NASA Moon to Mars Ice Prospecting Challenge

Aztec in-situ Resource Extraction System (ARES)

SAN DIEGO STATE UNIVERSITY

Problem Statement

Future manned missions to the Moon and to Mars will rely on in-situ resource utilization to meet astronaut needs. Subsurface ice deposits discovered on both bodies offer a promising source of water fit to be used for this purpose. The deposits lie below layers of overburden of unknown composition.

Create a device to extract water from subsurface ice below layers of overburden. The device must:

- Participate in a competitive demonstration at NASA Langley
- Drill through layered overburden
- Use drill telemetry to identify and describe the relative hardness of overburden layers
- Extract clean liquid water
- Be powered by ≤9 amps of 120V AC
- Be capable of autonomous operation
- Have a visual interface to report system parameters
- Have a clear path-to-flight for use on the Moon and Mars

Team ARES

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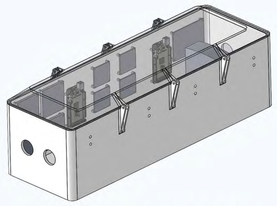
Major Components

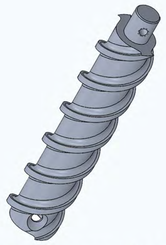
Rotary-hammer drill



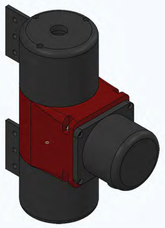
Power and controls box

Peristaltic pump

NEMA 23 Steppers (3x)



Flute sections (6x)



Filter

Sleeve heater

ARES prototype mounted on test frame

System Control

Two Arduino 2560s manage inputs and outputs from each subsystem

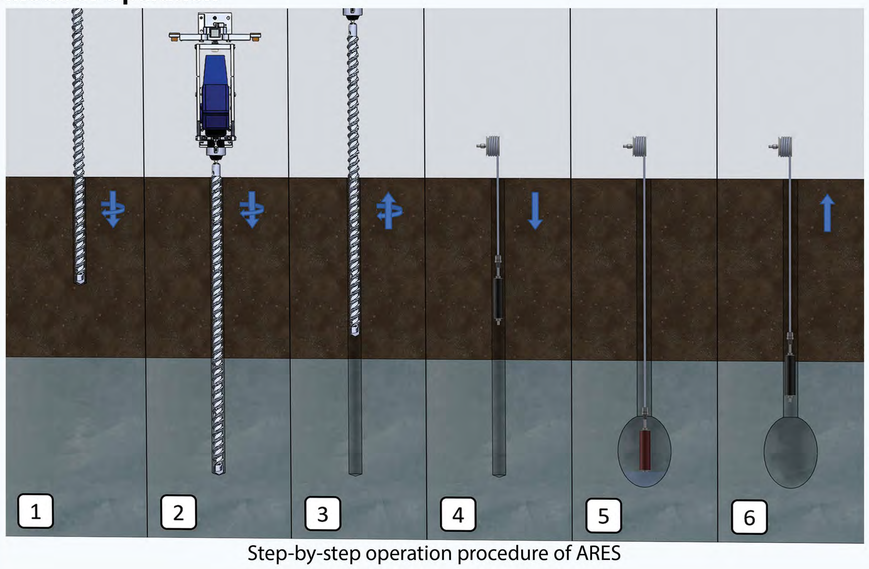
Drill Control
- optical rpm sensor
- hall effect current sensor
- zero-cross relays

Horizontal & Vertical Motion Control
- LIDAR range finders
- limit switches
- Gecko driver modules

Heater Control
- integral thermocouple
- phase-fired controller

Filter Control
- pressure sensor
- purge valve

Mode of Operation



Step-by-step operation procedure of ARES

1. Drill plunges through overburden layers
2. Drill penetrates ice to a final depth of 0.82m
3. Drill retracts
4. Heater assembly is reeled to the bottom of the hole
5. The heater is turned on and water is pumped out
6. After cooling, the heater is retracted from the hole

Design Architecture

Drill Bit
- identical replacable flute sections and a spade insert allow for easy repair
- auger flutes provide for ample removal of cuttings

Infrared Heater
- significant energy is dedicated to bringing the heater to over 700 °C
- heat is applied directly to ice at any distance for fast, sustained production

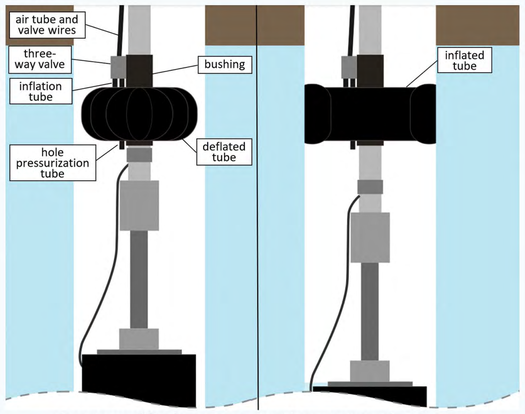
Seperate Drill and Melting/Extraction Systems
- independent systems could allow a path-to-flight system to set up a long-term well while freeing up the drill to produce more holes
- this avoids challenges with spinning connections, packing and durability

Paths to Flight

Martian and Lunar Surface Conditons:
- low gravity
- solar radiation exposure
- widely variant temperatures
- fine dust/sand
- low to no pressure

Design Adaptations:

Preventing sublimation
- an inflatable tube is used to create a seal with the ice
- air is pumped into the resulting chamber, raising the pressure above the triple point of water (611 Pa)

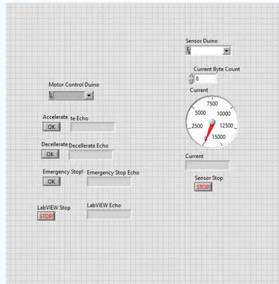


Proposed hole pressurization system in open position, left, and closed postion, right

Electronics
- radiation-shielding and heaters would be added to the controls box and wiring

Drill, motion systems and frame
- purpose-built drill and actuation systems would be developed
- the frame would be replaced by a rover or ground-mounting system

Testing



First-generation labVIEW drill monitoring and contol

First-generation flute, insert holder cutting, chip-clearing

First-generation heater temperature distribution, melt speed

Acknowledgements:
Team ARES thanks the National Institue of Aerospace for administering the competition through the RASC-AL program, San Diego State University for facilitating our participation, and Professors Shaffar, Dorr, and the team at Collins Aerospace for providing us with guidance

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