HONEYBEE ROBOTICS SAMPLE ACQUSITION, TRANSFER AND PROCESSING TECHNOLOGIES ENABLING SAMPLE RETURN MISSIONS.

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Introduction: In the last decade, Honeybee Robotics Spacecraft Mechanism Corporation has developed numerous sampling acquisition processing and sample transport devices. This abstract and conference presentation or a poster will detail each system with particular emphasis on design, performance, testing, results, and TRL level.

The Mini Corer: The Miniature Rock Coring and Rock Core Acquisition and Transfer System (Mini-Corer) was designed, built, and tested for the NASA's Mars Sample Return Athena Payload, scheduled for launch in 2003 [1]. It is a rover belly-mounted system and acquires rock cores for in-situ examination, and for caching for sample return Figure 1. The Mini-Corer weighs 2.7 kg (not including pitch-translate system) and its dimensions are 29.8 cm x 14.51 cm x 9.64 cm.

Figure 1. An engineering model of Mini-Corer was installed on JPL's field test rover, FIDO, to facilitate basic mission operations testing (see arrow). The Mini-Corer mass is 2.7 kg and the Mini-Corer box dimensions are 29.8 cm x 14.51 cm x 9.64 cm. This model currently resides at JPL.[2]

The Mini-Corer can obtain a 25 mm long and 8 mm in diameter core in strong basalt (compressive strength of 100 MPA) in less than six minutes while consuming fewer than 10 watt-hours of power. The Mini-Corer's carbide cutting teeth penetrate 30 cm in basalt at a penetration rate of more than 20 cm/hr (Figure 2).

The Mini-Corer can autonomously break off and retain the core. An internal pushrod is used to eject the core. This same pushrod is used to stabilize the target rock during the initial coring.

The Mini-Corer is also designed with a quick-change bit acquisition capability. Using the same quick-change subsystem, the Mini-Corer drill can be commanded to acquire a soil acquisition end effector for soil sampling.

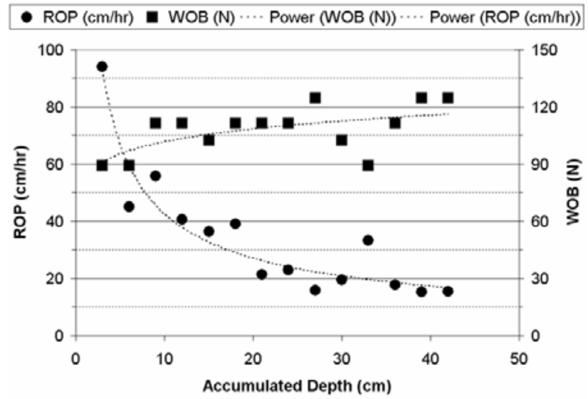

Figure 2. Rate of Penetration (ROP) and Wight on Bit (WOB) vs. Accumulated Depth for a single bit in 100 MPa Keweenaw Basalt. [2]

The Coring Abrading Tool (CAT): The integrated coring and abrading tool (CAT), is a hybrid of Honeybee's existing Rock Abrasion Tool (RAT) and Mini-Corer (MC) designs (Figure 3). The Rock Abrasion Tool is a TRL 9 instrument that is currently operating onboard of the Mars Exploration Rovers.

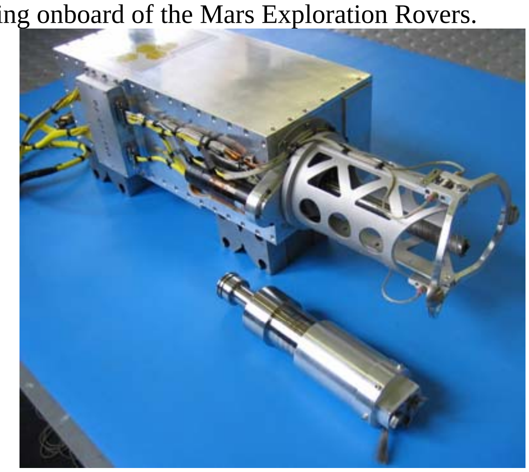

Figure 3. Corer Abrade Tool (CAT) can acquire rock cores and abrade rocks. It weighs less than 4 kg and is designed to be arm mounted.

The CAT is an arm-mounted, stand-alone device, requiring no additional arm actuation once positioned and preloaded. This instrument is capable of autonomously acquiring, retaining, and transferring cores 8 mm in diameter and up to 100 mm long of solid and unconsolidated material. In addition to coreing, this system is also capable of abrading and brushing rock surfaces and changing out bits and end-effectors autonomously. Shown in Figure 1, the CAT weighs less than 4 kg, and can penetrate 100 MPa basalt rock with only 120 Newton of preload (the actual Weight on Bit was less). The CAT was extensively tested in a vacuum chamber (under simulated Mars atmospheric conditions) and it is currently at TRL of 6.

The Sample Acquisition and Transfer Mechanism (SATM) drill: The SATM is a 1-meter class drill system that features sample handling abilities and sample return containers (Figure 4). A prototype was developed and successfully tested to validate the performance requirements for the NASA ST/4 Champollion mission goals. The SATM was designed to acquire samples at 20 cm and at one meter below the surface with little or no cross-contamination. Depending on the scientific sampling needs, the system can accommodate sample volumes ranging from 0.1-1.0 cc.

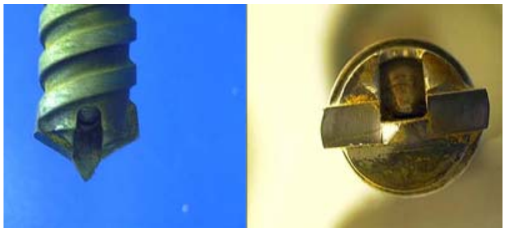

*Figure 4**: Detail of Sampling Tip (Door Closed) of the Sample Acquisition and Transfer Mechanism (SATM) drill.***

The Mechanized Sample Handler (MeSH): The MeSH is a miniature centralized sample preparation station that could be mounted on an MSL-class (large) rover.

Figure 5. The Mechanized Sample Handler (MeSH).

The MeSH capabilities include three main subsystems: a rock crusher, a sieving/shaking mechanism, and a portioning/distribution system. The MeSH is designed to receive a variety of sample types (loose regolith, pebbles and small rock cores) from a variety of sampling devices, crush a sample and distribute powdered samples to a variety of instruments.

MeSH's rock crusher uses compression and attrition to reduce rock cores from a solid core to a very fine powder. The sieving/shaking mechanism sorts fine powder samples into two size categories, both targeted to be below 150 microns. The portioning/distribution system takes the sieved sample and makes an aliquot (or small portion) of it. The aliquot is then passed off to one of several instrument inlet ports.

The Sample Manipulation System (SMS): The SMS as shown in Figure 6 was developed for the Sample Analysis at Mars (SAM) Instrument aboard the Mars Science Laboratory (MSL). The goal of the SMS is to precisely position a sample from the sample inlet device to pyrolysis ovens [3].

The main design driver for the SMS is precise, autonomous manipulation of 74 sample cups to multiple interfaces. The SMS positions each sample cup below any interface to within 0.71 millimeters of true position and delivers up to 1330 Newtons to create a hermetic seal between the sample cup and pyrolysis oven. The high sensitivity of the spectrometers require the SMS to be very clean and also capable of sealing the sample cups from the outside environment during Assembly, Test, Launch, Transit, and Surface Operations while it is not executing an experiment.

The SMS is a first generation flight system that was flight qualified and delivered to Goddard Space Flight Center (GSFC) in November 2007.

Figure 6. The Sample Manipulation System was developed for Mars Science Laboratory Sample Analysis at Mars instrument. It has 74 cups that transfer a sample to a pyrolysis oven and make a hermetic sea with the oven.

References: [1] Myrick T. et al. (2000) LPSC *XXXI*, Abstract #6105. [2] Zacny K. et al. (2008) Astrob. J. [3] Kennedy T. et al. (2006) Optimization of a Mars Sample Manipulation System Throught Concentrated Functionality, AIAA Space 2006.