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DEVELOPMENT AND PERFORMANCE OF A DOWNHOLE MODULE FOR MARTIAN DEEP DRILLING AND EXCAVATION

Abstract

The capability of deep drilling on the Martian surface is fundamental for both in-situ resource utilisation activities as well as retrieving samples from deep enough underground to be unaffected by cosmic radiation. Thus far, the Viking Lander 1 continues to hold the deepest drill depth of only 0.22m with the ESA Rosalind Franklin Rover designed to reach a maximum depth of 2m. However, these planetary drilling systems are not suitably scalable to reach penetrations beyond these depths without significant increases in mass. This necessitates the development of a new type of deep drilling architecture capable of reaching and extracting samples at depths up to 20m for future Mars missions.

The Drill for Extensive Exploration of Planetary Environments by Robots (DEEPER) has been developed to test the concept of a tethered mole architecture for planetary drilling. The system uses a downhole module that consists of a motor assembly, rotary-percussion mechanism, spoil extraction subsystem, and cutting face that are tethered to the surface. This tether provides structural support to the borehole, power to the downhole module, and a shuttle to transport samples to the surface. Thus, DEEPER is capable of drilling to 20m and beyond while maintaining a mass and power draw within the same range as the currently available technologies.

Initial tests demonstrated success in the overall architecture but showed lower than expected rates of penetration, particularly in high uniaxial compressive strength (UCS) materials, due to inefficiencies and losses in the rotary-percussion and the spoil extraction subsystems. Building on the initial tests, this study investigates the development and performance of three different downhole rotary-percussion mechanisms to evaluate the best candidate architecture for Martian deep drilling. These rotary percussion mechanisms are: a direct-drive sprung hammer, base-excitation sprung hammer, and a base-excitation sprung chisel.

The objective of this study is to test the operational performance of the three downhole modules across a variety of materials that represent the Martian regolith. The performance of each downhole module will be evaluated to determine a recommendation for their optimal operating environment, constraints, and overall capabilities. These results will drive the development and optimisation of the DEEPER system as flight hardware to be used in deep planetary drilling operations.