# NASA SBIR 2021 Phase I Solicitation

## S4.03 Spacecraft Technology for Sample Return Missions

**Lead Center: JPL**

**Participating Center(s): GRC, GSFC**

## Scope Title:

**Critical Technologies for Sample-Return Missions**

### Scope Description:

This Subtopic focuses on robotic sample-return (SR) missions that require landing on large bodies (e.g., Luna, Mars Sample Return (MSR)), as opposed to particulate-class SR missions (e.g., Genesis, Hayabusa) or touch-and-go (TAG) missions to relatively small asteroids or comets (e.g., OSIRIS-Rex, Hayabusa2). The mission destinations envisioned are dwarf planets (e.g., Vesta, Ceres) and planet or planet moons (e.g., Phobos, Europa). These are the most challenging missions in NASA's portfolioÂ but also the most scientifically promising, given the vast array of instruments available on Earth to study the retrieved samples. The challenges associated with these SR missions may be grouped into four categories: (1) Mass-efficient spacecraft architectures (e.g., efficient propulsion or materials that significantly reduce the mass of the launch payload required), (2) Sample handling (e.g., subsurface acquisition mechanisms), (3) Sample integrity (e.g., surviving reentry), and (4) Planetary protection/contamination control (PP/CC) (e.g., preventing leakage into the orbital sample (OS) canister). This Subtopic seeks potential solutions to areas (1), (3), and (4), considering it best that technologies associated with (2), sample handling, be directed to Subtopic S4.02. The intent is to have this Subtopic S4.03 manage only those technologies in areas (1),Â (3), and (4) that are specifically related to SR missions; technology solutions related to other classes of missions should instead be directed to Subtopics S4.04 (Extreme Environments) and S4.05 (Contamination ControlÂ and Planetary Protection).

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The heightened need for mass-efficient solutions in these SR missions stems from their extreme payload mass â€œgear ratio.â€Â For example, the entire MSRÂ campaign will require three heavy launch vehicle launches with rough spacecraft mass of 5,000 kg eachÂ in order to bring back multiple samples with an estimated total mass of 0.5 kg. Clearly, any mass savings in the ascent vehicleâ€™s gross liftoff mass (GLOM) or in the lander mass, for example, would yield many times more savings in the launch payload mass, enhancing the feasibility of these missions.

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Once acquired, samples must be structurally and thermally preserved through safe landing and transport to Johnson Space Center (JSC) for analyses. Sample integrity technology solutions that address the long, high-radiation return trip, as well as the dynamic and high-temperature environment of reentry, are sought. Potential solutions include near isotropic and crushable high-strength energy-absorbent materials that can withstand the ballistic impact landing. Materials that offer thermal isolation in addition to energy absorption are highly desirable given the reentry environment. In the case of cryogenically preserved samples, the technical challenge includes development of thermal control systems to ensure volatiles are conserved.

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Finally, acquired samples must be chemically and biologically preserved in their original condition. Examples of PP/CC technology solutions sought include:

- Materials selection: selection of metallic materials (non-organic) for the interior of the OSÂ capsuleÂ as well as materials that allow preferable surface treatments and bake-out sterilization approaches.
- Surface science topics: Adsorber coatings/materials for contaminant adsorption (getter-type materials, such as aluminum oxide, porous polymer resin) and/or low-surface-energy materials to minimize contaminant deposition.
- Characterization of contamination sources on lander, rover, capsule, ascent vehicle, and orbiter, for design of adequate mitigation measures.

**Expected TRL or TRL Range at completion of the Project:**Â 3 to 6Â
**Primary Technology Taxonomy:Â**
Level 1: TX 04 Robotics SystemsÂ
Level 2: TX 04.3 Manipulation**Â**
**Desired Deliverables of Phase I and Phase II:**

- Research
- Analysis
- Prototype

**Desired Deliverables Description:**

A Phase I deliverable would be a final report that describes the requisite research and detailed design accomplished under the project.Â

A Phase IIÂ deliverable would be successful demonstration of an appropriate-TRL performance test, such as at representative scale and environment, along with all the supporting analyses, design, and hardware specifications.

**State of the Art and Critical Gaps:**

The kind of SRÂ missions targeted in this solicitation are those that require landing on an extraterrestrial body. This most challenging kind of SRÂ mission has only been successfully done in the Soviet Luna program that returned 326 gÂ of Moon samples in three missionsâ€”out of eleven attemptsâ€”in the early 1970s. Hayabusa2 and OSIRIS-Rex are TAGÂ SR missions that are expected to return samples in December 2020 from asteroid RyuguÂ and in September 2023 from asteroid Bennu, respectively. The first segment of NASA's MSRÂ mission is the sample collection rover Perseverance, launch of which took place in July 2020. The MSR sample retrieval segment (lander, fetch rover, Mars Ascent Vehicle) is scheduled to begin Phase A development in October 2020 for a 2026 launch. The third MSR segment will be ESA's Earth return vehicle (ERV).

The content and breath of this Solicitation is informed by lessons learned in MSR over the Pre-Phase A years. Future SR missions are in need of technology improvements in each of the critical areas targeted: mass efficiency, sample acquisition, sample integrity, and planetary protection.

This solicitation seeks proposals that have the potential to increase the Technology Readiness Level from 3 or 4 to 6 within 5Â years, and within the cost constraints of the Phases I, II, and IIIÂ of this SBIR Program. Such progress would allow full flight qualification of the resulting hardware within 5 to 10 years.

**Relevance / Science Traceability:**

Medium- and large-class SR missions address fundamental science questions such as whether there is evidence of ancient life or prebiotic chemistry in the sampled body. Table S.1 ofÂ *Vision and Voyages for Planetary Science in the Decade 2013-2022 (2011)*Â correlates tenÂ "Priority Questions" drawn from three Crosscutting Science Themes, with "Missions in the Recommended Plan that Address Them". SR missions are shown to address eight out of the ten questions and cover every crosscutting theme, including Building New Worlds, Planetary Habitats, and Workings of Solar Systems.

**References:**

Vision and Voyages for Planetary Science in the Decade 2013-2022,Â http://nap.edu/13117

Visions into Voyages for Planetary Science in the Decade 2013-2022: A Midterm Review (2018),Â http://nap.edu/25186

Mars Sample Return (MSR),Â https://www.jpl.nasa.gov/missions/mars-sample-return-msr/

Comet NucleusÂ Sample Return (CNSR),Â https://ntrs.nasa.gov/search.jsp?R=20180002990

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