NASA SBIR 2020 Phase I Solicitation

Z5.04 Technologies for Intra-Vehicular Activity Robotics

Lead Center: ARC

Participating Center(s): JSC

Technology Area: TA4 Robotics, Telerobotics and Autonomous Systems

Scope Title

Improve the capability or performance of intravehicular activity robots

Scope Description

To support human exploration beyond Earth orbit, NASA is preparing to develop the "Gateway", which will be an orbiting facility near the Moon. This facility would serve as a starting point for missions to cis-lunar space and beyond. This facility could enable assembly and servicing of telescopes and deep-space exploration vehicles. This facility could also be used as a platform for astrophysics, Earth observation, heliophysics, and lunar science.

In contrast to the ISS (International Space Station), which is continuously manned, the Gateway is expected to only be intermittently occupied by humans – perhaps only 1 month per year. Consequently, there is a significant need for the Gateway to have autonomous capabilities for performing payload operations and spacecraft caretaking, particularly when astronauts are not present. Intra-Vehicular Activity (IVA) robots can potentially perform a wide variety of tasks including systems inspection, monitoring, diagnostics and repair, logistics and consumables stowage, exploration capability testing, aggregation of robotically returned destination surface samples, and science measurements and ops.

The objective of this subtopic, therefore, is to develop technologies that can improve the capability or performance of IVA robots to perform payload operations and spacecraft caretaking. Proposals are specifically sought to create technologies that can be integrated and tested with the NASA Astrobee or Robonaut 2 robots in the following areas: (1) Sensors and perception systems for interior environment monitoring, inspection, modeling and navigation; (2) Robotic tools for manipulating logistics and stowage or performing maintenance, housekeeping or emergency management operations (e.g. fire detection & suppression in multiple constrained locations or cleaning lunar dust out of HEPA (High-Efficiency Particulate Air) filters; and (3) Operational subsystems that enable extended robot operations (power systems, efficient propulsion, etc.), increase robot autonomy (planning, scheduling, and task execution), or improve human-robot teaming (software architecture, remote operations methods, etc.).

References

What is Astrobee? - https://www.nasa.gov/astrobee

What is a Robonaut? - https://www.nasa.gov/robonaut2

J. Crusan, et al. 2018. "Deep space gateway concept: Extending human presence into cislunar space", In Proceedings of IEEE Aerospace Conference, Big Sky, MT

M. Bualat, et al. 2018. "Astrobee: A new tool for ISS operations". In Proceedings of AIAA SpaceOps, Marseille, France.

T. Fong, et al. 2013. "Smart SPHERES: a telerobotic free-flyer for intravehicular activities in space". In Proceedings of AIAA Space 2013, San Diego, CA.

M. Diftler, et al. 2011. "Robonaut 2 - The first humanoid robot in space". In Proceedings of IEEE International Conference on Robotics and Automation, Shanghai, China.

M. Deans, et al. 2019. "Integrated System for Autonomous and Adaptive Caretaking (ISAAC)". Presentation, Gateway Intra-Vehicular Robotics Working Group Face to Face, Houston, TX; NASA Technical Reports Server [https://ntrs.nasa.gov/search.jsp?R=20190029054]

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

Desired Deliverables of Phase II

Prototype, Analysis, Hardware, Software, Research

Desired Deliverables Description

Prototype components or subsystems. Proposals must describe how the technology will make a significant improvement over the current state of the art, rather than just an incremental enhancement, for a specific IVA robot application.

State of the Art and Critical Gaps

The technology developed by this subtopic would both enable and enhance the Astrobee free-flying robot and Robonaut 2 humanoid robot, which are the SOA for IVA robots. SBIR technology would improve the capability and performance of these robots to routinely and robustly perform IVA tasks, particularly internal spacecraft payload operations and logistics. New technology created by 2020 SBIR awards can be tested with these robots in ground testbeds at ARC and JSC during the SBIR period of performance. On-orbit testing on ISS may be possible during Phase 2 and beyond (Phase 2-E, 2-X, 3, etc.).

The technology developed by this subtopic would also fill technical gaps identified by the proposed GCD (Game Changing Development) "Integrated System for Autonomous and Adaptive Caretaking" (ISAAC) project, which will mature autonomy technology to support the caretaking of human exploration spacecraft. In particular, the SBIR technology would help provide autonomy and robotic capabilities that are required for in-flight maintenance (both preventive and corrective) of Gateway during extended periods when crew are not present.

Relevance / Science Traceability

This subtopic is directly relevant to the following STMD (Space Technology Mission Directorate) investments:

- Astrobee free-flying robot – GCD
- Integrated System for Autonomous and Adaptive Caretaking (ISAAC) – GCD
- Deep Space Smart Habitats – Space Technology Research Institutes (STRI)

This subtopic is directly relevant to the following HEOMD (Human Exploration and Operations Mission Directorate) investments:

- SPHERES/Astrobee facility – ISS
- Robonaut 2 humanoid robot – ISS

- Gateway program – Advanced Exploration Systems (AES)
- Logistics Reduction project – AES

Autonomous Systems Operations project – AES