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Introduction: The proposed 2018 Mars Sample Return campaign consists of three individual missions [1]. In 2018 the Mars Astrobiology Explorer-Cacher, also called the MAX-C rover, will acquire rock cores with a core drill, and place the cores in the cache. The cache would be left on the ground, while the MAX-C rover would continue exploring the planet. The next two missions are the orbiter mission with an Earth Return Vehicle, and a Mars Ascent Vehicle (MAV) mission with a fetch rover. The fetch rover would navigate the terrain and collect the cache and bring the cache back to the lander and place it inside the Orbiting Sample (OS) within the MAV. The MAV would then launch, and place the OS in an orbit around Mars. The orbiter with the ERV would then capture the OS and return it back to Earth.

We present an approach to core acquisition and caching, a primary payload on the MAX-C rover [2].

Main Architecture Drivers: The main drivers for our architecture were to survive catastrophic slip, be able to eject a stuck bit and be able to drill basalt. In the first case, a bit must be strong enough so as not to break. In the second case, a bit having a side load (worst case is when the rover slips) is a very effective anchor, and thus can not be easily pulled out. The bit, therefore, has to be capable of being detached from the drill and left behind in the hole. This requirement drove the selection of tines with an actuated Z-axis internal to the drill (as opposed to a passive Linear Spring), and using individual bits for each core (instead of using the same bit to acquire several rock cores). In the third case, drilling basalt with limited Weight on Bit (because of the low mass of a rover at ~300 kg), required selection of a rotary-percussive (as opposed to rotary) drill.

Components of the Core Acquisition and Caching Architecture: Figure 1 shows the proposed Core Acquisition and Caching system in its deployed position. The system includes:

1. Drill
2. Sample/Bit Handling Carousel and Cache
3. 5 DOF Robotic Arm

The current best estimate mass of the drill, the arm and the Bit Carousel with the Cache are 5 kg, 12.5 kg and 10.7 kg, respectively. The total mass of the system is 28.26 kg. The bit assembly weighs 60 grams. The current best estimate mass of the Cache with 18 bits is 2kg.

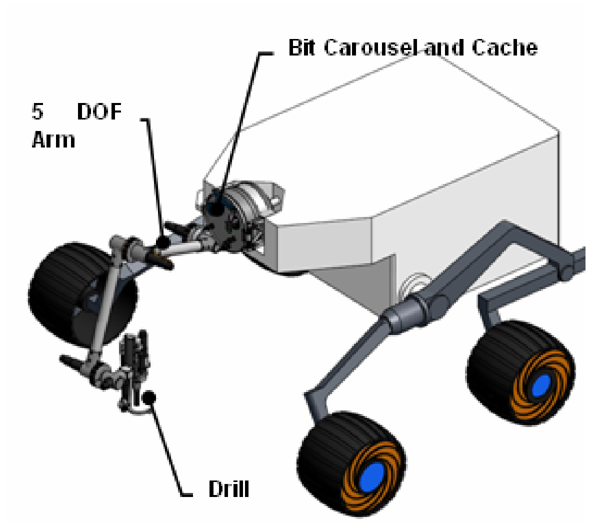

Figure 1. Sample Acquisition and Caching system in its deployed position.

Drill: The proposed core drill is a ~100 Watt rotary-percussive drill and includes five actuators for the following motions: Rotary motion, Percussive motion, Z-axis, Core Break-Off system, and the Chuck (Bit Change Out), which is a paraffin actuator [3].

The drill is deployed from a 5 Degree of Freedom arm. Since the drill has Z-axis transmission internal to the housing it requires no additional arm actuation once positioned and preloaded against a rock (Weight on Bit and pull forces are decoupled from the arm).

The drill is designed to acquire 1 cm diameter and up to 5 cm long cores. The same drill can also be used for brushing and abrading of rock surfaces with brushing and abrading bits, respectively, for rock powder acquisition and for acquisition of short cores for in-situ analysis.

The drill fits within a 30.8 cm long by 18.3 cm diameter envelope and weighs 5.06 kg (with one bit).

Sample/Bit Handling Carousel and Cache: The Bit Carousel and the Cache contain 15 and 6 separate bits, respectively (i.e. total of 21 bits). The Cache can store up to 18 bits (hence 18 bits can be returned back to Earth). Both the Carousel and the Cache can be made larger to accommodate additional bits, but then the mass of the entire system will grow.

The Bit Carousel and the Cache (with all the bits) weigh 10.7 kg. The Cache with the bits and rock cores (as returned to Earth) weighs 2 kg, its diameter is 15.24 cm and its height is 13.29 cm (including the bits).

Rock Core Encapsulation: In the proposed architecture, the cores are stored in individual bits (the rock cores are never taken out of their bits once acquired). This significantly reduces sample handling complexity and almost entirely eliminates cross contamination.

After acquisition of the rock core, the bit assembly with a core inside it is inserted directly into a thin encapsulation sleeve mounted inside the Bit Carousel or the Cache. The sleeve covers the entire bit and hence the core and the cuttings adhered to the bit are brought back.

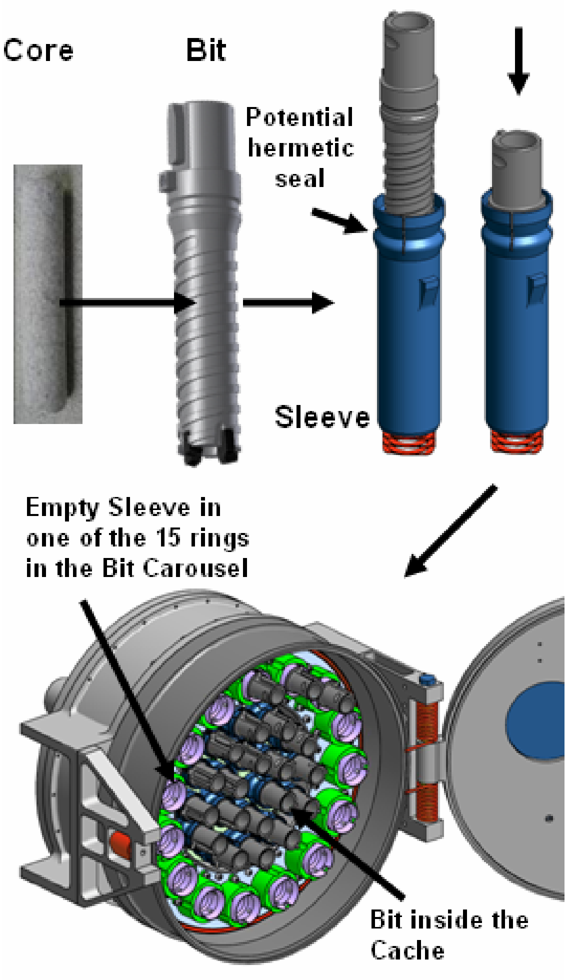

Figure 2. Cores are stored inside individual bits. The bits with cores inside them are inserted into dedicated sleeves within either the Cache or the Bit Carousel (for temporary storage). The bits with sleeves can be pulled out of the Bit Carousel and inserted into the Cache.

Bits for In-Situ Analysis: Thus far we have collected numerous Martian meteoriteson Earth, therefore bringing additional rock from Mars may be difficult to justify unless that rock is of special value. In order to select the appropriate sample for earth return, the rock has to be thoroughly interrogated in-situ. For that reason, our architecture includes additional four bits for the following tasks: brushing and abrading the rocks (as done with the Rock Abrasion Tool on MER); acquisition of small cores for in-situ analysis and also acquisition of rock powder for in-situ analysis.

We are using an approach that is used every day on Earth; that is to have one appliance (in our case it is a drill) and a suite of different tools (bits) for different applications (Figure 3). This approach can save mass and cost of the mission.

Also after the primary mission objective (caching of rock cores) is over, the MAX-C rover could continue exploring the Mars with the help of these additional bits.

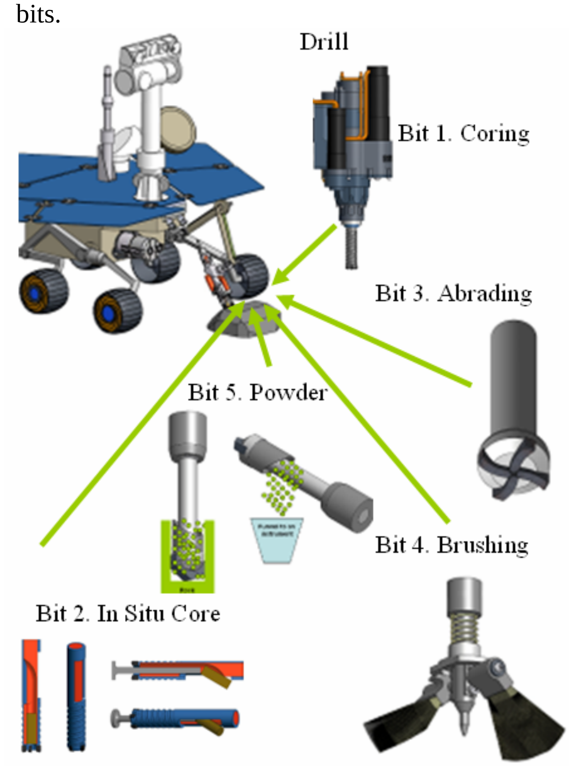

Figure 3. The drill can be used with 5 different bit types for in-situ rock interrogation.

References: [1] Beaty, D., et al. (2010) The Proposed Mars Astrobiology Explorer-Cacher (MAX-C) Rover: First Step in a Potential Mars Sample Return Campaign, 41st LPSC. [2] Zacny, K. et al., (2010) Honeybee Approach to the Sample Acquisition and Caching Architecture for the 2018 Mars Sample Return Mission, Paper #1573, IEEE Aerospace conference, 5-12 March 2011, Big Sky, MO [3] Zacny, K., et al., (2011), Prototype Rotary Percussive Drill for the Mars Sample Return Mission, Paper #1125, IEEE Aerospace conference, 5-12 March 2011, Big Sky, MO.