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Canadian Space Agency  
Longueuil, Canada  

CEOS SAR 2019 Workshop  
VH-RODA Workshop
RADARSAT Constellation Mission

• The evolution of the RADARSAT program with the objectives to:
  ✓ Ensure data continuity, and;
  ✓ Respond to the increasing needs of the Government of Canada for SAR data to support operations and timely delivery of products and services to Canadians.

• RCM is a government-owned mission, tailored to respond to the Canadian Government needs in 3 main areas:
  ✓ Maritime surveillance
  ✓ Disaster management
  ✓ Ecosystem monitoring
<table>
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<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>2750 kg</td>
<td>2300 kg</td>
<td>1430 kg</td>
</tr>
<tr>
<td>24 day</td>
<td>24 day</td>
<td>4 day (12 / sat)</td>
</tr>
<tr>
<td>28 min</td>
<td>28 min</td>
<td>15 min / sat</td>
</tr>
<tr>
<td>800 km</td>
<td>800 km</td>
<td>600 km</td>
</tr>
<tr>
<td>15 m</td>
<td>15 m</td>
<td>6.75 m</td>
</tr>
<tr>
<td>HH</td>
<td>HH, VV, HV, VH</td>
<td>HH, VV, HV, VH, Compact Pol.</td>
</tr>
<tr>
<td>Right</td>
<td>Right or Left</td>
<td>Right</td>
</tr>
<tr>
<td>Gov. of Canada</td>
<td>MDA</td>
<td>Gov. of Canada</td>
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</tbody>
</table>
Mission Numbers

• Evenly spaced satellites on same orbital plane (120 deg.)
• Altitude 600 km, sun-synchronous
• Orbit period of 96.4 minutes
• Orbit maintained within a 100m orbital tube
• Payloads:
  ➢ C-Band SAR – 5.405 GHz
  ➢ Automatic Identification System (AIS)
• 7 years design life

• Fast tasking capability: 4 hours from order input to satellite tasking
• Capability to observe, daily, a chosen point on 90% of the world’s surface
Evolution of RADARSAT data usage by GoC

GoC user departments forecast to use approximately 250,000 RCM images per year.
Year-round coverage

Coverage may be changed without notice to meet requirements of the Government of Canada.
Domestic and global coverages that are exclusively for defence and security not shown.
RCM acquisitions are planned to supply data required for Government of Canada service delivery to Canadians.
Imaging Modes

- 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
- Spotlight Mode
# Imaging Modes - Details

<table>
<thead>
<tr>
<th>Modes</th>
<th>Nominal Resolution m</th>
<th>Number of Looks for detected products rng x az</th>
<th>Nominal Swath Width (accessible) km</th>
<th>No of Swath Positions</th>
<th>Nominal NESZ dB</th>
<th>Polarization Options</th>
<th>Product Options</th>
<th>Fixed point (16-bit)</th>
<th>Floating point (32-bit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Resolution 100m</td>
<td>100</td>
<td>8x1</td>
<td>500 (500)</td>
<td>1</td>
<td>-22</td>
<td>✓        ✓ ✓ ✓       ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium Resolution 50m</td>
<td>50</td>
<td>4x1</td>
<td>350 (500)</td>
<td>4</td>
<td>-22</td>
<td>✓        ✓ ✓ ✓       ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium Resolution 30m</td>
<td>30</td>
<td>2x2</td>
<td>125 (350)</td>
<td>4</td>
<td>-24</td>
<td>✓        ✓ ✓ ✓       ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium Resolution 16m</td>
<td>16</td>
<td>1x4</td>
<td>30 (350)</td>
<td>16</td>
<td>-25</td>
<td>✓        ✓ ✓ ✓       ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Resolution 5m</td>
<td>5</td>
<td>1</td>
<td>30 (500)</td>
<td>23</td>
<td>-19</td>
<td>✓        ✓ ✓ ✓       ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very High Resolution 3m</td>
<td>3 @35°</td>
<td>1</td>
<td>20 (500)</td>
<td>42</td>
<td>-17</td>
<td>✓        ✓ ✓ ✓       ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Noise</td>
<td>100</td>
<td>4x2</td>
<td>350 (500)</td>
<td>4</td>
<td>-25</td>
<td>✓        ✓ ✓ ✓       ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ship Detection</td>
<td>variable</td>
<td>5x1</td>
<td>350 (350)</td>
<td>1</td>
<td>variable</td>
<td>✓        ✓ ✓ ✓       ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quad-Polarization¹</td>
<td>9</td>
<td>1</td>
<td>20 (250)</td>
<td>21</td>
<td>-24</td>
<td>✓        ✓ ✓ ✓       ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spotlight</td>
<td>1 (az) x 3 (grd) @35°</td>
<td>1</td>
<td>20 (350)</td>
<td>29</td>
<td>-17</td>
<td>✓        ✓ ✓ ✓       ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓</td>
<td></td>
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</table>

1) There are no performance requirements for the quad-polarization mode: expected performance shown.
2) Some performance parameters will be degraded in HH+VV: swath width is reduced to 250km for Low Resolution 100m and to 175km for Medium Resolution 50m; number of looks in azimuth is reduced to one for Medium Resolution 30m and two for Medium Resolution 16m; azimuth resolution is degraded to 10m for High Resolution 5m and to 6m to 8m for Very High Resolution 3m. Complex products (SLC, GRC or GCC) are not available for the HH+VV polarization.
Second RADARSAT Constellation Mission satellite separates from the Falcon 9 rocket.

**RCM Status**

- Launch and Early Orbit (LEOP) phase completed June 18.
- 1\textsuperscript{st} Engineering Image published June 29.
- More than 5,000 images have been acquired from all three satellites since start of commissioning.
- SAR Data Policy released in August.
- Successful Commissioning Nov 14.
- Phased operation transition to RCM has begun.

Credit: SpaceX
IQS

IQS Core Component provides analysis capabilities for calibration activities:

1. Image Quality Analysis
   - Point target analysis (CRs and transponders)
   - Distributed target analysis
   - Beam pattern analysis
   - Polarimetric analysis
   - Noise analysis
   - 2D bandwidth overlap measurement
   - Non-imaging calibration analysis
   - Coverage analysis

2. Statistics and Trending

Reference sites: Amazon basin, corner reflector, precision transponders
First RCM Engineering Image

Qikiqtarjuaq, Baffin Island, Nunavut

2019-06-29
10:24:35 UTC
Descending
Low Noise ScanSAR
100m x 100m
350 km
HH
3-bit BAQ
GRD Product
Commissioning

Spacecraft initial attitude
• Pitch bias (ADCS timing issue)
• Incorrect sign in yaw steering
  ➢ Manifested as large geolocation errors and IQ issues
• Large roll bias on RCM-2

ScanSAR image quality issues (resolved)
• Incorrectly commanded “stepped receive”
• ScanSAR missing beams (payload timing)
  ➢ Fully corrected via ground configuration

Spacecraft CCRs leading to the CCCR

Initial Calibration Metrics:
• Resolution
• Geolocation
• Radiometry
• Full Polarimetry
• Compact Polarimetry
• CCD

Montreal, 2019-07-19
Ascending
Very High Res Stripmap
3m x 3m
20 km
CH+CV
Improved response to disaster events

Abaco Islands (Bahamas)

- 7 reported killed in the Bahamas as of Sept. 4
- 5 Coast Guard helicopters ran near-hourly flights to the stricken Abaco, flying more than 20 injured people to safety
- 13,000 houses damaged or destroyed
- 60,000 people on the islands will need food, and the Red Cross said some 62,000 will need clean drinking water

Acquisition Date: Sept 7, 2019
Resolution: 3m x 3m
Swath width: 20 km
Polarisation: Compact Pol
What’s new with RCM - Highlights

Average daily complete coverage of Canada’s land and maritime approaches

Ability to observe daily a chosen point on 90% of the world’s surface + Fast Tasking (4 hour)

4-day repeat pass for CCD (spacecraft-to-spacecraft CCD with stepped receive ScanSAR)

Secondary payload - Automatic Identification System (AIS) for ship detection and identification

Circular Compact Polarization (all modes) + Multi-polarization on High (5m) and Very High (3m) resolution modes

Next Steps:
- Operation phase-in with users, transitioning to RCM
- Initiate Standard Coverage submissions
- Consolidate calibration numbers and operationalize cal-val monitoring
- Finalize and integrate data access and data use modalities (EULA, vetting)
To know more about the mission

What is the RCM?
Overview of the RADARSAT Constellation Mission, its characteristics and its applications.

Providing solutions to key challenges
Effective maritime surveillance, ecosystems monitoring, timely disaster management.

Meet RADARSAT users
Who uses RADARSAT data and how, applications and benefits of satellites in our everyday lives.

Mission milestones
A look back at RCM milestones, starting with the planning phase in 2004.

Technical features
Components and technical specifications; comparison between RADARSAT-1, RADARSAT-2 and the RCM.

Access to the data
Data policy, data distribution and use, FAQ.

Canadian Space Agency
RADARSAT Constellation Mission

SAR Data Policy

Revision: Initial Release (IR)
August, 2019

Web: www.asc-csa.gc.ca/rcm
Email: asc.mcr-info-rcm-info.csa@canada.ca
Canadian suppliers*

**NOVA SCOTIA**
- Braden's Tool and Die - Amherst
- MDA, a Maxar company - Dartmouth
- IMP Group - Halifax
- STELIA Aerospace - Lunenburg

**QUEBEC**
- F.J. Machine Shop - Baie-D'Urfé
- C&R Développement - Gatineau
- CMR Summit Technologies - Pointe-Claire
- MDA, a Maxar company - Sainte-Anne-de-Bellevue
- MecaChrom - Mirabel
- Apex Precision - Saint-Laurent
- JLM - Saint-Augustin-de-Desmaures
- Sonaca - Mirabel
- Atelier d'usinage - Vaudreuil-Dorion
- Pierre Fortier

**BRITISH COLUMBIA**
- MDA, a Maxar company - Richmond

**MANITOBA**
- Magellan Aerospace - Winnipeg

**ONTARIO**
- COM DEV - Cambridge
- Hi-Rel Alloys - Niagara Falls
- Filtran - Kanata
- Wejay - Kingston
- ITL Circuits - Markham
- FTG - Scarborough
- A-Line/Muru - Toronto

*Companies listed on the illustration are the main suppliers in terms of contract dollars spent. In total, there are over 125 suppliers in seven Canadian provinces.
RADARSAT Constellation Mission: CANADA’S NEW GENERATION OF EARTH OBSERVATION SATELLITES

THANK YOU!

LAUNCH: Spring 2019 aboard a SpaceX Falcon 9 rocket

3 IDENTICAL SATELLITES working together

MAIN USES:
Monitor the environment, oceans and ice; support emergency teams during natural disasters; detect ships

ALTITUDE: 600 km

SPEED: 27,200 km/h
One Earth orbit every 96 minutes

APPROXIMATELY 250,000 IMAGES PER YEAR will be used

50 times more than the first generation of RADARSAT

MASS: 1,430 kg each (like a black rhino)

WWW asc-csa.gc.ca/rcm
## RCM SAR Data Policy and Access in Brief

<table>
<thead>
<tr>
<th>Acquisition</th>
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<tbody>
<tr>
<td>• Government of Canada task the satellites, though Standard Coverages and ad hoc acquisitions</td>
</tr>
<tr>
<td>• Industry, non-GoC governments and academic users</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Access Distribution</th>
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</thead>
<tbody>
<tr>
<td>• Data distribution is non-commercial: Standard Coverage image products to be made available to users via NRCan’s EO Data Management System</td>
</tr>
<tr>
<td>• Registration is required to access data</td>
</tr>
<tr>
<td>• Additional vetting to provide greater data access</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Ownership and Use</th>
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</thead>
<tbody>
<tr>
<td>• Ownership of RCM SAR data is with the GoC</td>
</tr>
<tr>
<td>• IP rights to Value Added Products (VAPs) remain with creators</td>
</tr>
<tr>
<td>• Conditions of use of the RCM SAR data specified in EULAs</td>
</tr>
</tbody>
</table>

In Canada, the **Remote Sensing Space Systems Act** prescribes operating licenses for EO satellite missions to be operated, with implications in terms of data access.
Questions on RCM
asc.mcr-info-rcm-info.csa@canada.ca
• AIS is a National Defence sensor.
• Each RCM satellite includes a receiver for AIS transmissions from vessels.
• Using AIS in conjunction with SAR allows improved detection and tracking of vessels, and improved surveillance timeliness.
Standard Coverages

Standard Coverages are SAR data acquisition plans that are based on the imaging needs of the Government of Canada.

They:

- cover predominantly the Canadian AOI
- are designed to offer consistent and predictable SAR coverage based on long-lead planning
- provide departments with coordinated acquisition plans reducing imaging conflicts to achieve satisfactory coverage for their application
- are intended to have a long lifespan
- are managed by the Standard Coverage Working Group (SCWG), a group tasked with defining requirements and coordinating coverages within the GoC, and order submission into the RCM