SMART: INSTRUMENTED DRILL FOR ISRU INVESTIGATIONS ON THE MOON. L. Stolov[1], K. Zacny[1], J. Heldmann[2], J. Palmowski[1], K. Bywaters[1], C. Fortuin[1], S. Kwok[1], A. Colaprete[2], A. Dave[2], R. Elphic[2], D. Kemp[2], K. B. Chin[3], [1]Honeybee Robotics, 2408 Lincoln Ave, Altadena, CA 91001, [2]NASA Ames Research Center, Moffett Field, CA 94035, [3]Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91109 (Contact: lastolov@honeybeerobotics.com)

Introduction: SMART (Sensing, Measurement, Analysis, and Reconnaissance Tool) is a next generation drilling system for in situ science on the Moon. SMART is a rotary percussive drill mounted on a linear stage, similar to The Regolith and Ice Drill for Exploration of New Terrains (TRIDENT) that is flying to the Moon in 2022 and 2023 [1]. Unlike TRIDENT, which uses the auger to move drill cuttings up to the surface for analysis, the SMART auger and bit assembly is integrated with instruments that can perform analysis inside of the drilled borehole. By instrumenting the auger, we are changing the paradigm of exploration – we are bringing an instrument to the sample as opposed to bringing the sample to an instrument.

Instruments: SMART is instrumented with five sensors in a 2 inch (5.08 cm) diameter auger and bit assembly: (1) neutron spectrometer for hydrogen detection, (2) near infrared spectrometer for volatiles and mineralogical information, (3) dielectric spectroscopy probe for electrical properties, (4) temperature sensor and heater for thermal gradient and thermal conductivity measurements, and (5) camera for visible light images and surface texture. The drill is also an instrument, as drilling power and penetration can be used to determine regolith strength. The chosen instruments are used to detect water ice, determine regolith composition, and perform additional scientific measurements below the lunar surface. SMART allows missions to make to make educated and expeditious decisions as to whether the downhole soil sample should be delivered to any rover mounted ISRU instruments for further analysis or processing.

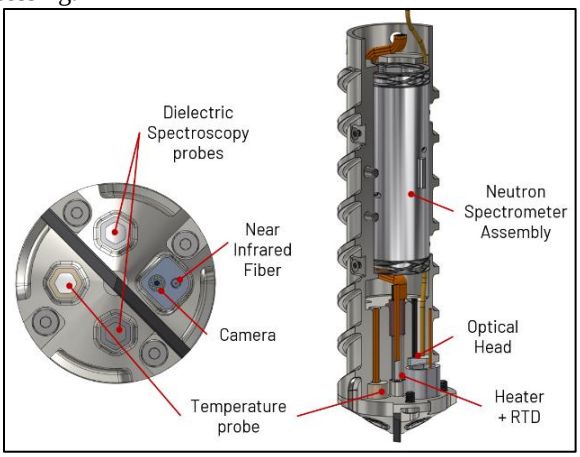

Figure 1 SMART Instrumented drill bit and auger

System design: SMART consists of several major subsystems: an instrumented drill bit and auger, a rotary-percussive drill head for providing percussion and rotation to the drill string, a linear stage for advancing the drill string into the subsurface, a slip ring section to feed the electrical signals to a data acquisition box, and a fiber optic rotary joint section to feed the optical signal out to the near-infrared spectrometer. A prototype has been developed with the goal of demonstrating instrument functionality and testing in a relevant lunar environment.

Figure 2 SMART prototype system

Applications: SMART can be mounted to a lander, rover, or even be adapted as a handheld system for high grading on the lunar surface as part of the Artemis program. The instrumented drill bit and auger is also being developed for a >10 meter drilling system called Rapidly Excavated Borehole for Exploring Lunar Subsurface (REBELS). REBELS is designed for in situ science

below the lunar surface. The concept leverages existing Honeybee Robotics technologies: RedWater – a coiled-tube drilling system currently under development for penetrating 25 m below the surface of Mars [2], LISTER – a 3 m pneumatic drill scheduled to fly to the Moon in 2023 (Mare Crisium), and 2025 (Shodinger basin) [3], and the integrated downhole instruments from SMART. Various subsystems of REBELS are currently being developed to a TRL ranging from 4 to 9 via several NASA projects.

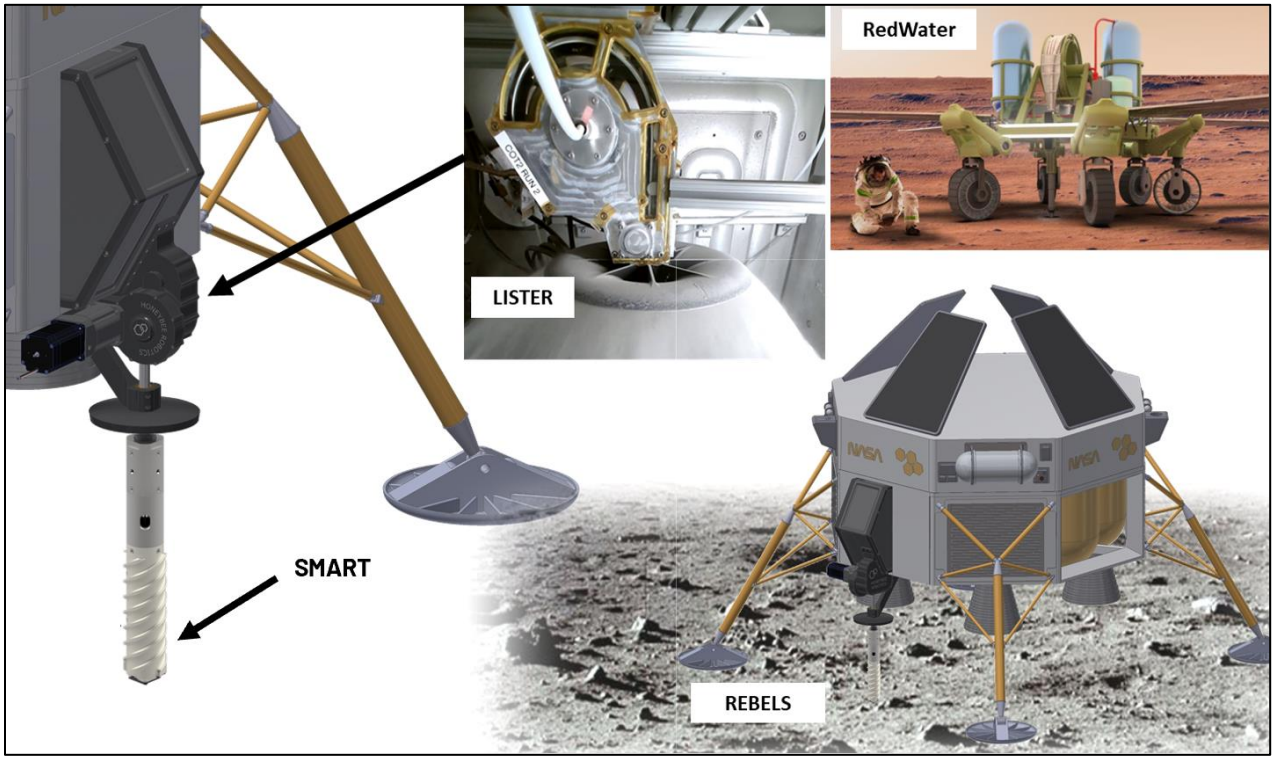

Figure 3 Concept for REBELS, a 10 meter scale lunar drilling system

References: [1] K. Zacny, et al., (2021) LPSC 52, Abstract #2400. [2] J. Palmowski, et al. (2021) AIAA 2021-4038. [3] S. Nagihara, et al. (2020) LPSC 51 Abstract #1432.