NASA SBIR 2021 Phase I Solicitation

Z5.04 Technologies for Intravehicular Activity Robotics

Lead Center: ARC

Participating Center(s): JSC

Scope Title:

Improve the Capability or Performance of Intravehicular Activity Robots

Scope Description:

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

In contrast to the International Space Station (ISS), which is continuously manned, Gateway is expected to be occupied by humans only intermittentlyâ€”perhaps only 1 month per year. Consequently, there is a significant need for Gateway to have autonomous capabilities for performing payload operations and spacecraft caretaking, particularly when astronauts are not present. Similar capabilities are needed for future lunar or planetary surface habitats. Intravehicular 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 operations.

The objective of this subtopic 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, Robonaut 2, or other NASA robots in the following areas:

- Sensors and perception systems for performing contact tasks; manipulation; and/or interior environment monitoring, inspection, modeling, and navigation.
- Robotic tools for manipulating logistics and stowage or performing maintenance, housekeeping, or emergency management operations (e.g., fire detection and suppression in multiple constrained locations or cleaning lunar dust out of air filters).
- Operational subsystems that enable extended robot operations (power systems, efficient propulsion, etc.); increase robot autonomy via computationally efficient

methods (planning, scheduling, and task execution); or improve human-robot interaction between IVA robots and human teams on the ground under communications constraints, including low bandwidth and extended loss-of-signal periods (software architecture, remote operations methods, etc.).

This subtopic also seeks to advance technologies that will enable the next generation of IVA robots to operate in lunar surface habitats, including:

- Novel robotic end effectors capable of reliably performing fine grasping tasks, such as plugging and unplugging MIL-STD-38999 electrical connectors and fluid quick-disconnect connectors.
- Compact, reliable, modular robotic actuators and controllers for IVA robots.
- Software that enables autonomous management of robot operational and hardware faults such that the robot can â€œfail operational.â€ For example, the software may use algorithms to determine how to automatically respond to a failure in a motion planner for move to a commanded location by taking into account a projected collision and replanning to the next closest point not in collision.

Expected TRL or TRL Range at completion of the Project:Â 4 to 5Â
Primary Technology Taxonomy:Â
Level 1: TX 04 Robotics SystemsÂ
Level 2: TX 04.X Other Robotic Systems**Â**
Desired Deliverables of Phase I and Phase II:

- Research
- Analysis
- Prototype
- Hardware
- Software

Desired Deliverables Description:

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.

Deliverables should focus on prototype components, subsystems, and the demonstration thereof. Specifically, Phase I awards shall deliver an interim and final report discussing these results. Phase II awards shall deliver demonstration reports along with supporting software, design information, and documentation.

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 state of the art 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 2021Â SBIR awards could potentially be tested with these, or other, robots in ground testbeds at Ames Research Center (ARC) and Johnson Space Center (JSC) in follow-on awards. Likewise, on-orbit testing on ISS may be possible during follow-on awards.

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The technology developed by this subtopic would also fill technical gaps identified by the proposed Game Changing Development (GCD) 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 freeflying robot, GCD
- Integrated System for Autonomous and Adaptive Caretaking (ISAAC), GCD
- Smart Deep SpaceÂ Habitats (SmartHabs), Space Technology Research Institutes (STRI)

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

- SPHERES (Synchronized Position Hold, Engage, Reorient, Experimental Satellite)/Astrobee facility, ISS
- Robonaut 2 humanoid robot, ISS
- Gateway program, Advanced Exploration Systems (AES)
- Logistics Reduction project, AES
- Autonomous Systems Operations project, AES

References:

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

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

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M. Bualat, et al. 2018. "Astrobee: A new tool for ISS operations." In Proceedings of AIAA SpaceOps, Marseille, France. [https://ntrs.nasa.gov/citations/20180006684]

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. [https://ntrs.nasa.gov/citations/20160006694]

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. [https://ntrs.nasa.gov/citations/20100040493]

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[https://ntrs.nasa.gov/search.jsp?R=20190029054]

N. Radford, et al. 2015. â€œValkyrie: NASA's First Bipedal Humanoid Robot.â€ In Journal of Field Robotics, vol. 32, no. 3, pp. 397-419, 2015.

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