years. Before crews can return, these environments must be verified prior to crew return. These novel methods have the potential to enable remote autonomous microbial monitoring that does not require manual sample collection, preparation or processing.

References

A list of targeted contaminants for environmental monitoring can be found at "Spacecraft Water Exposure

Guidelines for Selected Waterborne Contaminants" located at: https://www.nasa.gov/feature/exposure-guidelines-smacs-swegs

Advanced Exploration Systems Program, Life Support Systems Project: https://www.nasa.gov/content/life-support-systems

NASA Environmental Control and Life Support Technology Development and Maturation for Exploration: 2018 to 2019 Overview", 49th International Conference on Environmental Systems, ICES-2019-297

https://ttu-ir.tdl.org/bitstream/handle/2346/84496/ICES-2019-297.pdf

National Aeronautics and Space Administration, NASA Technology Roadmaps, TA 6: Human Health, Life Support, and Habitation Systems (National Aeronautics and Space Administration, Draft, May 2015, https://www.nasa.gov/sites/default/files/atoms/files/2015_nasa_technology_roadmaps_ta_6_human_health_life_support_habitation.pdf

NASA Standard 3001 - Requirements: https://www.nasa.gov/hhp/standards

Expected TRL or TRL range at completion of the project for Phase I: 3

Expected TRL or TRL range at completion of the project for Phase II: 4 to 5

Desired Deliverables of Phase II

Prototype, Analysis, Hardware, Research

Desired Deliverables Description

Phase I Deliverables - Reports demonstrating proof of concept, test data from proof of concept studies, concepts and designs for Phase II. Phase I tasks should answer critical questions focused on reducing development risk prior to entering Phase II.

Phase II Deliverables - Delivery of technologically mature hardware, including components and subsystems that demonstrate performance over the range of expected spacecraft conditions. Hardware should be evaluated through parametric testing prior to shipment. Reports should include design drawings, safety evaluation, test data and analysis. Prototypes must be full scale unless physical verification in 1-g is not possible. Robustness must be demonstrated with long term operation and with periods of intermittent dormancy. System should incorporate safety margins and design features to provide safe operation upon delivery to a NASA facility.

State of the Art and Critical Gaps

The State of the Art (SOA) on ISS for microbial monitoring is culturing and counting, as well as grab samples which are returned to earth. NASA has invested DNA-based (PCR) systems, partially robotic in some cases, to eliminate the need for on-orbit culturing. However, a fully automated system is still not ready and there is still a gap for a low- or no-crew time detection system.

Relevance / Science Traceability

The technologies requested could be proven on the ISS and would be useful to long duration human exploration missions away from earth, where sample return was not possible. The technologies are applicable to Gateway, Lunar surface, and Mars, including surface and transit. This subtopic is directed at needs identified by the Life Support Systems Capability Leadership Team (CLT) in areas of water recovery and environmental monitoring, functional areas of Environmental Control and Life Support Systems (ECLSS). The Life Support Systems (LSS) Project, under the Advanced Exploration Systems Program, Human Exploration and Operations Mission Directorate (HEOMD), is the expected customer. The LSS Project would be in position to sponsor Phase III and technology infusion. The ISS Program will have interest in successful awards for potential flight demonstrations.