HYDRATION III

High-Yield Dihydrogen-monoxide Retrieval And Terrain Identification On New worlds

The RASC-AL Moon to Mars Ice & Prospecting Challenge

NASA's project **Artemis** aims to establish a sustainable human presence on the Moon by 2028, as a first step on the agency's long-standing goal of sending humans to Mars. In situ supplies of water will be essential for sustainable outposts on other worlds. **HYDRATION III** is an Earth analog system to explore novel flight concepts for digital core prospecting on the Moon and for extracting water from subsurface ice sheets on Mars using radiative heating and distillation.

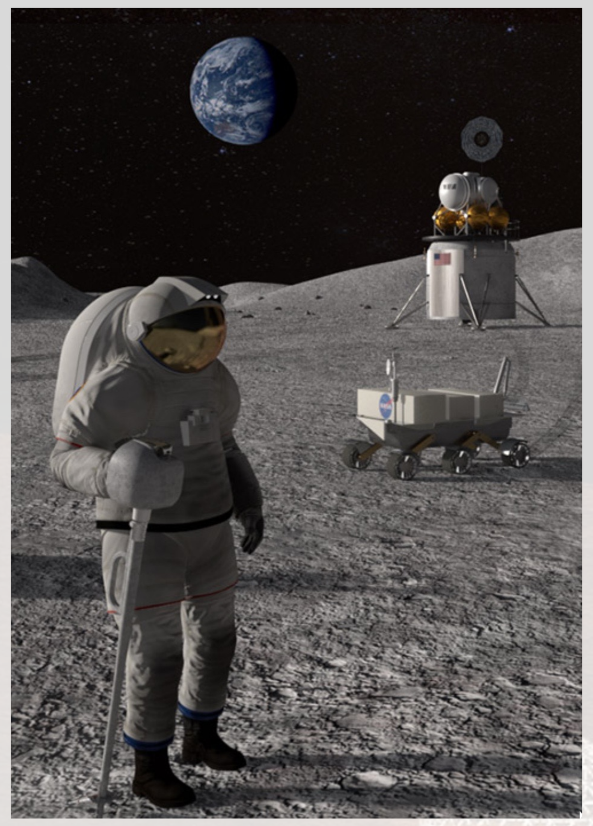


Image credit: NASA

Digital Core Prospecting capabilities summary: Data streams from multiple sensors (power, weight on bit, accelerations and servo torque) are presented to the operator who infers the makeup of a digital core based on experience gained during testing.

For the Lunar path to flight, additional resources will be required to build up a data set sufficient to train a neural network to infer the makeup of the digital core.

Water Extraction capabilities summary: A rotary-percussive 8A drill driving a 1" carbide-tipped bit excavates a hole through the overburden and into the ice layer. Mud lines the hole wall as the drill bit is removed, and a heater and water inlet assembly is lowered into the ice layer. The 700W radiative heater melts the ice in-situ while the peristaltic pump continuously brings up water for filtration and collection. The filtration system can be cleaned by reversing the pump.

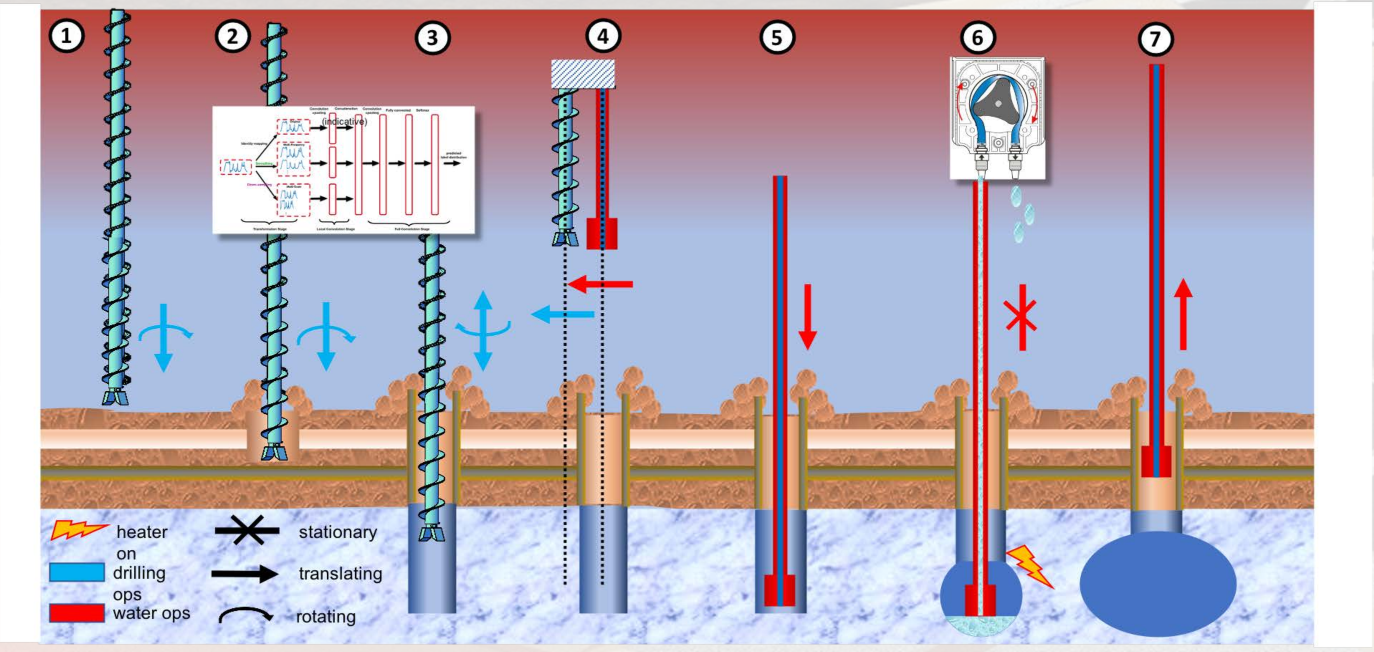
For the path to flight to Mars, the peristaltic pump and downhole filter are replaced by a packer, scroll compressor and cold trap to pressurize and condense sublimated water vapor.

Mounting Structure: HYDRATION III is based on the structural frame of MIT's HYDRATION 2019 [1] prototype, with modifications to remove the redundant X axis and also to reduce vibrations to negligible levels.

For the Lunar path to flight, a much simpler and lighter structure can be used as HYDRATION will be mounted on a rover and water extraction will not be required, making the X, Y and Z2 axes redundant.

For the path to flight to Mars, a somewhat lighter and simpler structure can also be used as HYDRATION will be mounted on a rover, making the X axis redundant. The Y axis will be needed to position the heater over the hole.

Concept of Operations: A 1" hole is drilled through the overburden and into the ice, using data collected during drilling to reconstruct the digital core. The hole will be reamed 2-3 times, each time progressing deeper into the ice, with the bit spinning during drilling to protect against refreezing. This will line the hole wall with mud and should clear at least 35cm of the ice hole, providing enough space for the radiative heater. The 700W heater will then be translated over the hole and lowered into the ice layer melting it in situ, while the peristaltic pump continuously removes cold meltwater via the downhole inlet for filtration and collection.

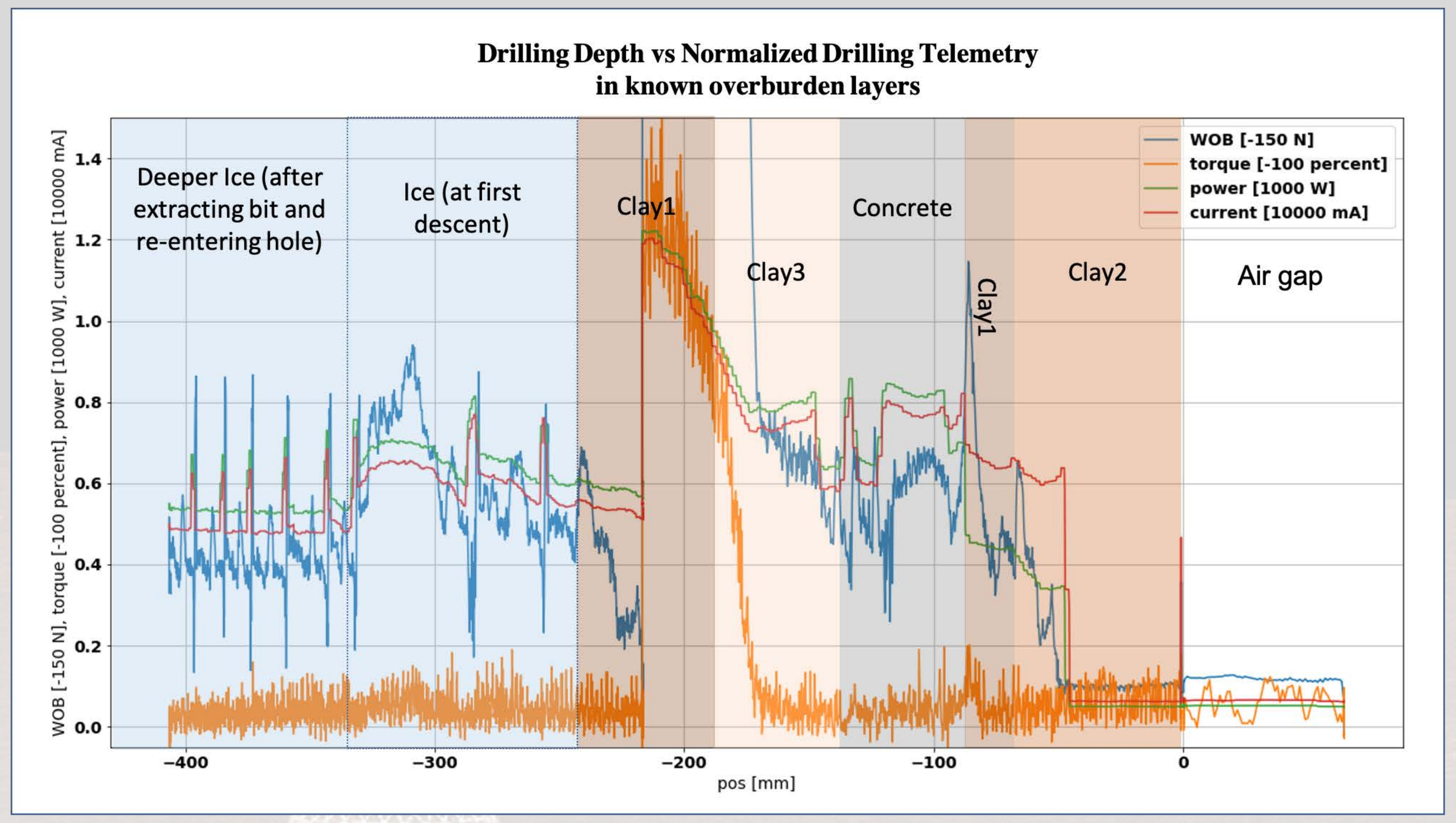


For the Lunar path to flight, only steps 1-3 of the CONOPS will be required.

For the path to flight to Mars, an inflatable choke will be added to the housing of the heater and water inlet assembly to seal the hole and reduce losses.

[1] HYDRATION submission by MIT team to the MMIP 2019 Forum

Reconstructing a Digital Core using Sensor Data Fusion: Data from multiple sensors is used to provide feedback to the drill operator. The operator or a trained neural net can use it to estimate the makeup of layers of overburden.



For the Lunar path to flight, in addition to a larger data set for training a neural net as previously discussed, a laser-ranging vertical distance sensor will also be required.

Melting ice in-situ using radiative heating: Our experiments indicated that radiative heating with constant water extraction using a peristaltic pump results in lower heat losses than classic Rodwell-type approaches.

For the path to flight to Mars, a scroll compressor will constantly evacuate downhole water vapor as it boils and/or sublimates.

Snapshot of our HYDRATION III Mission Control client / server software system

Background image credit: "Star City, Mars" by Delta Architects / George Lordos / Alexandros Lordos

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