Proposed New Testing Facility for Cold and Operational Long Duration Testing of Lunar and Mars ISRU and Mobility

P.J. van Susante & R. Alger - MTU

Paul van Susante, Ph.D.
Senior Lecturer / Assistant Professor Fall 2019
Michigan Technological University
Dept of Mechanical Engineering
pjvansus@mtu.edu
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What is needed for a space economy

• Recoverable Resource
• Technology
• Customer(s)

“A recoverable resource, technology to recover it, and a customer.”
SRR I, 1999
## Travel Perspective

<table>
<thead>
<tr>
<th>Case</th>
<th># RASSOR-class loads (@80 kg/load)</th>
<th>Distance from Ore to Plant, typical</th>
<th># RASSOR – class Excavators used (@ 60% On-Duty)</th>
<th>Travel Distance (km in 480 sols)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1 – Regolith @425K</td>
<td>&gt;25,000</td>
<td>~100 m</td>
<td>3 excavators</td>
<td>5,000 (3) [1,667 (1)]</td>
</tr>
<tr>
<td>D2 – Regolith @575K</td>
<td>&gt;15,800</td>
<td>~100 m</td>
<td>2 excavators</td>
<td>3,160 (2) [1,580 (1)]</td>
</tr>
<tr>
<td>C – Smectite (proximity)</td>
<td>&gt;7,000</td>
<td>~100 m</td>
<td>1 excavator</td>
<td>1,400</td>
</tr>
<tr>
<td>B - Gypsum</td>
<td>&gt;2,000</td>
<td>~100 m</td>
<td>1 excavator</td>
<td>400</td>
</tr>
<tr>
<td>B - Gypsum</td>
<td>(same)</td>
<td>~1,200 m</td>
<td>1 excavator</td>
<td>4,800</td>
</tr>
<tr>
<td>B - Gypsum</td>
<td>(same)</td>
<td>~3,000 m</td>
<td>2 excavators</td>
<td>12,000 (2) [6,000 (1)]</td>
</tr>
</tbody>
</table>
• Design of machines needs to be done as part of the overall system of systems
• The ‘right’ size can vary enormously based on target resource, target production(rate) and distance to site
• These are NOT science machines, they are industrial grade production machines
• Repetitive actions, yet hard to automate
• Batch vs. continuous
• Specialization vs. Swiss Army Knife approach

• DUST will get everywhere
• ROCKS!

• Different design paradigm
Initial start: testing in relevant environment

• Small to medium scale and short to long duration
  • MTU Planetary Surface Technology lab
    • Currently working on water extraction from gypsum rock for Mars ISRU
    • Lunar Frozen icy regolith water extraction
    • Landing pad and other site construction Subsystem or small system testing

• NASA Early Stage Innovation grant
• Co-I on NASA ISRU BAA NextSTEP : RedWater
• Co-I on NASA SSERVI CLASS
New Dusty Thermal Vacuum Chamber (Fall)

- interior dimension of 60x60x80 inches
- with an internal thermal shroud and thermal base plate.
- The effective internal space 50x50x60 in
- $10^{-4}$ to $10^{-6}$ torr (roughing and turbo pump with dust protection)
- cooled by LN$_2$ (3000 gal LN$_2$ tank - can test for many days in a row, with refills even weeks if needed).
- The temperature range: -196 C to +150C.
- Several feedthroughs (data & power up to 3 phase 440V)
- Built in LED lighting and several windows (upgrade to vertical height)
- Regolith bin of entire bottom surface, height as desired (12 in min)
Future – Industrial Large Scale, Long Duration ISRU Testing

KRC

- 900 acres test terrain (all year)
- Cold, ice, snow, winter testing
- Many different terrains, slopes, surface features
- 30x40ft Bays temp controlled to -40 C
- Mobility, robotics, detection etc.
- Basalt quarry

Expansion of facilities to include Lunar temps and Mars Environment for long duration ISRU testing

- Need for such a facility?
- Could be part of National ISRU lab / consortium / (virtual) Institute
- Capabilities?
Abstract due August 9

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Seattle, Washington | April 20–23, 2020
Engineering for Extreme Environments

https://www.earthspaceconference.org/

Thank You!
Feedback:
pjvansus@mtu.edu