NASA SBIR 2020 Phase I Solicitation

Z3.05 Satellite Servicing Technologies

Lead Center: GSFC

Participating Center(s): LaRC, MSFC

Technology Area: TA4 Robotics, Telerobotics and Autonomous Systems

Satellite servicing technology developments are needed to enable robotic science and human exploration missions that are sustainable, affordable, and resilient and may not be realizable based on current approaches to space systems design, launch, and operations. The focal areas for technology development are remote inspection, relocation, refueling, repair, replacement of equipment, and augmentation of existing on-orbit assets. The intended application for these technology developments are servicing, assembly, exploration, sample return, and mission extension.

This subtopic seeks two specific technologies that will enhance satellite servicing by: 1) providing improved sensing/perception during close proximity robotic manipulator operations; and 2) providing a mechanical swivel for use with liquid hypergolic oxidizer propellant.

Scope 1 Title: Development of low mass low power proximity sensor for satellite servicing

The first technology scope covers small robot proximity range sensor which can be mounted at the end of a robotic arm and provide mm-class range performance inside of a few cm, for measurement of range from the sensor to an arbitrary object. Restore-L autonomous capture utilizes only cameras for this operation, a sensing modality which cannot enable “capture before contact” or soft-capture of a legacy vehicle. A direct ranging sensor, operating at high frequency (>10Hz) would greatly enhance this operation, and enable many other autonomous robotic operations.

Phase 1 proposals are expected to identify options, or develop prototypes, and test potential sensor options in laboratory demonstrations at various distances from centimeters to contact, and with typical satellite external surface materials including multi-layer insulation blankets, launch vehicle interfaces (marman rings), and other materials found on or near space grapple or grasp fixtures. Phase I proof of concept and preliminary design efforts that will lead to, or can be integrated into, flight demonstration prototypes in a Phase 2 effort are of interest.

Scope 2 Title: Mechanical swivel for liquid hypergolic oxidizer propellant

The second technology scope concerns the selection or development of materials, and subsequent design and test of mechanisms capable of introducing a mechanical swivel in the fluid lines of a liquid hypergolic oxidizer propellant system. While Restore-L does not plan to transfer Oxidizer, other refueling missions will need to do so. One option for this transfer includes a flexible hose with no dynamic seals, and therefore limited dexterity and ability to accommodate a large variety of clients (for example, imagine an automobile gas station hose with no swivel – filling the tank with a more than one specific vehicle would be very challenging). Introduction of a dynamic seal and swivel would greatly expand the ability of such a system to accommodate multiple clients and fluid coupler locations. This flexibility is essential for the commercial refueling business case, which must amortize the cost of the refueler over many clients and configurations.

Phase 1 proposals are expected to develop a mechanical swivel joint that can be utilized for fluid transport with flow rates in the range of 2-20 kg / min and maximum expected operating pressure of 500 psia with a low quantity of dynamic cycles (<10) with exposure to liquid hypergolic oxidizer propellant (N2O4 MON-3), and also varying degrees of prior accelerated radiation exposure to softgoods to assist with determining possible on-orbit life cycle use estimates. Phase I proof of concept and preliminary design efforts that will lead to, or can be integrated into, flight demonstration prototypes in a Phase 2 effort are of interest.

References

Fourth Technology Transfer Industry Day; Plan to Facilitate Commercial On-Orbit Robotic Servicing, Assembly and Manufacturing (OSAM) - Federal Business Opportunities: Opportunities, National Aeronautics Space Administration, 30 July 2019, www.fbo.gov/index.php?s=opportunity&mode=form&id=1f59d52003a1a1538aba9975a854ec9e&tab=core&tabmode=list& .

Reed, Benjamin B. “On-Orbit Satellite Servicing Study Project Report.” *Satellite Servicing Projects* Division, NASA, Oct. 2010, On-Orbit Satellite Servicing Study Project Report.

Expected TRL or TRL range at completion of the project: 2-4

Desired Deliverables Description

Scope 1: Proximity sensor with mass < 0.25 kg, range 20 cm to 0.5 cm, precision better than 0.5 mm, power less than 3 W at 10 hz update rate.

Scope 2: A mechanical swivel joint that can be utilized for fluid transport with flow rates in the range of 2-20 kg / min and maximum expected operating pressure of 500 psia with a low quantity of dynamic cycles (<10) maintaining a leak rate better than 1x10^-5 sscs gHe with exposure to liquid hypergolic oxidizer propellant (N2O4 MON-3), and also varying degrees of prior accelerated radiation exposure to softgoods to assist with determining possible on-orbit life cycle use estimates. Laboratory demonstration would involve determining top material selection (metal and latest available Teflon or polymer), fabrication of small test unit, and post-exposure GHe precision leak testing utilizing as much of existing standardized testing infrastructure as possible (NASA STD 6001 Test 15, etc.).

State of the Art and Critical Gaps

Scope 1: Mass is critical at the end of robotic arms during autonomous capture. Having knowledge of the distance from the end of the arm to the adjacent free flying satellite would reduce the risk of a collision or missed capture.

Scope 2: Dynamic seals exist today for chemical fuel propellants (hydrazine, monomethyl hydrazine, etc.), however there is no known oxidizer seal that can meet the requirements listed above.

Relevance / Science Traceability

Restore-L, ISS, Gateway, Artemis, iSAT, commercial refueling.

Each of the technologies are considered key for satellite servicing. These technologies could be applicable to the Restore-L mission as well as other potential servicing missions, platform demonstrations, or smallsats. These technologies could also be applicable to refueling at Artemis.