Government of Canada:
Innovation Agenda

New Federal Government – October 2015

Canada’s Innovation Agenda – June 2016

New Space Strategy – June 2017

“[the] Space Strategy is in effect a research and innovation strategy that will support growth in the sector and leverage the benefits of space for all Canadians.”

Source: Minister Bain’s Speech at the Aerospace Industries Association of Canada Summit on 16 November 2016
Highlights of 2016-17

Canadian Budget 2016

- June
  - Applications sought: Canadian astronauts (2)
  - Consultations

- September
  - Launch of OLA on NASA OSIRIS-REx

- October
  - MSL APXS EM2 approval

- November
  - Canadian MSR Analogue Deployment (Utah)
  - ESA Ministerial
  - Canadian Space Exploration Workshop (Montreal)

- December
  - NeMO SAR Concept Study posting

Canadian Budget 2017

- March
  - Applications sought: Canadian Space Advisory Board

- April
  - Canadian Space Advisory Board convened

- June
  - CSEW Science Priorities report
  - Canadian Space Strategy
  - NeMO SAR Concept Study posting

- APXS
OSIRIS-REx Laser Altimeter

• ‘High power’ laser: direct heritage from CSA’s Mars Phoenix MET
• 4% of sample to be curated in Canada

OSIRIS-REx
OLA: CANADA’S CONTRIBUTION
PI: Mike Daly, York
Built by MDA, Brampton

WHAT IS OLA?
The OSIRIS-REx Laser Altimeter (OLA) is a scanning lidar (light detection and ranging) instrument that works similarly to radar, but uses infrared light instead of radio waves to measure distances.

WHAT IT WILL DO
OLA will scan and measure the entire surface of the asteroid Bennu to create a highly accurate 3D model of the asteroid, and provide mission scientists with unprecedented information on the asteroid’s shape, topography, distribution of boulders, rocks and other surface features.

HOW OLA WORKS
Similar to a police radar, OLA is a time-of-flight system, whereby scientists measure the round-trip time of laser pulses travelling from OLA to millions of points on the surface of Bennu and back. This will allow scientists to determine the topography of the asteroid.

OLA IN NUMBERS
- Mass: 22.9 kg
- 4,000 mechanical parts
- 3,000 electrical parts
- 30 optical parts
- 15 circuit cards
- 2 lasers
- 1 scanning mirror

OLA only uses the power of a 75 W light bulb!
~400 samples to date
10 MSc & PhD theses

Quantify rock chemistry, relate rock formations along traverse, triage and context for sampling, elemental correlations

EM2: APXS - CANADA’S CONTRIBUTION TO MSL
PI: Ralf Gellert, Guelph
Built by MDA, Brampton

Participating Scientists:
Richard Leveille, McGill
John Moores, York
Mariek Schmidt, Brock

UNIVERSITY OF GUELPH
CSA ASC
APXS
NASA
MARS SCIENCE LABORATORY
2016 Canadian Mars Sample Return Analogue Deployment

22nd Oct – 18th Nov, Utah

Week 0 Set-up
Weeks 1&2 Cache Rover Mission
Week 3 Fetch Rover Technology testing
‘human rover’ Cache Mission continuation
Field validation team
The road to the Canadian 2016 MSR Analogue Deployment

iMARS 1 Working Group

2009

2010

2011

2012

2013

2014

2015

2016

CSA MSR analogue mission Science Definition Team (with NASA, JPL participation)

Stimulus: prototype rovers, drill, vision system, science instruments

Rover, hardware, and instrument tests

Analogue geological sample library contract

MSR Field Site selection contract

iMARS 2 Working Group

Utah Field Deployment

Utah Analogue Deployment
2016 Canadian MSR Analogue Deployment

Building on successful 2015 operations...

Analogue Mars Mission 2015

Training tomorrow’s planetary space explorers

In partnership with the Canadian Space Agency (CSA), Western University is serving as science mission control for a Mars rover simulation exercise taking place from November 16 to 27, 2015.

The Science Team

Western University
London, Ontario
Role: Interpreting data, planning daily operations of the simulation

The Rover Control Team

Canadian Space Agency
Saint-Hubert, Quebec
Role: Validating the science plan, preparing command sequences, executing commands and monitoring systems

The Field Site Team

Utah, United States
## 2016 Canadian MSR Analogue Deployment

### Objectives: Cache science & Fetch technology

<table>
<thead>
<tr>
<th>Element</th>
<th>Objective</th>
<th>Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>International</strong></td>
<td><strong>collaboration</strong></td>
<td><strong>Develop and strengthen partnerships + position Canada for future contributions</strong></td>
</tr>
<tr>
<td><strong>Science / Operations</strong></td>
<td><strong>Advance MSR science operations and sample targeting.</strong></td>
<td><strong>Sought ‘highest organic carbon’ samples:</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Co-ordination through Science Plan</strong></td>
<td><strong>Utilized autonomous targeting &amp; decision-making to increase efficiency of Mars 2020 simulated payload</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Tested the accuracy of sample selection vs. traditional field party</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Tested the efficiency of remote science operations using pre-planned strategic traverse days</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Determine factors that affect the quality of sample-selection decision (analysis of returned samples)</strong></td>
</tr>
<tr>
<td><strong>Technical Development</strong></td>
<td><strong>Advance selected rover autonomy and arm positioning technologies</strong></td>
<td><strong>929m fully autonomous traverse. Navigated to sample cache locations and returned samples to MAV</strong></td>
</tr>
<tr>
<td><strong>Communications</strong></td>
<td><strong>Attract and inspire the general public in STEM subject matter</strong></td>
<td><strong>Messages from the CSA about MSRAD were displayed more than a million times on social media.</strong></td>
</tr>
<tr>
<td><strong>Education / Training</strong></td>
<td><strong>Provide valuable learning opportunities to students</strong></td>
<td><strong>Participation of &gt; 30 appreciative students &amp; PDFs</strong></td>
</tr>
</tbody>
</table>
2016 Canadian MSR Analogue Deployment
Analogue site
5km NW of Hanksville, Utah

- **2016 CAMPAIGNS**
  - **2015 Cache mission**
  - **2016 Fetch mission**
  - **2016 Cache mission**

Inverted riverbeds exhumed from Morrison formation (e.g., Williams et al., 2007); poorly consolidated sandstones source of hematite concretions.
Sample selection and collection tools

Hand-carried:

- Delta-Nu Rockhound Raman (785nm);
- B&W Tek iRaman (532nm);
- SciAps Z-500 contact LIBS;
- VIS-IR: ASD Fieldspec 3.
2016 Canadian MSR Analogue Deployment
Week 3: Cache Mission continued
Hand-held instruments only, 1 day = 3 sols

Sites visited, revisited, sampled, and visited again!
Pre-planned ‘Strategic observation days’ – use of autonomous rover targeting, and, science team resources to improve depositional model with the expectation this would improve decision-making. With support from Scott McLennan, Ken Williford and Raymond Francis.

- Pilles et al, *Implementation of Strategic Traverse Days During the CanMars 2016 Mars Sample Return Analogue Mission [#2018]*
Cloutis et al, *A Hydrologic- and Biosignature-Driven Field Campaign at an Inverted Fluvial Channel Site: Hanksville, UT, USA [#2464]*

Human field team given same task to perform in one day: Seek priority organic carbon sample for ‘return to Earth’.

Beaty et al. *Field Validation for the 2016 CANMARS Analogue Mission [#2750]*

Hipkin et al, *Learning from Traditional Field Geology and 2016 CANMARS Rover-Based Remote Science Operations Approaches to Sample Selection [#2709]*

Extensive data set. Further validation planned after analysis of ‘returned samples’.

MEPAG, Feb 22 2017
2016 Canadian MSR Analogue Deployment

Week 3: Fetch mission
Seek, capture, transfer to MAV
2016 Canadian MSR Analogue Deployment
Rover technology results

Science mission (Ops weeks 1&2)

<table>
<thead>
<tr>
<th>Distance traveled (autonav)</th>
<th>316 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number arm placements, rock abrasions, cores taken</td>
<td>1</td>
</tr>
<tr>
<td>Number of sols</td>
<td>10</td>
</tr>
<tr>
<td>Total ops time (ExDOC)</td>
<td>44 h</td>
</tr>
</tbody>
</table>

Fetch mission (Ops week 3)

<table>
<thead>
<tr>
<th>Distance traveled (autonav)</th>
<th>613 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samples captured</td>
<td>6</td>
</tr>
<tr>
<td>Samples delivered to the MAV</td>
<td>6</td>
</tr>
<tr>
<td>Number of sols</td>
<td>6</td>
</tr>
<tr>
<td>Total ops time (ExDOC)</td>
<td>47 h</td>
</tr>
</tbody>
</table>

- Vision systems approach for sample transfer to the MAV worked well
- Arm operations in an unstructured environment remains challenging
- Tube handling requirement for avoiding magnetism adds complexity
- 3D printing machine allows the team to deliver quick prototypes
Video

MSRAD-2016-Fetch-Rover-Ops-Sol-1-short-story-with-CSA-watermarks.mp4
Follow on MSR activities: in discussion
What science objectives and investigations should Canada pursue to effectively engage in future space exploration missions? *(mid-2020 to 2040)*

**Topical Teams:**
- Astrobiology
- Planetary Geology, Geophysics & Prospecting
- Planetary Atmospheres
- Planetary Space Environment

**Final report anticipated April-May 2017**
CSA Mars SAR Concept Study RFP

  • C-band, polarimetric, 1 x 3m resolution
  • Interest in next-generation
    P-band for terrestrial permafrost

• Canadian community interested in Mars SAR
  • Canadian Mars SAR Studies in 2007 and 2009
    • P,C band, polarimetric

• 2017 Concept Study RFP based on NEX-SAG report
• 2017 Space Technologies Development Program RFI
  • Mars SAR Signal Amplifier / Antenna Technologies
Questions?

asc-csa.gc.ca