

Sample Acquisition Systems for Sampling the Surface Down To 10 Meters Below the Surface for Mars Exploration. S. Rafeek, (Honeybee Robotics, Inc., 204 Elizabeth Street, NY, NY 10012, rafeek@hbrobotics.com), T. M. Myrick, (Honeybee Robotics, Inc., 204 Elizabeth Street, NY, NY 10012, myrick@hbrobotics.com), S.P. Gorevan, (Honeybee Robotics, Inc., 204 Elizabeth Street, NY, NY 10012, gorevan@hbrobotics.com), K.Y. Kong, (Honeybee Robotics, Inc., 204 Elizabeth Street, NY, NY 10012, kykong@hbrobotics.com), S. Singh, (Honeybee Robotics, Inc., 204 Elizabeth Street, NY, NY 10012, sase@hbrobotics.com), J. Ji, (Honeybee Robotics, Inc., 204 Elizabeth Street, NY, NY 10012, chunlei@hbrobotics.com), C. Batting, (Honeybee Robotics, Inc., 204 Elizabeth Street, NY, NY 10012, cbatting@hbrobotics.com)

Introduction: Mars missions may benefit from sample acquisition systems under development that are capable of acquiring samples from the surface, from a few centimeters below the surface, from 1 meter below the surface and from 10 meters or more below the surface.

The SATM: The Sample Acquisition and Transfer Mechanism (SATM)¹ is a highly developed sampling tool that features interfaces with in-situ science instruments and sample return containers.



Figure 1: The 1 Meter Deep Drilling SATM Prototype

A prototype SATM has been developed and successfully tested at Honeybee Robotics to demonstrate the performance requirements necessary to meet the ST/4 Champollion mission goals., many of which could be applicable to a Mars sampling mission. The SATM has been designed to:

- acquire surface samples, samples at 20 centimeters below the surface and samples at 1 meter (or more) below the surface, without cross contamination. To accommodate the different sample volume requirements by each instrument, the SATM is also designed with a sample chamber that can be infinitely adjusted from 0.1 cc to 1.0 cc. A newer version of SATM is being planned for development in FY01 in collaboration with the JPL Exploration Technology program, where the sample volume will be increased to a maximum of 50.0 cc. This new SATM will also be capable of taking a core sample.

- transport and transfer samples to a microscope/IR spectrometer, chemical analysis ovens, and a sample return container. For the microscope, the SATM features a sapphire window through which the samples in the chamber can be presented for analysis.

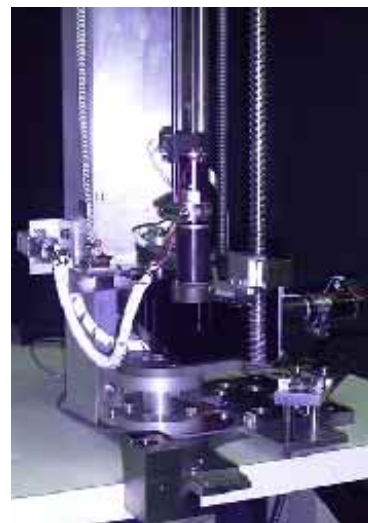


Figure 2: SATM Interface with OVEN

Deep Drilling Sampler: a Deep Drilling Sampler (DDS) for use on Mars has been initiated this year by Honeybee Robotics for the NASA PIDDP program. This system will be capable of acquiring and manipulating a stratigraphy maintained sample from 10 meters deep below the surface of Mars. The DDS technology will be a scalable, low mass (10-25 kg), small form factor (58cm x 37cm x 13 cm), deep drilling (5 m in the PIDDP implementation but easily scalable), core sampling robotic device. The DDS will be capable of supporting both in situ analyses of collected samples, as well as transferring of samples to sample return containers. The DDS samples can be taken from many depth levels and will always have its stratigraphy maintained.

Leveraging Mature Sample Acquisition Developments: The DDS is already quite developed as the basic drilling technology closely leverages the highly developed SATM.. Additionally the method of ac-

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quiring the sample, with its stratigraphy maintained is closely related to the method first advanced by the Athena Mini-Corer, which is nearly flight ready.¹

The DDS Sample Capture subsystem: The sample capture subsystem of the DDS is the mechanism capable of acquiring a stratigraphy maintained sample. During the development of the Mars Athena Mini-Corer, technology was developed that allowed core samples to be taken from rocks. The DDS will enhance this capability to enable the acquisition of short cores down to the 10-meter range. Furthermore the technology will be refined to allow a more complete sealing of the acquired sample so that unconsolidated samples may be acquired. Under the PIDDP effort, a breadboard will be developed to achieve these goals, by putting motors needed for actuation inside the lead drill string, and by enhancing the nested tube geometry to prevent loose grains from escaping the sample chamber. The motors inside this lead drill string provide a method of moving a center-drill/pushrod device used for drilling-sample ejection and for rotating the shear tube which shears the sampled core from the base rock and captures it inside the sample chamber. A key goal is to develop this technology into as small a form factor (small diameter drill string) as possible, while still maintaining high reliability and the strength needed to shear cores from strong rock.

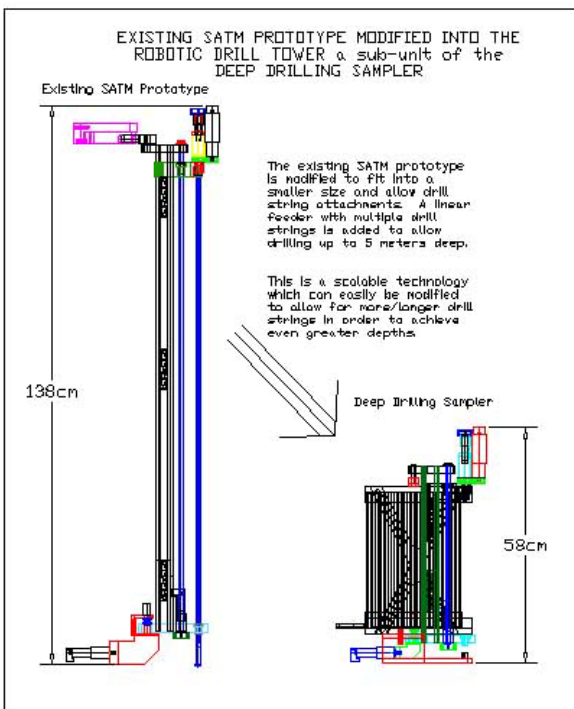


Figure 3: A copy of the existing Champollion/ST4 SAMT prototype will be modified into a Robotic Drill Tower capable of accepting drill string segments.

To Reach 10 Meters Below the Surface: Deep drilling will be achieved by using multiple drill strings (segments) which can be autonomously attached to one another during drilling, and then detached during extraction. Instead of a tall drill tower with a single long drill string attached, a much smaller device will be created which will be able to use many smaller drill string segments. This segmented approach allows deep drilling to take place from a small, low mass device. To enable this, a drill string feeder is being developed to present the individual drill strings to a robotic drill tower.

Miniature Samplers: Additional miniature sample acquisition systems have been developed by Honeybee Robotics under a NASA Phase I SBIR award.² They include:

- A miniature penetrator that is ballistically fired from a rover or lander. The miniature penetrator is tethered to a rover or a lander. Retraction of the penetrator activates a sampling mechanism that captures a sample at the furthest depth penetrated.
- A miniature inchworm sampling system that is deployed from a rover or a lander. This system employs an inchworm locomotion technique for subsurface travel.
- A telescoping sampling system is highly compact in the stowed condition but extends to the surface to acquire stratigraphy maintained cores.



Figure 4: Miniature Penetrator Sample Acquisition System

References: [1] S. Gorevan, S. Rafeek, The SAMT for Champollion, Advanced Developments in Space Robotics AIAA Tech. Forum, University of Wisconsin, August, 1996. S. Gorevan, T. Myrick, Shaheed Rafeek.

[2] Rover Mounted Sample Acquisition Systems, Proceedings of Interntl. Rover Conference, The Planetary Society, Santa Monica, CA, March 1997.