RADARSAT Constellation Mission Update

Stéphane Chalifoux
Canadian Space Agency

POLinSAR 2015 & 1st BIOMASS Science Workshop
January 26, 2015
Frascati, Italy
Outline

✓ Mission & Satellite Description
✓ Enhancements
✓ Ground Segment
✓ Data Products
✓ Data Policy
✓ Data Acquisition & Capacity
✓ Applications
Key Mission Drivers

• **Ensure continuity** of C-Band SAR data, available to Canadian operational users since 1995

• **Daily coverage** of Canadian land and waters, enabling daily monitoring of Canada’s maritime approaches for detection of illegal vessel activity and pollution

• Supports **northern development** through surveillance of the North West passage, ice monitoring and mapping

• Supports response to **natural disasters** with an average daily global access

• **Greater revisit capability** for a more efficient monitoring and management of natural resources and sensitive ecosystems.

• Design addresses the increasing requirement for radar imagery in support of existing and new operational Canadian government programs
# System Description

## Specifications

<table>
<thead>
<tr>
<th>Bus</th>
<th>Canadian Smallsat Bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Launcher</td>
<td>SpaceX - Falcon 9</td>
</tr>
<tr>
<td>Total Mass</td>
<td>1400 kg</td>
</tr>
<tr>
<td>Antenna</td>
<td>9.45m²</td>
</tr>
<tr>
<td>Power</td>
<td>&lt;1600 W peak; &lt;220 W average</td>
</tr>
<tr>
<td>SAR Frequency</td>
<td>C band – 5.405 GHz</td>
</tr>
<tr>
<td>Polarisation</td>
<td>Single Pol / Dual cross selectable pol &amp; Compact polarimetry available on all modes; One fully polarimetric mode</td>
</tr>
<tr>
<td>Imaging Time</td>
<td>15 minutes/orbit average (peak 25 minutes every 3 orbits) 10 minutes continuous imaging</td>
</tr>
<tr>
<td>On-board data storage</td>
<td>500 Gbit (EOL)</td>
</tr>
<tr>
<td>Data Downlink</td>
<td>X-band (2x 150Mbps)</td>
</tr>
<tr>
<td>Lifetime</td>
<td>7 years (each satellite)</td>
</tr>
</tbody>
</table>

## Orbit

<table>
<thead>
<tr>
<th>Nominal Altitude</th>
<th>592.7 km circular</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orbit Type</td>
<td>Dusk-Dawn, Sun Synchronous, Frozen</td>
</tr>
<tr>
<td>Ascending Node Crossing Time</td>
<td>18:00 (local time)</td>
</tr>
<tr>
<td>Inclination</td>
<td>97.74°</td>
</tr>
<tr>
<td>Orbital Period</td>
<td>96.4 minutes</td>
</tr>
<tr>
<td>Orbit Repeat Cycle</td>
<td>12 days</td>
</tr>
<tr>
<td>Spacecraft Separation</td>
<td>120 degrees (3 spacecraft on one orbit plane)</td>
</tr>
<tr>
<td>Coherent Change Detection Period</td>
<td>4 days</td>
</tr>
<tr>
<td>Orbital Tube (CCD)</td>
<td>100 m radius</td>
</tr>
</tbody>
</table>

Drawing courtesy of MDA
SAR Imaging Modes

Satellite Velocity Vector

Sub-satellite Ground Track (Nadir)

Low Resolution 100m Mode
Medium Resolution 50m Mode
Medium Resolution 30m Mode
Medium Resolution 16m Mode
High Resolution 5m Mode
Very High Resolution 3m Mode
Low Noise/Ship Detection Mode
Quad-Pol Mode
Spotlight Mode
### Modes Details

<table>
<thead>
<tr>
<th>Mode</th>
<th>Res. m</th>
<th>Looks rng x az</th>
<th>Swath Width (accessible) km</th>
<th>Nominal NESZ (dB)</th>
<th>Polarization Options</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Single VV, VV, HH</td>
</tr>
<tr>
<td>Low Resolution</td>
<td>100</td>
<td>8x1</td>
<td>500 (500)</td>
<td>-22</td>
<td>✓ ✓ ✓ ✓</td>
</tr>
<tr>
<td>Medium Resolution</td>
<td>50</td>
<td>4x1</td>
<td>350 (500)</td>
<td>-22</td>
<td>✓ ✓ ✓ ✓</td>
</tr>
<tr>
<td>Medium Resolution</td>
<td>16</td>
<td>1x4</td>
<td>30 (350)</td>
<td>-25</td>
<td>✓ ✓ ✓ ✓</td>
</tr>
<tr>
<td>Medium Resolution</td>
<td>30</td>
<td>2x2</td>
<td>125 (350)</td>
<td>-24</td>
<td>✓ ✓ ✓ ✓</td>
</tr>
<tr>
<td>High Resolution</td>
<td>5</td>
<td>1</td>
<td>30 (500)</td>
<td>-19</td>
<td>✓ ✓ ✓ ✓</td>
</tr>
<tr>
<td>Very High Resolution</td>
<td>3</td>
<td>1</td>
<td>20 (500)</td>
<td>-17</td>
<td>✓ ✓ ✓ ✓</td>
</tr>
<tr>
<td>Low Noise</td>
<td>100</td>
<td>4x2</td>
<td>350 (500)</td>
<td>-25</td>
<td>✓ ✓ ✓ ✓</td>
</tr>
<tr>
<td>Ship Detection</td>
<td>var.</td>
<td>var.</td>
<td>350 (600)</td>
<td>variable</td>
<td>✓ ✓ ✓ ✓</td>
</tr>
<tr>
<td>Spotlight</td>
<td>1 x 3</td>
<td>1</td>
<td>20 (350)</td>
<td>-17</td>
<td>✓ ✓ ✓ ✓</td>
</tr>
<tr>
<td>Quad-Polarization</td>
<td>9</td>
<td>1</td>
<td>&gt; 20 (&gt;250)</td>
<td>-24</td>
<td>✓</td>
</tr>
</tbody>
</table>
Automatic Identification System (AIS)

- Each satellite will include an **AIS payload** which will receive AIS transponder transmissions from ships.

- RCM 3-satellites will provide a very high probability of **detecting and tracking all ships** approaching Canada.

- Real time coherent acquisition of **AIS signal in conjunction with SAR data** will enable the identification of vessels of interest that are non-compliant with regulations prescribing that all ships beyond 300 tons (Class A) transmit their identification and location.
Project Status

- Design completed – Mission Critical Design Review held in Nov 2012
- Project approved and funded (phase D, launch and operations)
- The Government of Canada will own the RCM satellites and data, and will control data dissemination. CSA is the prime authority for its operation and management.
- **Phase D ongoing.** All units are in full flight manufacturing as per plan.
- Spacecraft assembly, integration and test plan are being finalized.
- Ground segment system level preliminary design review completed.
- Planned for launch in Q3 2018.
Outline

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# RADARSAT Satellites

<table>
<thead>
<tr>
<th></th>
<th>RADARSAT-1</th>
<th>RADARSAT-2</th>
<th>RCM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mass</strong></td>
<td>2750 kg</td>
<td>2280 Kg</td>
<td>1400 Kg</td>
</tr>
<tr>
<td><strong>Complete Coverage</strong></td>
<td>2-3 days</td>
<td>2-3 days</td>
<td>Daily coverage</td>
</tr>
<tr>
<td><strong>Exact Revisit</strong> $^1$</td>
<td>24 days</td>
<td>24 days</td>
<td>4 days (12/sat)</td>
</tr>
<tr>
<td><strong>Imaging time /orbit</strong></td>
<td>28 min</td>
<td>28 min</td>
<td>15 min /sat$^1$</td>
</tr>
<tr>
<td><strong>Antenna Span</strong></td>
<td>15 m</td>
<td>15 m</td>
<td>6.75 m</td>
</tr>
<tr>
<td><strong>Polarization</strong></td>
<td>Single HH</td>
<td>Single, Dual, Polarimetric</td>
<td>Single, Dual, Compact Pol, Polarimetric (exp)</td>
</tr>
<tr>
<td><strong>Altitude</strong></td>
<td>800 km</td>
<td>800 km</td>
<td>600 km</td>
</tr>
</tbody>
</table>

(1) Non-eclipse period.
• **3 satellite constellation** flying in the same orbit plane equally spaced (32 minutes). Will be controlled to fly in an “orbital tube” of radius 100 meters.

• **4-day displacement detection** (CCD using SAR interferometry)

• Multi-polarization including **Compact Polarisation**.

• Average **daily access** to 95% of any point on the globe.

• **Fast tasking** capability; Imaging requirement can be uploaded to the satellite in less than 4 hours.

• **Phase Preserving ScanSAR** Processing.

• Includes a vessel **Automatic Identification System (AIS)** on each satellite.
Satellite Daily Coverage

Current coverage with RADARSAT-2

- 4 days required to complete coverage of Canadian AOI
- Major gaps in maritime approaches
- Northwest West Passage coverage also incomplete.

Coverage with RCM

- Complete daily coverage of Canadian AOI
- Increased maritime probability of detection
- Coverage of North West Passage up to 4 times daily
Compact polarization

- Quad-Polarization provides full scattering matrix, but with a reduced swath

- Objective of Compact Polarimetry is to realize many (but not all) benefits of quad-polarization, without the reduced swath

- RCM Compact Polarimetry:
  - Transmit circular polarization
  - Receive dual linear H and V

Credit: François Charbonneau, NRCan

RADARSAT-2 Data and Product © MacDonald, Dettwiler and Associates Ltd. (2010) – All Rights Reserved
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Proprietary Information to the Crown or a third party
Coherent Change Detection (CCD)

- Short-period (4-day)
- ScanSAR (125 km) and Stripmap (30 km) modes optimized for CCD
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Ground Stations Mask
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Raw Products
- Raw Radar data in Framed Raw Expanded Data (FRED) format

Image Products
- Variety of processing levels
  - single-look complex products (SLC); equivalent to a SLC product for RADARSAT-1 or RADARSAT-2.
  - multi-looked power-detected geo-referenced products (GRD, GRC); equivalent to an SGX, SCN or SCW product for RADARSAT-1 or RADARSAT-2.
  - geo-coded products (GCD, GCC); equivalent to an SSG or SPG product for RADARSAT-1 or RADARSAT-2.
- Same format as RADARSAT-2: GeoTIFF images with XML meta-data + NITF 2.1 format.
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RCM Data Policy Principles

As approved by Deputy Ministers Governance Committee on Space (February 2014):

- **Canadian Interests First**
  - Give priority to GoC requirements in support of sovereignty, security and safety
  - Fuel prosperity and advance foreign policy objectives

- **Economic Growth**
  - Strengthen Canadian industry’s capacity to commercialize value added application products and services, at home and abroad

- **Support Partnerships**
  - Enable cooperation with allies/partners to meet socio-economic and security objectives
  - Support international organizations related to safety, humanitarian programs and other initiatives of benefit to Canadians

- **Commercial distribution of RCM data**
  - Enable the commercial distribution of RCM data, while being compliant with the Open Government Strategy

**Next Step:**
- Baseline Policy currently within internal approval chain
- Initiate work on the Data Policy Implementation document for SAR and AIS data
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Standard Coverage Concept

✓ Situation in Canada
  • Large geographic and temporal overlaps in users and applications requirements
  • Various preferred imaging modes

✓ Approach
  • Analyse user imaging requirements spatially and temporally over the annual cycle to determine a "feasible" imaging scenario, with agreed upon plans in overlapping zones

✓ Result → **Standard Coverage**
  • Collections of data acquired routinely in harmonized and de-conflicted imaging modes intended to optimize and maximize the utility of the data across all User requirements.

**Fast Tasking Capability.** If a fast tasking request is received at the command and control centre, it shall be possible to analyze the request, generate commands, contact the satellite, supersede planned operations if necessary and upload request in less than 4 hours, regardless of where the satellite is in its orbit. This capability will only be used exceptionally, e.g. for emergency situations.
# Maritime Operational User Needs Coverage Areas

## Ice
- **Arctic**:
  - Weekly – Dec.– May
  - Daily – June – Nov.
- **Inland Lakes**: Weekly – Oct. to June
- **GL, East Coast & Nfld.**:
  - Daily – Dec. – August

## Oil Pollution
- **Arctic**:
  - Daily – June – Nov.
  - Open Water Areas
- **West Coast**:
  - Daily – Year Round
- **GL & East Coast**:
  - Daily – June– November

## Marine Winds
- **Arctic**:
  - Daily – June – Nov.
  - Open Water Areas
- **West Coast**:
  - Daily – Year Round
- **GL & East Coast**:
  - Daily – May– November

## Vessel Detection
Outline

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Applications

Sovereignty and Security – RCM will provide enhanced coverage of Canada and abroad to assure the safety and security of Canadians to contribute satellite images for international security. Combining space-based radar images and AIS signals will provide a powerful surveillance capacity over Canada’s maritime approaches.

Maritime monitoring - The daily coverage of marine areas will support activities such as fisheries monitoring, ice and iceberg monitoring, oil pollution monitoring and integrated ocean and coastal zone management.

Northern Development - The regular and comprehensive imaging of Canada’s North and maritime approaches will be a direct contribution to the Arctic sovereignty, pillar of Canada’s Northern Strategy.
Applications

**Disaster management** - RCM will provide critical data in a timely manner to support disaster mitigation, warning, response and recovery activities, as well as contributing to Canada’s obligations to international disaster relief.

**Environmental monitoring** - RCM will provide data for wide area change detection. RCM data will contribute to the production of more accurate weather forecasts, marine conditions, ice condition and ecosystems.

**Management of natural resources** - RCM data will be a source of information on Canada’s agriculture, forestry and wildlife habitat. In addition, RCM data will be used to support mining and energy sectors for explorations operations to ensure that infrastructure is monitored properly for safety and its integrity.
Sentinel-1 / RCM Joint Activities

- The following collaboration items are discussed:
  - Joint / integrated pre-defined observation plans (complementarities in observations / modes, increased revisit, etc.)
  - Harmonisation of catalogue interface
  - Development of common tools
  - Harmonised communication, joint publications etc.

- A joint calibration working group has been set up

- Canadian users data requirement assessed and defined

- Collaborative Ground Segment process

In addition, cooperation to support international activities should be continued to set up complementary observations (GFOI, PSTG, etc)
Thank You!