NASA SBIR/STTR — Small Business Innovation Research / Small Business Technology Transfer

NASA SBIR 2019 Phase I Solicitation

H3.03 Microbial Monitoring and Control for Spacecraft Cabins

Lead Center: JPL

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

Technology Area: TA15 Aeronautics

This subtopic has two areas of scope. The primary area of emphasis is non-gene based microbial monitoring technologies. The secondary scope is alternative methods and agents for microbial control in potable water systems.

Spacecraft Microbial Monitoring for Long Duration Human Missions

With the advent of molecular methods, emphasis is now being placed on nucleic acids to rapidly detect microorganisms. However, automation for these systems is still in development and the time from sample collection to result output is not instantaneous. Recent advancements in the field of metabolomics have potential to substitute (or augment) current gene-based microbial detection technologies. NASA is soliciting non-gene based microbial detection technologies and systems that target microbial metabolites and which quantify the microbial burden of surfaces, air, and water inside future long-duration deep space habitats.

Airborne Contamination

Future human spacecraft such as Gateway and Mars vehicles may be uncrewed between missions. Crew could be absent from the vehicle for periods that could last up to 1 to 3 years. Before crews can return, these environments must be verified prior to crew return. Novel methods that have the potential to enable remote autonomous microbial monitoring are sought, which do not require manual sample collection, preparation or processing.

Potable Water

A simple integrated, microbial sensor system that enables sample collection, processing, and detection of microbes or microbial activity in a spacecraft potable water supply is sought. A system that is fully-automated and which could be integrated within a spacecraft's water processing system as an in-line detector is preferred. Such a system could be used to monitor microbial burden in the water supply during both uncrewed and crewed operations.

Habitat Surfaces

Future habitats for human habitation of cis-lunar space, such as Gateway, are expected to be crew tended only 1 to 3 months at a time and then left unoccupied for many months between missions. When the crew returns to occupy 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.

Alternative Sanitation Agents for Potable Water

For water recovery during human exploration missions, NASA ensures compliance with microbial requirements by initially disinfecting the process water and removing organic content that serves as nutrients for microbial growth. In addition, a biocide is added to the potable water as further mitigation against microbial growth. For the Shuttle and International Space Station programs, NASA used iodine as the biocide. However, iodine can create health issues for the crew and thus has to be removed from the potable water prior to crew consumption. This approach is undesirable for future missions and thus NASA is pursuing new sanitation agents and methods for spacecraft potable water.

The use of silver at biocidal concentrations of 0.05 – 0.4 mg/L is under consideration, but dosing and maintenance in potable water systems have not been satisfactorily worked out. Alternative biocides may be available. NASA seeks a biocide that provides effective microbial control at a given concentration, can be reasonably added to the process water, is acceptable for long term storage prior to use, can be consumed by the crew for long duration without undesirable side effects, and is compatible with typical materials used in potable water systems such as Teflon, Viton, 316 L SS, Inconel 718, and Titanium.

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. The expected TRL for these scopes is 2 to 4.

Phase II Deliverables

Delivery of technologically mature components/subsystems that demonstrate performance over the range of expected spacecraft conditions. Prototypes must be full scale. Robustness must be demonstrated with long term operation and with periods of intermittent dormancy. Systems and chemical agents should incorporate safety and design features to provide safe operation upon delivery to a NASA facility.

Hardware attributes should include robust design, low volume and compact size, low mass, reduced or zero requirements for crew time, and minimized consumable mass. For example, typical ISS Express Rack instruments have a volume of 64 L and a mass of 30 kg; a reasonable goal for this subtopic would be 10 L and 10 kg for an autonomous instrument; closer to 1 L for a hand-held device.

References:

- Pierson, D., Botkin, D. J., Bruce, R. J., Castro, V. A., Smith, M. J., Oubre, C. M., Ott, C. M., "Microbial Monitoring of the International Space Station," in Environmental Monitoring: A Comprehensive Handbook, edited by J. Moldenhauer, DHI Publishing: River Grove, IL., 2012, pp. 1-27.
- A list of targeted abiotic 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
- Li, Wenyan, Calle, Luz, Hanford, Anthony, Stambaugh, Imelda and Callahan, Michael "Investigation of Silver Biocide as a Disinfection Technology for Spacecraft – An Early Literature Review", 48th International Conference on Environmental Systems, Paper ICES-2018-82 https://ttu-ir.tdl.org/ttu-ir/bitstream/handle/2346/74083/ICES_2018_82.pdf