SAMPLE ACQUISITION AND CACHING ARCHITECTURES FOR THE MARS2020 MISSION.

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Introduction: The goal of the Mars2020 mission is to acquire up to 37 samples (incl. 3 blanks), and cache them for future return mission. Honeybee Robotics has been continuously engaged in developing technologies applicable to the Mars sample return mission. In particular, we built nine coring drills, ranging in mass from 1 to 5 kg, 3 grinding tools and a range of sampling bits including the SLOT caching bit, the Powder and Regolith Acquisition Bit (PRABit), Rock Abrasion and Brushing Bit (RABBit), and PreView Bit [1, 2]. We also developed three unique caching architectures; however only two are promising for the M2020 mission.

Caching Architectures:

***One Bit One Core (OBOC)*:** In the One Bit One Core architecture, a core is acquired with a SLOT bit having an integral break-off system. After visual verification of sample enabled by the SLOT bit, the entire bit with core sample is placed directly into the cache (Figure 1). 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).

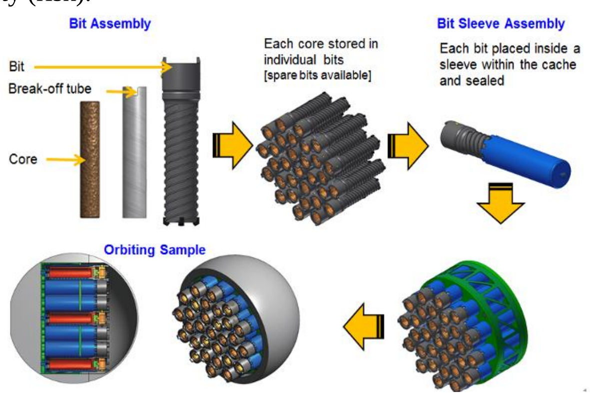


Figure 1. One Bit One Core (OBOC).

One Breakoff System One Core (OBSOC): In the One Breakoff System One Core (OBSOC) architecture, a core is acquired using a SLOT bit with an integral break-off system just like in the OBOC architecture. 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 2). 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.

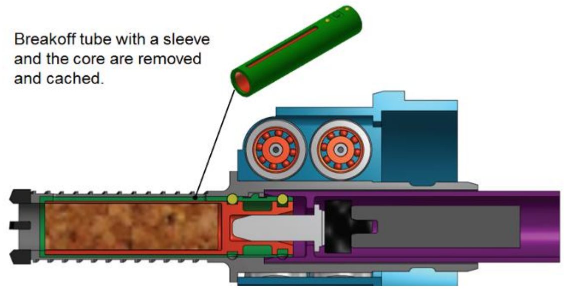


Figure 2. One Breakoff System One Core (OBSOC).

Trade Studies for 31 and 37 Cores: Figure 3 and Figure 4 compare OBOC and OBSOC architectures. The total mass for 37 samples (incl. bits/tubes and cache) is less than 2.5 kg for the OBOC architectures and less than 2 kg for the OBSOC architecture. The diameter of the OS rangers from 17 cm to 20 cm.

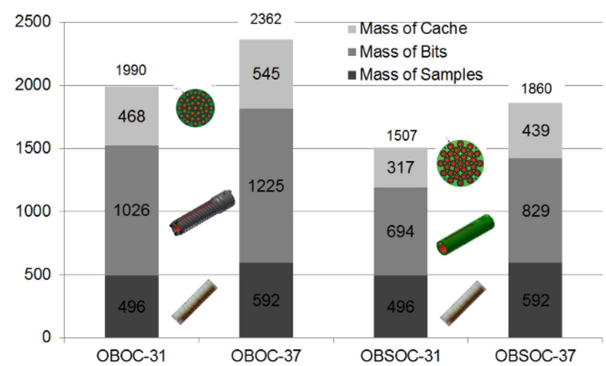


Figure 3. Mass of the two architectures.

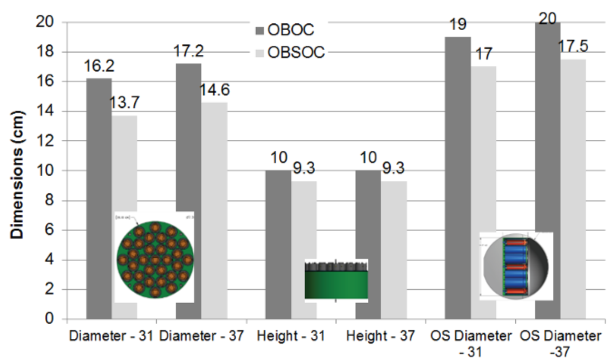


Figure 4. Cache dimensions and OS diameter.

Unique Technologies and Bits:

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 5. It has been implemented in eight core drills and succesfully verified in dozens of rock types.

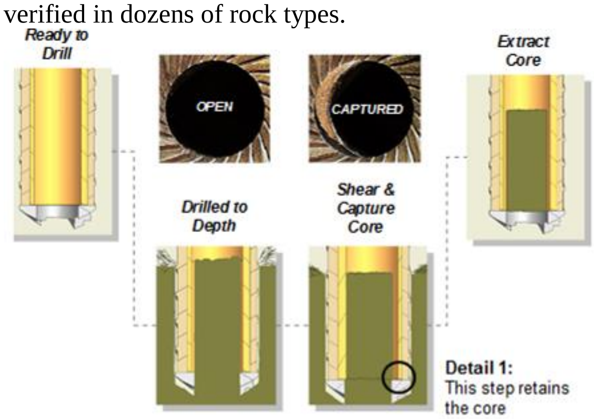


Figure 5. Eccentric tubes core breakoff and retention technology (patented).

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 6).

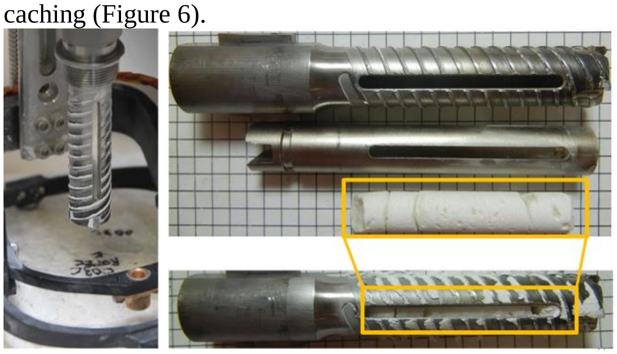


Figure 6. The SLOT Bit allows viewing of cores in situ and serves as a caching bit.

Powder and Regolith Acquisition Bit (PRABit): The powder and regolith acquisition bit allows capture of rock powder or regolith sample for earth return (Figure 7). For rock powder acquisition, the bit could be integrated with two sieves (e.g. 1 mm and 150 micron).

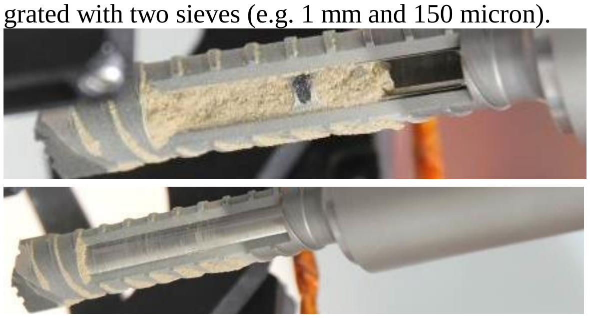
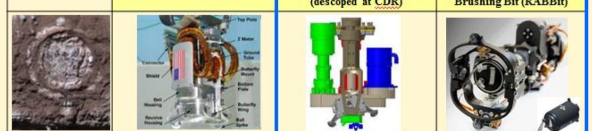


Figure 7. Powder and Regolith Acquisition Bit (PRABit).

PreView Bit: The PreView bit (Figure 8) 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. The PreView bit has also been tested and verified in various rock types and has been demonstrated to TRL 5.

Figure 8. The PreView bit allows capture and in-situ analysis of rock cores.

Grinding and Brushing of Rocks: In general, there are two approaches for addressing SDT requirements 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 9). The RAT is at TRL 9 and RABBit is at TRL 5/6.



	MER Rock Abrasion Tool	MSL-Surface Removal Tool (descoped at CDR)	Rock Abrasion and Brushing Bit (RABBit)
Space required 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)	None (uses MSR drill). The drill requires tines.
Brush while grind	Yes (and just Brush)	Yes (and just Brush)	Yes (and just Brush)
Life	Actual as of 10/2013: • Opportunity Grind/Brush: 47/42 • Spirit Grind/Brush: 15/92	• Required: 2x37=74 grinds • Recent M2020 life tests: • ~100 grinds in basalt (45 mm diameter x 5 m deep) in a Mars chamber	

Figure 9. Rock Abrasion Tools options for the Mars2020 missions.

Acknowledgements: M2020 related technologies were funded by NASA through various programs.

References: [1] Zacny et al. (2014), Mars2020 Sample Acquisition and Caching Technologies and Architectures, IEEE Aero Conf. [2] YouTube: http://www.youtube.com/watch?v=VhfL3htrtZ8, and https://www.youtube.com/watch?v=cf47bvULtEQ, https://www.youtube.com/watch?v=NphWPvi9cy4,