NASA SBIR 2005 Phase I Solicitation

S1.05  Sample Return Technologies

Lead Center: JPL
Participating Center(s): JSC

The NASA Mars Exploration Program has recently adopted a plan that includes a Mars Sample Return mission. Such a mission would require breaking the chain of contact with Mars: the exterior of the sample container must not be contaminated with unsterilized Mars material. One mission concept involves placing a grapefruit sized sample container in Mars orbit where it can be picked up by an orbiting spacecraft for return to Earth. Tenuous issues of contamination of the sample container exterior with Mars dust must be dealt with as well as contamination-free handling of the return sample in the receiving facility.

Receiving Facility Sample Handling Technologies

The items described briefly below would find eventual utilization in a sample receiving facility whose basic functions are to do physical and chemical characterizations, bio-hazard detection, and life detection, within a series of double-walled containment vessels. The facility would be operated with significant utilization of robotics, operated either in situ, or remotely, or both.

- Demonstrate fine-scale manipulations, either in situ or remotely, of a strawman 6-axis ultra-clean robot within the confines of a double-walled containment vessel. The robot can be current state-of-art. Demonstrate the use of different end effectors to manipulate small samples for observation. The task may require use and/or modification of current state-of-the-art control software.

- Demonstrate a sample container/carrier, possibly adapted from a container/carrier currently in use by semiconductor and/or pharmaceutical industries; that has the capability to be identified (labeled) and tracked, for use in cataloging, transporting, and tracking samples of various kinds; generally of approximately 100-micron size, and consisting of fines, dust, individual grains, and very small rocks, or gases; following the certification of these samples for release to a facility for long-term curation and distribution;

- Develop double-walled gloves for use within a double-walled containment vessel. Such gloves would perhaps require self-healing and/or warning systems, in case of a breach, and be compatible with ports developed for double-walled containment vessels; and

- Identify specific sterilization methods and techniques for use in sterilization of extraterrestrial samples.
Determine the sterilization levels achieved for sample coupons defined and/or provided by a NASA-sponsored science/biosafety working group.

Miniature Leak Detector

Proposals are sought for the development of a miniature, low-mass, low-power leak detection sensor that can be used to indicate a loss of pressure from a container with a volume of 0.5 liter, that has a pressure of 6 torr, as expected on Mars. Areas of interest include:

- A sensor, driver, and the power source designed for placement inside the container that is made of metal. The metal alloy that will be used will be determined at a later time;
- The sensor and its control electronics that provides power, data processing, and communications should not exceed the volume of 5-cm$^3$;
- The device should be operational at temperatures that are as low as -70°C and as high as room temperature; and
- A miniature battery as power source is acceptable. Preferably, a wireless power transfer mechanism and a rechargeable battery that is designed for placement inside the container, would be preferred.

Sample Containerization and Protection

Proposals are sought for the development of a robust method of sealing a sample that would be acquired from an extraterrestrial surface for possible return to Earth in future NASA missions. Areas of interest include:

- A simple and reliable process of hermetically seaming and sealing a "coffee-cup" size container with a rock or soil sample;
- The process needs to simultaneously perform sterilization of the container sealed area and its external surface while releasing the container into an area that simulates a clean section of a lander;
- This process should "break-the-chain" of contact of an acquired soil or rock sample from the original area that simulates the environment of an extraterrestrial planet;
- The required process needs to simultaneously seal the contained sample while destroying any potential biological materials that may contaminate the external surface of the container;
- The process to sterilize the surface of a grapefruit-sized sample container in Mars orbit (e.g., pyrotechnic paint) requiring minimal power and minimizing effect on the sample container interior;
- The contained sample should be protected from any mechanical, chemical, or thermal damage during or after the activation of the "break-the-chain" process;
- The process needs to be computer simulated and allow a high degree of control of its parameters; and
- Demonstrate probability of success of the feasibility to seal the container while performing sterilization.
Sample Acquisition

Proposals are sought for mechanisms to acquire clean core samples for Mars rocks and regolith including development of low-mass, low-normal-force, 10x1 cm coring tool, low-mass core sampling tool integrated with sample containment, acquire Mars dust samples, and development of six-axis force-torque sensor (ranges about 160 Newtons, 15 N-m) operating in Mars ambient.