MARS IN-SITU WATER EXTRACTOR (MISWE). K. Zacny[1], G. Paulsen[1], J. Craft[1], L. Oryshchyn[2], J. Sanders[2], R. Mueller[3], [1]Honeybee Robotics, 398 W. Washington Ave, Suite 200, Pasadena, CA 91103, zacny@honeybeerobotics.com, [2]NASA Johnson Space Center, [3]NASA Kennedy Space Center

Introduction: We present an alternative method for excavating water-ice and ice cemented ground and also for extracting water from ice and icy-soils. The system is based on the Honeybee Robotics IceBreaker drill [1, 2].

We performed a number of digging in soil with various water concentrations and frozen to -20°C. The digging system used a 45 mm wide scoop. At water concentration of ~5 wt%, the scoop managed to penetrate ~1 cm into a soil at 3500 N force. Using a 150 W percussive system to drive the scoop into the regolith, the maximum penetration depth was 5 cm at 3500 N force. In order to generate 3500 N forces on Mars, the Martian excavator would need to weigh approximately 2100 kg on Earth. This is more than twice the mass of the 2011 Mars Science Laboratory rover, which is currently launched on the largest rocket available. Clearly, this method of water extraction is not feasible.

MISWE: The system, called the Mars In-Situ Water Extractor (MISWE), consists of the Icy-Soil Acquisition and Delivery System (ISADS), and the Volatiles Extraction and Capture System (VECS). The ISADS is a deep fluted auger that drills into the ice or icy-soils and retains material on its flutes. Upon material acquisition, the ISADS is retracted into VECS and sealed. The VECS consists of a cylindrical heat exchanger and volatiles transfer system (a reactor). The material on the deep flutes is initially heated, for example via conduction or microwave. Once some water sublimes and pressure inside the reactor increases, the further heat transfer could be accomplished via very efficient convection. The reactor pressure gage monitors the pressure at all times to prevent liquid forming. Vapor is bled into a water collection canister by a one way valve where it condenses. The heat is transferred back to the reactor. After water extraction the ISADS is lowered towards the ground and spun at high speed to eject the dry soil. At the same time, the collected water is pumped from the canister into a storage container within the rover's Warm Electronics Box. The MISMWE rover then moves to the next location and the operation is repeated. Once the water tanks on the MISMWE rover are full, the rover drives back to the base while leaving behind dry soil and a "Swiss cheese" field of holes in the ground.

Since the regolith is not actually transferred, there is no need for a transfer system and associated dust tolerant valves. Also if a rover is powered using Radioisotope Thermal Generators (RTG) or more efficient the Advanced Stirling Radioisotope Generator (ASRG), the heat generated by the unit can be transferred to the reactor. For example, the RTG on the 2011 MSL rover generates ~120 Watts electrical power and > 1 kW heat, which is used to keep the Warm Electronics Box (WEB) warm.

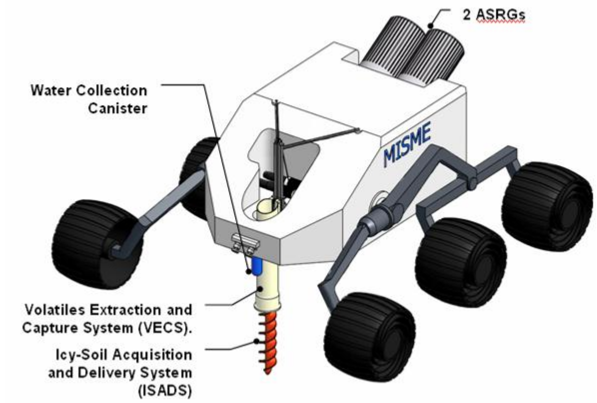
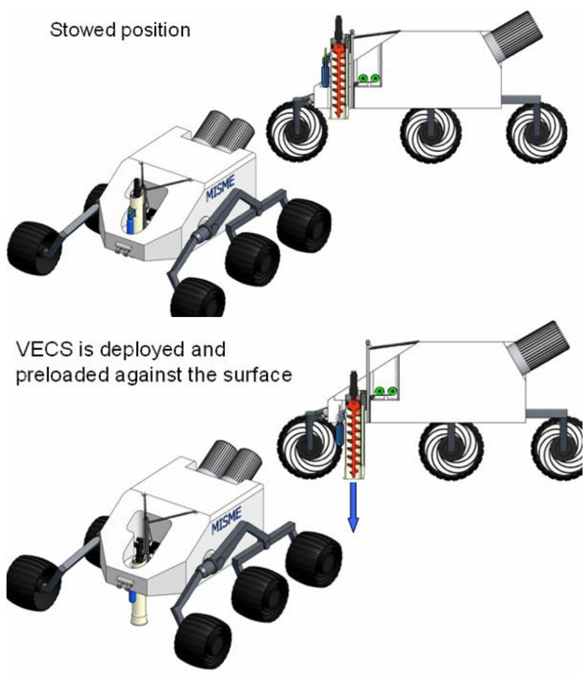
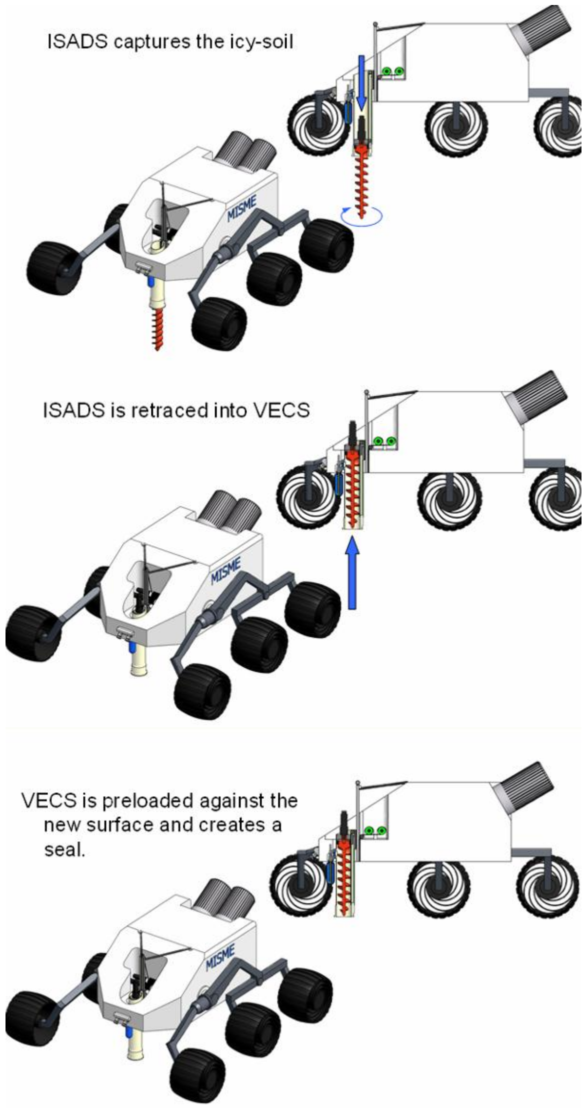
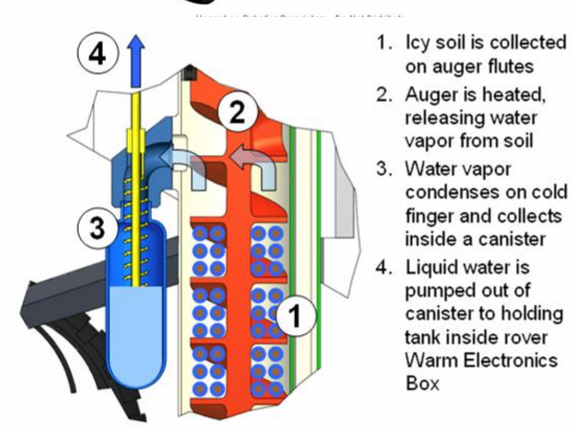


Figure1. Mars In-Situ Water Extractor (MISWE).

Concept of Operation: MISWE is designed to be deployable from a mid-size rover or a lander. In case of the lander deployment, MISWE will be limited to a couple of holes, provided the drill is boom deployable. The ISADS auger, in its base configuration is 10 cm diameter and drills up to 50 cm deep. Volume of sample per single operation is approximately 3500 cc and the mass ~ 5 kg at 1.5 g/cc material density (mixture of ice and soil). Figure 2 shows sequence of operation.







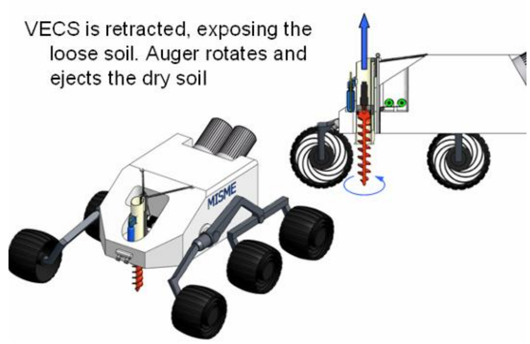


Figure 2. MISME sequence of operations.

Proof of Concept: We demonstrated drilling to 1 meter depth into ice and ice cemented ground under Mars conditions. The drilling power was ~100 Watt and Penetration Rate was 1 m/hr [1, 2]. We also built a scaled model of the MISMWE system to demonstrate feasibility of water extraction. The system shown in Figure 4 was tested in a Mars chamber. In preliminary tests we successfully recovered more than 50% of the water present in the soil.

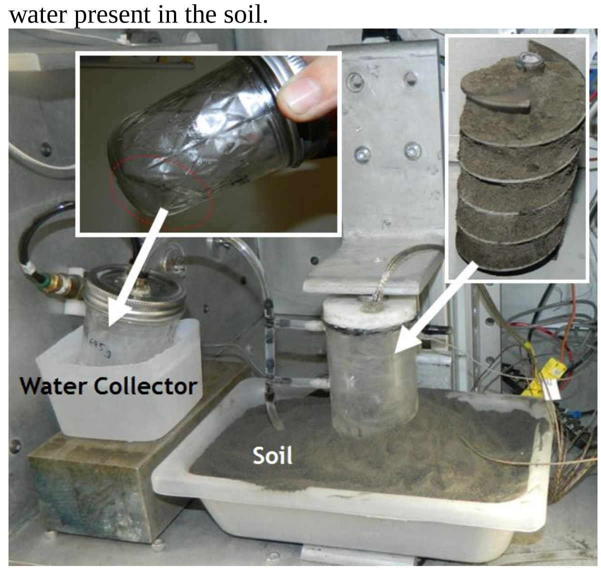


Figure 4. MISWE water extraction system being tested in Mars chamber.

References: [1] Paulsen, et al., Testing of a 1 meter Mars IceBreaker Drill in a 3.5 meter Vacuum Chamber and in an Antarctic Mars Analog Site, AIAA SPACE 2011 Conference; [2] Zacny et al., The Icebreaker: Mars Drill and Sample Delivery System, Abstract 1153, LPSC 2012;