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AUTOMATED MARS DRILLING FOR "ICEBREAKER"

Abstract

The proposed "Icebreaker" mission is a return to the Mars polar latitudes first visited by the Phoenix mission in 2007-08. Given the hard icy layers and perchlorates found there, Icebreaker is based on the Phoenix spacecraft bus but will carry both an automated 1m rotary-percussive drill and a non-pyrolytic instrument capable of detecting organics in the presence of perchlorates. Downhole materials will be captured in the bottom 10cm of the drill string and raised to the surface where they will be mechanically removed and transferred to on-deck instruments. A life-detection instrument and spectrometer will accompany the low-temperature organics analyzer there.

Planetary drilling and sampling beyond the Moon requires intelligent and autonomous systems. Unlike terrestrial drills, the Icebreaker drill will work dry (without drilling muds or lubricants), blind (with no prior local or regional seismic or other surveys beyond Phoenix's excavations), and weak (very low [200N] downward force or weight on bit, and perhaps 100W power available). Given the 7-20 minute lightspeed transmission delays to Mars, while drilling faults manifest in terms of seconds, the Icebreaker drill cannot be controlled directly from Earth. Therefore highly reliable automated operations will be necessary, with the ability to safe the drilling system and recover from almost any downhole fault condition.

This paper will examine the tradeoffs in drill power and mass, drill architectures and software automation in the operations and requirements for drilling on Mars. To achieve the technology readiness levels required to propose the Icebreaker mission, we have tested both rotary-drag and rotary-percussive drill designs in laboratory chamber tests and in field tests at a Mars-analog Arctic impact crater site. These have been in turn used to validate and test the controls and drill health management software necessary for Icebreaker automated drilling and sampling operations. Test results show that rotary-percussive outperforms rotary-drag drilling in terms of mass and efficiency, and that the DAME-derived controls and software is capable of managing hands-off drilling operations including fault detection and recovery.