



NASA SBIR 2021 Phase I Solicitation

S4.02 Robotic Mobility, Manipulation and Sampling

Lead Center: JPL

Participating Center(s): ARC, GRC, GSFC

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 as well as acquisition and handling of samples for in situ analysis or return to Earth from planets and other planetary bodies including the moon, Mars, Venus, Ceres, Europa, Titan, Enceladus, comets, and asteroids.

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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.

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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.

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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 and value should be demonstrated during Phase I via analysis or prototype demonstration, 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 include a discussion of challenges and appropriate testing) to fully develop a technology and infuse it into a NASA program. Specific areas of interest include the following (order does not reflect priority):

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- 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.
 - Force-torque sensors that can operate in cryogenic and high-radiation environments such as Europa.
 - Electromechanical connectors enabling tool change-out in dirty environments.
 - Tethers and tether play-out and retrieval system.
 - Miniaturized flight motor controllers.
 - Cryogenic operation actuators.
 - Robotic arms for low-gravity environments.

Expected TRL or TRL Range at completion of the Project: 2 to 4

Primary Technology Taxonomy:

Level 1: TX 04 Robotics Systems

Level 2: TX 04.3 Manipulation

Desired Deliverables of Phase I and Phase II:

- Research
- Analysis
- Prototype
- Hardware
- Software

Desired Deliverables Description:

Hardware, software, and designs for component robotic systems.

- Phase I:Â proof of concept toÂ include research and analysis along with design in a final report.
- Phase II:Â prototype for further testing.

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.Â Some of these environments still present risk and have gaps that need to be addressed (i.e. Venus).Â

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Ocean worlds exploration presents new environments and unique challenges not met by existing mobility and sampling systems.Â Â New mobility, manipulation, and sampling technologies are needed to enable new types of missions and missions to different and challenging environments.Â

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 with surface and deep drills for Europa, and future awards could include technologies to support missions to Enceladus, Titan, and other planetary bodies with subsurface oceans.Â Sample-return missions could be supported such as from Ceres, comets, and asteroids. 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.

References:

- Mars Exploration/Program & 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>