DRILLING AND CACHING FOR THE MARS2020 MISSION. K. Zacny[1], P. Chu[2], G. Paulsen[1], K. Davis[3], [1]Honeybee Robotics, 398 W. Washington Ave, Suite 200, Pasadena, CA 91103, zacny@honeybeerobotics.com, [2]Honeybee Robotics, Houston, TX, [3]Honeybee Robotics, New York, NY.

Introduction: The goal of the Mars2020 mission is to acquire up to 28 rock/regolith samples and 3 blanks (with ability to replace 6 cores) or 34 rock/regolith samples and 3 blanks, and cache these for the future return mission. To address core acquisition and caching requirements for the Mars2020 and any other sample return or coring missions, Honeybee Robotics developed a range of surface coring drills [1]. These reached TRL 4-6 and range in mass from 1 to 5 kg. In addition, we investigated several caching architectures and developed one to TRL 4. A number of unique technologies, and sampling bits have been developed to help with in situ investigations as well as caching [2-4]. These include the SLOT caching bit, Powder and Regolith Acquisition Bit (PRABit), Rock Abrasion and Brushing Bit (RABBit), and PreView Bit, see Figure 1.

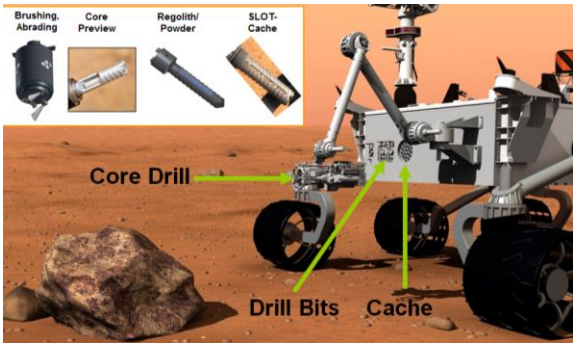


Figure 1. Mars2020 architecture with 4 bit types.

Unique Technologies: This section describes unique technologies developed for the surface core drills and sample return missions.

Core Breakoff and Capture System: This patented, eccentric tube design, offers a low profile method for shearing and positively capturing cores (no reliance on friction or gravity), as shown in Figure 2. It has been implemented in eight core drills and succesfully verified in dozens of rock types.

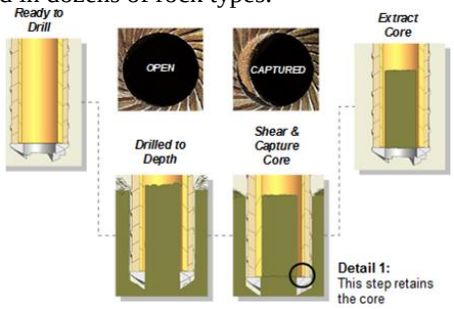


Figure 2. Eccentric tubes core breakoff and retention technology (patented).

SLOT Caching Bits with Visual Verification System: The SLOT bit (closeable slot along length of coring bit), enables visual inspection of the entire core before caching (Figure 3).

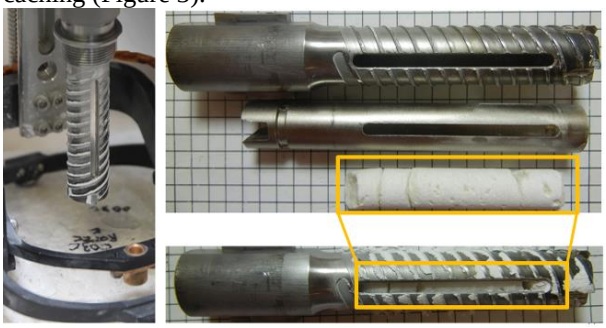


Figure 3. The SLOT Bit allows viewing of cores in situ and serves as a caching bit.

Powder and Regolith Acquisition Bit (PRABit): The powder and regolith acquisition bit allows capture of rock powder or regolith sample for earth return (Figure 4). For rock powder acquisition, the bit could be integrated with two sieves (e.g. 1 mm and 150 micron).

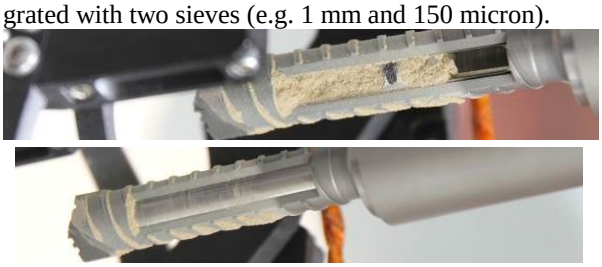


Figure 4. Powder and Regolith Acquisition Bit (PRABit).

PreView Bit: The PreView bit (Figure 5) has been designed specifically to help with in situ rock analysis by instruments such as Raman, IR, and LIBS. The PreView bit is very similar to the SLOT bit except the window is much larger allowing access to a wider viewable area of the core.

Figure 5. The PreView bit allows capture and in-situ analysis of rock cores.

Grinding and Brushing of Rocks: In general, there are two approaches for grinding of rock surfaces. In the first approach, a dedicated grinding tool such as the Rock Abrasion Tool can be used. In the second approach, a grinding tool that is actuated by the Mars2020 drill could also be a viable option (Figure 6). The RAT is at TRL 9 and RABBit is at TRL 5/6.

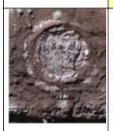
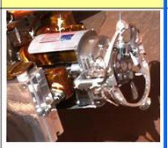
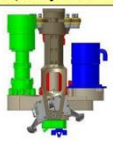
		M2020 Options	
	MER Rock Abrasion Tool	MSL-Surface Removal Tool (descoped at PDR)	Rock Abrasion and Brushing Bit (RABBit)
			 
On Turret?	Yes	**Yes**	**No**
Grind diameter	45 mm	38.4 mm	38.4 mm or 45 mm
Mass/Volume:	860 g / 85 mm x 128 mm	2.5 kg / 116 x 142 x 153 mm	380 g / 60 mm x 97 mm
Number of Actuators:	Rotate (Grinding) Revolve (Feed Rate) Z (WOB / Depth of Cut)	Rotate (Grinding) Revolve (Feed Rate) Z (WOB / Depth of Cut)	Uses M2020 drill

Figure 6. Rock Abrasion Tools options for the Mars2020 missions.

Caching Architectures: To address sample caching requirements, we investigated several unique architectures; however only deemed to be promising for the M2020 mission.

***One Bit One Core (OBOC*):** In the One Bit One Core architecture, a core is acquired using a low mass drill bit with integral break-off system. Following visual verification of sample enabled by the SLOT bit, the entire bit with core sample is placed directly into the cache (Figure 7). To collect and store 37 samples, the mission must be equipped with at least 37 bits (plus spares). The advantage is lower operational complexity (risk).

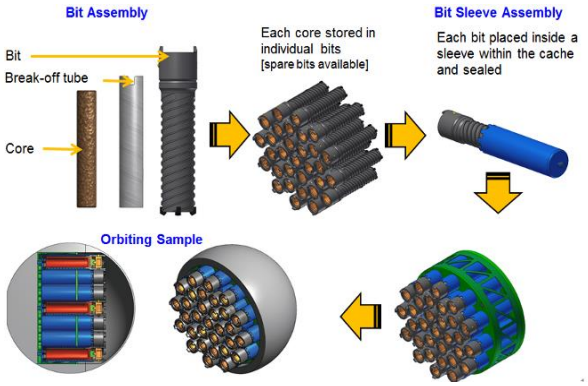


Figure 7. One Bit One Core (OBOC).

One Breakoff System One Core (OBSOC: In the One Breakoff System One Core (OBSOC) architecture, a core is acquired using a low mass drill bit with integral break-off system just like in the OBOC architecture. However, following visual verification of sample the bit's cutting teeth, flute sleeve and shank (i.e. an auger bit) are discarded and the core sample, positively captured within the break-off tube, is stored in a cache (Figure 8). Hence only the breakoff tube and sleeve are retuned with the core. To collect and store 37 samples, the mission must be equipped with at least 37 bit assemblies (removable break-off systems are pre-installed in bits). The main advantage is that only the minimum elements necessary to maintain positive control of core sample are retuned. This yields lowest returned mass and volume.

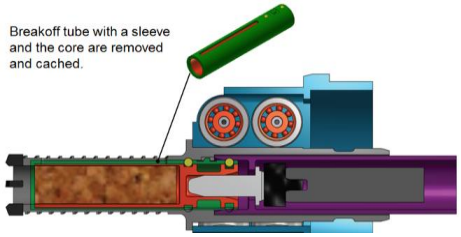


Figure 8. One Breakoff System One Core (OBSOC).

Trade Studies: Figure 9 compare OBOC and OBSOC architectures. The total returnable mass increases for both architectures by ~400 gram when the number of cacheable samples increases from 31 to 37.

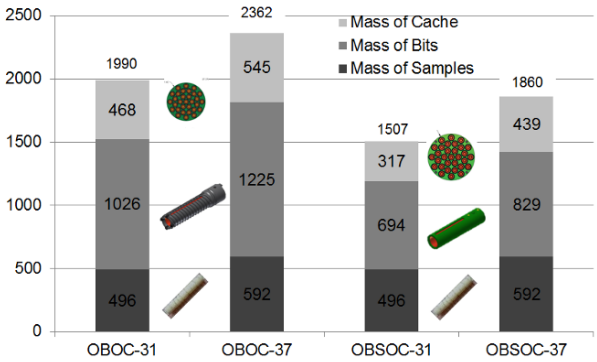


Figure 9. Mass of the two architectures.

Mars2020 prototype videos can be watched here:

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References: [1] Zacny (2011) Approach to the Sample Acquisition and Caching Architecture for the 2018 Mars Sample Return Mission, IEEE [2] Zacny (2011) Development of the Brushing, Abrading, Regolith, Core PreView and the Coring Bits for the Mars Sample Return Mission, AIAA Space. [3] Zacny , Sample Acquisition and Caching Architecture for the Mars Sample Return Mission, IEEE. [4] Core acquisition and caching: http://www.youtube.com/watch?v=VhfL3htrtZ8

https://www.youtube.com/watch?v=cf47bvULtEQ

https://www.youtube.com/watch?v=NphWPvi9cy4