The Lunar Analogue Rover “Artemis Jr.”

Peter Iles – May 15, 2013

ASTRA 2013
Overview

- In-Situ Resource Utilization (ISRU) motivation
- Artemis Jr. rover
  - Mobility
  - Power and Avionics
  - Communication and Control
  - Navigation and Vision
- Mission Simulation Performance
- Path to flight
ISRU Motivation

• Use water, oxygen, hydrogen in the lunar regolith to support lunar activities
• Previous missions found evidence of water and volatiles at south pole
• Desire to verify and map these materials on the ground

(Larson et al., 2011)

Cabeus Crater:
Traversable terrain
Partial illumination
Direct-to-Earth comms

Cold traps
Hydrogen concentrations
ISRU Motivation - RESOLVE payload

- NASA and CSA developed payload
- RESOLVE can:
  - Measure hydrogen in regolith during rover traverse
  - Extract core samples to a depth of 1m
  - Heat core sample to separate volatiles for analysis
  - Produce water from extracted oxygen and hydrogen

(Sanders et al. 2012)
Canadian Lunar Rover Team

• Team led by Neptec Design Group
• CSA funded concept studies and prototyping contracts
Artemis Jr. - Overview

Navigation & Vision Sensors

Chassis & Mobility subsystem

Power subsystem

Communications & Avionics
Chassis & Mobility

1 drive motor per wheel pair/chain drive (skid-steer)

Large compliant metallic wheels

Modular U-shaped payload bay with 150kg capacity

(Visscher et al., 2011)
Chassis & Mobility

Chassis pitch control through actuated suspension

Rough terrain traversal
Power and Avionics

• Battery system:
  • Pair of lithium-ion battery packs installed in frame rails
  • More than 5 kWhr of available energy
• Three (3) Payload power ports
• Solar panel
Power and Avionics

• Central Electronics Unit:
  • 3 single-board computers
  • Gigabit Ethernet network
• Rugged external harness design
Communication and Control

- Remote control station
- RF control, remote teleoperation, autonomous navigation
- Fully configurable telemetry stream
Navigation and Vision

- Stereo navigation cameras
- Sun sensing camera
- Zoom camera with illuminator on PTU
- Wide-FOV camera
- Stereo odometry cameras
Navigation and Vision

• Absolute localization
• Relative localization:
  • Visual odometry x 2
  • Inertial localization
  • Wheel odometry
  • Sun sensor
• Autonomous navigation
• Complementary visual odometry techniques
Navigation and Vision

• Autonomous navigation: path planning and obstacle avoidance
Artemis Jr. with RESOLVE payload
2012 Mission Simulation

Analog ISRU technology demonstration mission:

- Traverse planning
- Roving
- ‘hot spots’ identification
- Sample acquisition and analysis
- Mission operations
Mission Simulation Performance

• Supported mandatory mission simulation objective to map volatiles across >100m
• Carried payload and drill to support coring operations at three locations

(Sanders et al. 2012)
Mission Simulation Performance

• Rover-specific:
  • 2km without issues on-site demonstrated robustness and reliability
  • Power system provided reliable power to RESOLVE; no need to recharge during mission day
  • Localization system demonstrated <1m accuracy during mission out to 500m from lander
  • 2% relative localization error demonstrated
  • Teleoperation and autonomous traverses
Path to Flight

Hawaii

Moon

Similar terrain

Similar scenario

Weather is slightly different...
Path to Flight

- Ongoing CSA funded Phase 0 Concept study:
  - Environmental considerations: thermal, radiation
  - Power self-sufficiency
  - Lander interface
  - Payload interface refinement
  - Communications
  - Shadowed operations and night survivability

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume Envelope</td>
<td>2m x 1.4m x 1.6m (H x L x W)</td>
</tr>
<tr>
<td>Maximum Mass</td>
<td>150 Kg</td>
</tr>
<tr>
<td>Driveline</td>
<td>All-Wheel-Drive</td>
</tr>
<tr>
<td>Speed</td>
<td>10 cm/s (nominal) .. 50 cm/s / (max)</td>
</tr>
<tr>
<td>Maximum Range</td>
<td>5 km (radius of 1km, 3Km max range)</td>
</tr>
<tr>
<td>Maximum Gradient</td>
<td>15 degrees</td>
</tr>
<tr>
<td>Side Slope</td>
<td>10 degrees</td>
</tr>
<tr>
<td>Ground Clearance</td>
<td>25 cm</td>
</tr>
<tr>
<td>Payload bay</td>
<td>670mm x 1000mm (propose to change to 0.7mX1m)</td>
</tr>
<tr>
<td>Payload Mass</td>
<td>100 kg</td>
</tr>
<tr>
<td>Communication Delay</td>
<td>5 to 10 sec. round-trip (currently being clarified with DSN)</td>
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<tr>
<td>Bandwidth limits</td>
<td>Surface ops: 2 kbits/s (Uplink), 400 kbits/s (Downlink) while stationary minimum</td>
</tr>
<tr>
<td>Navigation Self-Sufficiency</td>
<td>No reference to external navigational aids (e.g. No total station)</td>
</tr>
<tr>
<td>Sun Shadow Operations</td>
<td>6 hours</td>
</tr>
<tr>
<td>Lunar Night Survivability</td>
<td>Augmented mission</td>
</tr>
<tr>
<td>Data Storage</td>
<td>32 GBytes</td>
</tr>
<tr>
<td>Autonomous GN&amp;C</td>
<td>As applicable to achieve the concept of ops</td>
</tr>
<tr>
<td>ISRU Reactor</td>
<td>25 Samples @ 150 C</td>
</tr>
<tr>
<td>GasChrom. / Mass Spec.</td>
<td>25 Samples</td>
</tr>
<tr>
<td>Neutron Spectrometer</td>
<td>3,000 m</td>
</tr>
<tr>
<td>Near-IR Spectrometer</td>
<td>3,000 m, 10 angular cuttings</td>
</tr>
<tr>
<td>Mission Energy</td>
<td>51,500 W-hr available</td>
</tr>
<tr>
<td>Mission Ave. Power</td>
<td>181 W predicted</td>
</tr>
<tr>
<td>Payload Mass</td>
<td>72 kg</td>
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<tr>
<td>Rover + P/L Mass</td>
<td>243 kg</td>
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<tr>
<td>Landed Mass</td>
<td>1,285 kg</td>
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<tr>
<td>Wet Mass @ TLI</td>
<td>3,476 kg</td>
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<tr>
<td>Launch Vehicle</td>
<td>Atlas V-411</td>
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Questions