NASA Moon to Mars Ice Prospecting Challenge

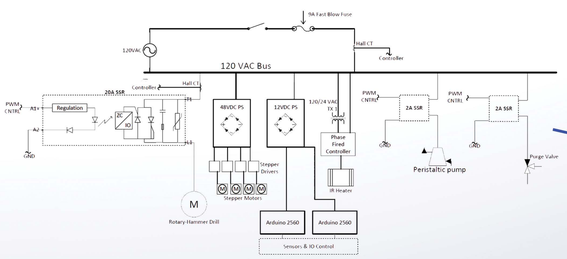
Aztec in-situ Resource Extraction System (ARES)

SAN DIEGO STATE UNIVERSITY

Design

Power
- 120 VAC input limited by 9 amp fast blow fuse
- Current sensors monitor system, drill power
- 12 VDC rail powers microcontrollers
- 48 VDC rail powers stepper motors

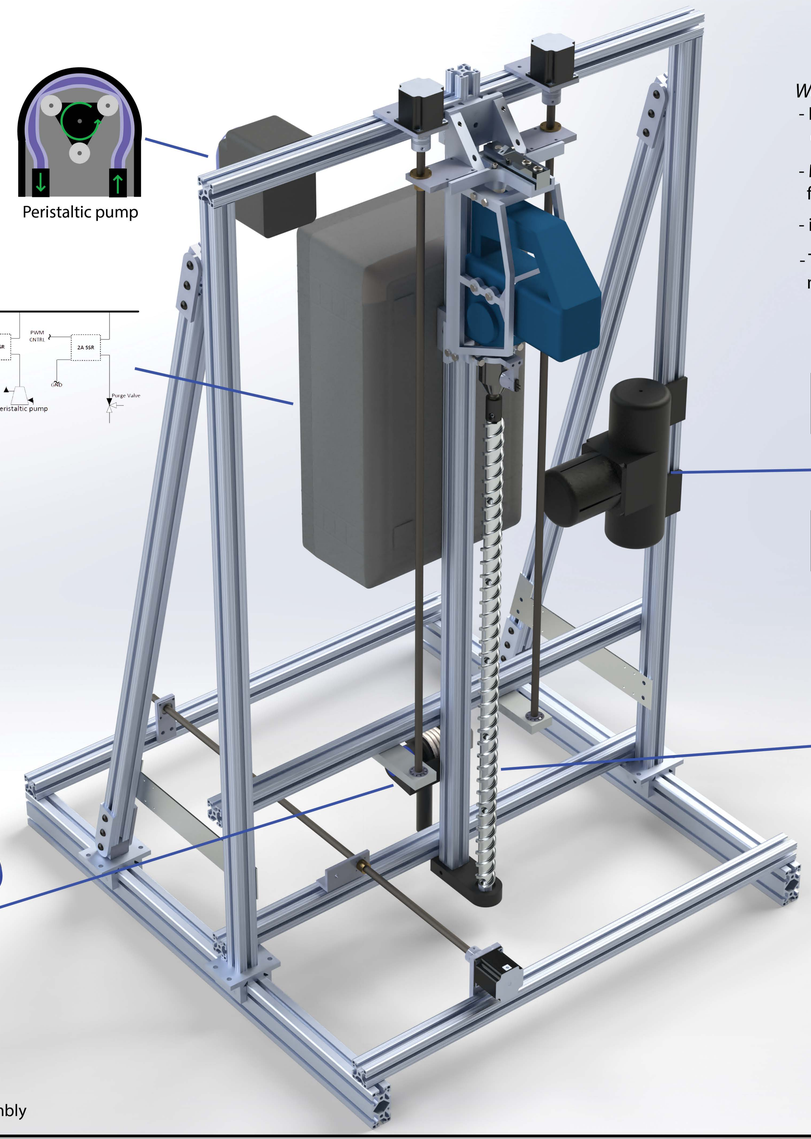
Peristaltic pump



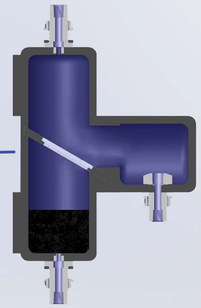
Power system diagram

Control and Data Aquisition
- Dual Arduino 2560 microcontrollers
- USB connection to laptop
- LabVIEW user interface

Digital Core Data		Control Data	
Data	Sensing Method	Data	Sensing Method
Drill current	Hall effect current sensor	System current	Hall effect current sensor
Drill RPM	Optical sensor	Winch rotation	Optical sensor
Weight on bit	Bar load cell	Heater temperature	Type-K thermocouple
Vertical position (plunge rate)	LIDAR sensor	Horizontal position	LIDAR sensor
		Filter pressure	Pressure sensor
Vertical limits	Limit switches	Horizontal limits	Limit switches



Water extraction
- Peristaltic pump drives continuous water extraction while ice is melted
- Moving pump components are kept awy from fouled water, preventing damage
- inlet mesh prevents clogs
- Two-stage filter passes water through mesh, activated laslcarbon



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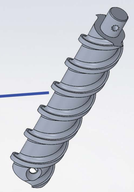


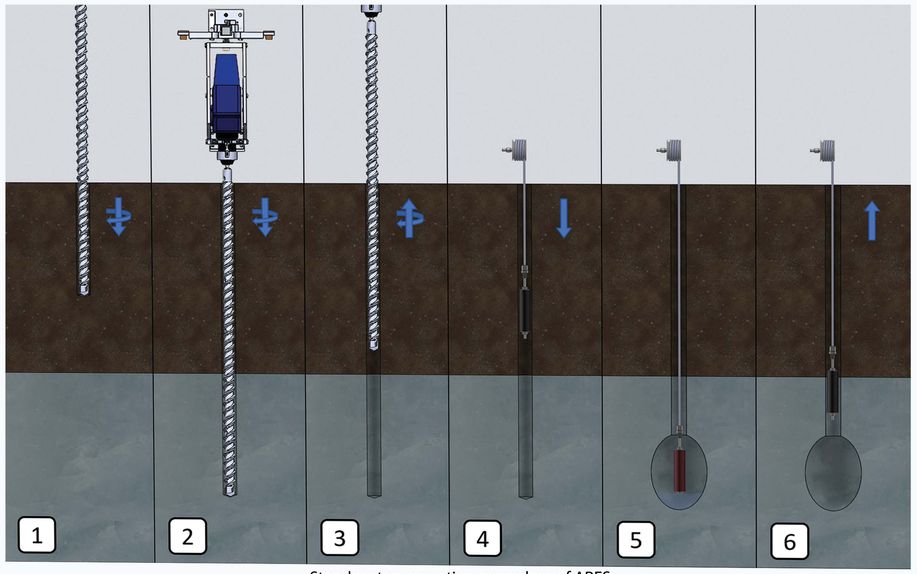
Flute section

Ice Melting
- Hollow swaged sleeve heater
- Melts ice with infrared radiation produced by high heat
- High emmisivity coating
- lowered on a hose via reel

Heater & winch assembly

Drilling
- Rotary-percussive Bosch drill
- 6A average power consumption
- Aluminum auger-fluted bit
- High speed steel insert tip
- Plunged by dual stepper-motor driven lead screws

Mode of Operations



Step-by-step operation procedure of ARES

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

Path to Flight: Mars

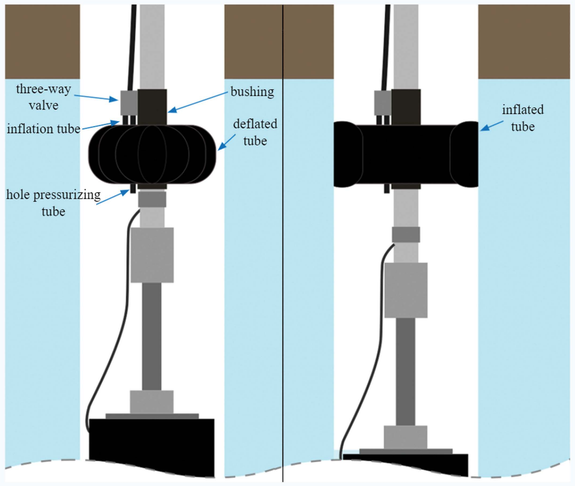
Martian Surface Conditons:
- low gravity
- solar radiation exposure
- widely variant temperatures
- fine dust/sand
- low to no pressure

Design Changes:

Rover or Stationary Drilling Rig
- A rover would allow water collection to begin before humans arrive on Mars
- Autonomously deep drilling and installing a long term water extraction structure would be challenging
- A stationary drilling rig would be lighter and cheaper

Water Extraction Structure
- After drilling, a seperate long term water extraction structure will be installed

Filtration
- ARES will extract water straight to a tank with no filtration
- Water transferred to a filtration and storage facility closer to the base of operations
- Prevents filter failure from stopping production and provides for recycling



Proposed hole pressurization mechanism

Hole Pressurization
- 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)
- 6.5 kPag (1 psig) would allow water to be heated to 38 C before evaporation
- a compressor in the water extraction structure provides air supply

Path to Flight: Moon

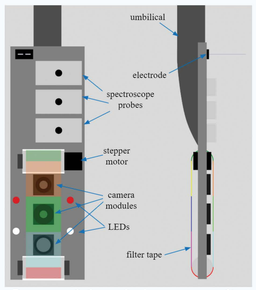
Lunar Surface Conditons:
- low gravity
- solar radiation exposure
- extreme temperature variation
- fine, sharp, electrically charged dust
- no appreciable atmosphere

Design Changes:
- Drill mounted on rover
- Ground penetrating radar for site selection
- Design and tolerance for extreme temperatures

Design Changes:

Prospecting Mission
- Rover reels sensor assembly into hole instead of heater
- Downhole sensor assembly includes spectroscope probes, electrode, cameras
- a flim strip with various filters increases the utility of cameras

Water Extraction Mission
- Water extraction structure, hole pressurization system, and seperate filtration facility similar to the Mars version
- A hydrolosis system replaces the compressor to provide air



Proposed downhole sensor suite

Path to Flight: Both Versions

- radiation shielding for the controls box and wiring
- dust ingress protection for all moving components
- upgraded drill bit to improve durability
- a custom hammer drill with heat sinking, dust protection, and actuation methods suitable to extraterrestrial environments
- FPGA autonomous control system
- Radioisotope thermoelectic generator or solar plus battery power

Acknowledgements:
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