NASA SBIR 2020 Phase I Solicitation

S4.02 Robotic Mobility, Manipulation and Sampling

Lead Center: JPL

Participating Center(s): ARC, GRC, GSFC, JSC

Technology Area: TA4 Robotics, Telerobotics and Autonomous Systems

Scope Title

Robotic Mobility, Manipulation and Sampling

Scope Description

Technologies for robotic mobility, manipulation, and sampling are needed to enable access to sites of interest and acquisition and handling of samples for in-situ analysis or return to Earth from planets and small planetary bodies. The Moon and planetary moons with liquid oceans are of particular interest, as well as Mars, comets, and asteroids.

Mobility technologies are needed to enable access to steep and rough terrain for planetary bodies where gravity dominates, such as Earth's moon and Mars. Wheeled, legged, and aerial solutions are of interest. Wheel concepts with good tractive performance in loose sand while being robust to harsh rocky terrain are of interest. Technologies to enable mobility on small bodies and access to liquid below the surface (e.g., in conduits or deep oceans) are desired, as well as the associated sampling technologies. Manipulation technologies are needed to deploy sampling tools to the surface, transfer samples to in-situ instruments and sample storage containers, and hermetically seal sample chambers. Sample acquisition tools are needed to acquire samples on planetary and small bodies through soft and hard materials, including ice. Minimization of mass and ability to work reliably in the harsh mission environment are important characteristics for the tools. Finally, design for planetary protection and contamination control is important for sample acquisition and handling systems.

Component technologies for low-mass and low-power systems tolerant to the in-situ environment, e.g. temperature, radiation, and dust, are of particular interest. Technical feasibility should be demonstrated during Phase I and a full capability unit of at least TRL 4 should be delivered in Phase II. Proposals should show an understanding of relevant science needs and engineering constraints and present a feasible plan to fully develop a technology and infuse it into a NASA program. Specific areas of interest include the following:

- Surface mobility and sampling systems for planets, small bodies, and moons
- Near subsurface sampling tools such as icy surface drills to 30 cm depth deployed from a manipulator
- Subsurface ocean access such as via a deep drill system
- Sample handling technologies that minimize cross contamination and preserve mechanical integrity of samples
- Pneumatic sample transfer systems and particle flow measurement sensors

- Low mass/power vision systems and processing capabilities that enable fast surface traverse
- Active lighting stereo systems for landers and rovers
- Electro-mechanical connectors enabling tool change-out in dirty environments
- Tethers and tether play-out and retrieval systems
- Miniaturized flight motor controllers
- Cryogenic operation actuators
- Robotic arms for low gravity environments

Proposers should also note a related subtopic exists that is focused solely on lunar robotic missions (see Z5.05, Lunar Rover Technologies for In-Situ Resource Utilization and Exploration), under the Space Technology Mission Directorate). With NASA's present emphasis on lunar exploration, Z5.05 is provided to help develop innovative lunar rover technologies to support in-situ resource utilization activities and for developing ideas, subsystem components, software tools, and prototypes that contribute to more capable and/or lower cost lunar robots. In particular, cryogenic or cryo-capable actuators that are specifically for lunar rover applications should be directed towards Z5.05.

References

Mars Exploration/Programs & Missions: https://mars.nasa.gov/programmissions/

Solar System Exploration: https://solarsystem.nasa.gov/

Ocean Worlds website: https://www.nasa.gov/specials/ocean-worlds/

Ocean Worlds article: https://science.nasa.gov/news-articles/ocean-worlds

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

Desired Deliverables of Phase II

Prototype, Analysis, Hardware, Software, Research

Desired Deliverables Description

Hardware and software for component robotic systems.

State of the Art and Critical Gaps

Scoops, powder drills, and rock core drills and their corresponding handling systems have been developed for sample acquisition on Mars and asteroids. Non-flight systems have been developed for sampling on comets, Venus, and Earth's moon. However, these have not been incorporated in a robotic mission, and the lack of a sufficient solution or technology readiness level is in some cases the reason a mission has not yet been possible. Exploration of icy ocean worlds is in the concept phase and associated sampling and sample handling systems do not exist.

Relevance / Science Traceability

The subtopic supports multiple programs within Science Mission Directorate (SMD). The Mars program has had infusion of technologies such as a force-torque sensor in the Mars 2020 mission. Recent awards would support the Ocean Worlds program: surface and deep drills for Europa. Products from this subtopic have been proposed for New Frontiers program missions. With renewed interest in return to Earth's moon, the mobility and sampling technologies could support future robotic missions to the moon.