Exploration of Mars (08)
Mars Sample Return and Human Exploration (2)

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AUTOMATED MARS DRILLING MISSION STUDIES

Abstract

Looking for organics and signs of past or extant life on Mars will require the ability to break through the ice layers that were a barrier to the Phoenix scoop. Planetary drilling and sampling beyond the Moon also requires intelligent and autonomous systems, given lightspeed delays and periodic communications intervals. 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 would carry both an automated 1m rotary-percussive drill, the SOLID life-detection instrument, APXS and a non-pyrolytic instrument (JPL's Wet Chemistry Lab) capable of detecting organics in the presence of perchlorates. A variant of the Icebreaker mission concept, called "Red Dragon", would carry the Icebreaker instruments and deploy an upgraded 2m drill from a SpaceX Dragon capsule, landed on Mars at polar or mid-latitudes. Both approaches are being studied as Discovery-class mission proposals for 2018 or 2020 launch opportunities.

To achieve the technology readiness levels required to propose these missions, we have tested both rotary-drag and rotary-percussive drill designs in laboratory chamber tests and in field tests at Mars-analog sites in the Arctic and Antarctic. These have been in turn used to validate and test the controls and drill health management software necessary for automated drilling and sample transfer operations. This paper will discuss the requirements and initial trades to operate a drill with its supporting controls and sample handling from either platform, including the scientific goals addressed by drilling, the power and mass constraints, geometries, automation and robotic complexity, margins and targeting flexibility. We will link these to the objectives and results from recent and planned laboratory and analog-site field tests.

Icebreaker/Red Dragon, as lander systems that would be specifically investigating potential Martian life, are COSPAR Category IVb missions. As with the Robotic Arm and ISAD on Mars Phoenix, planetary protection requires both that the part of the drill extending below the ground be dry heat sterilized, and that the chain of contact with the less-clean spacecraft and instruments be broken. We discuss the implications on drill stowage, deployment, and sample transfers between the drill and instruments.