RADARSAT-2

Program Update

20 September 2007
CSA-MDA Public-Private Partnership

Objectives

- Provide SAR data continuity from RADARSAT-1
- Meet user needs for new applications opportunities
- Maintain Canada's position in the commercialization, utilization and development of advanced operational SAR capabilities

Roles

**MDA-GSI**
- Design Authority
- Will own and operate RADARSAT-2
- MDA-GSI will sell and distribute RADARSAT-2 SAR imagery worldwide

**CSA**
- Technical expertise and Interface with other Canadian Government Departments
- CSA's contribution will allow access to the SAR imagery required by the Canadian Government User Departments
Spacecraft

Extensible Support Structure (ESS)

SAR Antenna and Sensor Electronics

Bus and Solar Arrays
RADARSAT-2 Imaging Modes

All beam modes available in Right- and Left-looking

Satellite Velocity Vector
Sub-satellite Ground Track (Nadir)
Extended High

Ultra-Fine
Standard
Fine Quad-Pol

Wide
Standard Quad-Pol
Fine

Multi-Look Wide
Fine
ScanSAR Narrow
ScanSAR Wide

Figure shows...
Operational Performance
The spacecraft can provide as much as 315 minutes of imaging time each day. Therefore, enough image data could be acquired and downloaded in a single day to support all the following tasks:

- Acquire 320,000 sq. km. UltraFine beam (3-meter resolution) imagery in support of targeting

- Acquire 9,100,000 sq. km. of Wide beam (25-meter resolution) imagery in support of wide area surveillance

- Acquire 25,000,000 sq. km. Of ScanSAR (100-meter resolution) imagery in support of ocean surveillance

An area equivalent to the size of the state of New Mexico

An area equivalent to the size of the United States of America

An area equivalent to 25% the size of the Atlantic Ocean
Planning & Delivery Timelines

- RADARSAT 1 experiences show increasing demand for rapid planning and data delivery.
- New planning tools and procedures reduce planning lead time to 12 hours (routine) and 3 hours (emergency).
- Near real-time delivery target is 15 minutes.

### Planning

![Graph showing planning timelines](image)

### Processing

![Graph showing processing timelines](image)
### Improved Planning, Ordering and Tasking Timelines

**RADARSAT-1**

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-14</td>
<td>Request confirmed</td>
</tr>
<tr>
<td>D-7</td>
<td>Deadline for submitting</td>
</tr>
</tbody>
</table>

**R.S.I. process:**
- Time booked through the ODSys
- Service: Basic, Priority, Emergency

**M.M.O. User request status:**
- Unplanned, Planned or Rejected

**RADARSAT-2**

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-3</td>
<td>12 Hrs</td>
</tr>
<tr>
<td>D</td>
<td>Ordering deadline</td>
</tr>
</tbody>
</table>

**Before D-3 Commit Time:**
- Higher priority requests bump lower priority
- Requests of equal priority are first come first served

**After D-3 Commit time**
- New requests on best effort basis
- All planned requests are protected except for emergencies
Slew Plan Visualisation

The Antenna has 1516 Radiating Elements for 620 TRM channels.

Timeline

Start 1995 Dec 04 10:56:34.21  Stop 1995 Dec 04 14:02:43.01

DRF

Imaging Activities

Slew Activities

MDA
Global Data Access via Solid State Recorder

- The SSR allows images to be acquired anywhere throughout the orbit & randomly selected for downlinking.
- Solid-state recorders have a memory of 305 Gbits (EOL) and addressable data retrieval.
Product Format and Specifications

- Image product will be delivered as GeoTIFF
- The Meta-Data file will follow Extensible Markup Language (XML) format, which is widely used for database and computer communication applications.
- RAW data will be archived in FRED format

Available online:
New Imaging Modes
RADARSAT-2 supports a variety of polarization modes that dramatically increase per pixel information content.

**Multipolarization:**

**Selective Single Polarization**
- -22 dB NESZ (nominal)

**Selective Dual Polarization**
- -23 dB NESZ (nominal)

**Polarimetry**
- -30 dB NESZ (nominal)
- relative phase error 5°

Selecting Single or Dual Polarization will enable better discrimination and recognition of objects on the ground and improved classification capability—complementing high-res optical sensors.

Interchannel Polarimetry provides for unsupervised classification and for much stronger inferences on:
1. Target identification
2. Change detection
3. Land cover type (surface moisture, roughness, vegetation cover)
<table>
<thead>
<tr>
<th>Beam Mode Type</th>
<th>Operating Mode</th>
<th>Polarization Options</th>
<th>Elevation Angles</th>
<th>Incidence Angles</th>
<th>Noise Equivalent Sigma-Zero</th>
<th>Ground Resolution (Rng x Az) (m)</th>
<th># of Looks Range X Azimuth (grnd rng. prod)</th>
<th>Swath Width</th>
<th>Max Acquisition Area Per Orbit (sq km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spotlight</td>
<td>Spotlight</td>
<td>HH or VV</td>
<td>26°-47°</td>
<td>30°-55°</td>
<td>-21±4 dB</td>
<td>2.0-3.3 x 0.8</td>
<td>1x1</td>
<td>20 km</td>
<td>21170</td>
</tr>
<tr>
<td>Standard Quad-Pol</td>
<td>Polarimetric Stripmap</td>
<td>HH+HH + VV+VH</td>
<td>18°-36°</td>
<td>20°-41°</td>
<td>-31±2 dB</td>
<td>22.3-28.6 x 7.9</td>
<td>1x1</td>
<td>25 km</td>
<td>177500</td>
</tr>
<tr>
<td>Fine Quad-Pol</td>
<td>Polarimetric Stripmap</td>
<td>HH+HH + VV+VH</td>
<td>18°-36°</td>
<td>20°-41°</td>
<td>-28±2 dB</td>
<td>8.4-16.0 x 7.9</td>
<td>1x1</td>
<td>25 km</td>
<td>177500</td>
</tr>
<tr>
<td>UltraFine</td>
<td>Dual-Receive Stripmap</td>
<td>HH or HV or VV or VH</td>
<td>26°-43°</td>
<td>30°-40°</td>
<td>-21±2 dB</td>
<td>2.5-3.4 x 3.0</td>
<td>1x1</td>
<td>20 km</td>
<td>115400</td>
</tr>
<tr>
<td>Multi-Look Fine</td>
<td>Dual-Receive Stripmap</td>
<td>HH or HV or VV or VH</td>
<td>26°-43°</td>
<td>30°-50°</td>
<td>-20±2 dB</td>
<td>7.4-9.1 x 7.9</td>
<td>2x2</td>
<td>50 km</td>
<td>419700</td>
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<tr>
<td>ScanSAR Wide</td>
<td>ScanSAR</td>
<td>HH+HV or VV+VH</td>
<td>18°-42°</td>
<td>20°-49°</td>
<td>-23±2 dB</td>
<td>82-183 x 90.113</td>
<td>4x2</td>
<td>500 km</td>
<td>5628000</td>
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<tr>
<td>ScanSAR Narrow</td>
<td>ScanSAR</td>
<td>HH+HV or VV+VH</td>
<td>18°-40°</td>
<td>20°-46°</td>
<td>-23±2 dB</td>
<td>43-91 x 46-77</td>
<td>2x2</td>
<td>300 km</td>
<td>3376800</td>
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<tr>
<td>Standard</td>
<td>Stripmap</td>
<td>HH+HV or VV+VH</td>
<td>18°-42°</td>
<td>20°-49°</td>
<td>-24±2 dB</td>
<td>19.2-29.2 x 25.6</td>
<td>1x4</td>
<td>100 km</td>
<td>1125600</td>
</tr>
</tbody>
</table>
Interpretation of polarimetric data and polarimetric change detection will benefit from fusion with higher resolution single-polarization data.

RADARSAT-2 Quad-Fine polarimetric image (~9m resolution, $\alpha$-angle representation)

RADARSAT-2 Ultra-Fine single-polarization image (~3m resolution, HH)

Result of sharpening polarimetric data with higher resolution image.
RADARSAT-2 Customised Imaging Modes

The re-configurable design of the RADARSAT-2 payload permits programming of new imaging modes tailored to customers requirements.

- Re-configurable parameters
  - Resolution
  - Incidence angle
  - Polarization
  - Swath width

- New imaging modes are subject to power, noise level and data rate constraints

- Possible example additions to RADARSAT-2 standard offering:
  - Higher resolution polarimetric mode (reduced coverage)
  - Hybrid look-ahead, look-behind modes (ultrafine + polarimetric?)

- The capability to re-configure has major implications on maintaining critical performance as the system ages
Advance Modes
Moving Object Detection Experiment (MODEX)

- MODEX has been implemented as an experimental mode
- MODEX is essentially Along Track Interferometry (ATI) which provides measurements of the radial velocity of targets
- Applications:
  - vehicles/ships: studies indicate a minimum detectable speed of ~ 5 m/s
  - ocean currents: analysis suggests that speeds to 0.25 m/s at 100 m resolution cells can be obtained

Split-antenna ATI concept
MSSR Concept

- MSSR concept improves target detection while retaining wide area coverage

- Increased visibility of AOI with beams that look further out

- Improved revisit time with 50% wider swath

- Reduced turnaround time through direct feed to MOC

- Detect smaller ships with higher resolution beam (30m ship detected in MSSR; missed with ScanSAR)

- Sea State 3
  - FAR = $5 \times 10^{-7} \text{km}^2$
  - Prob Detection = 0.90
  - 90% 80% mode
  - 29.1 24.7 MSSR
  - 48.4 40.4 Scan Far

- a) Sea State 3 with 90% PD

- 30m Ship

- Halifax

- Improved revisit time with 50% wider swath

- Extended visibility of AOI with beams that look further out
Maritime Surveillance

Key Improvements
- Tasking & delivery enhancements
- Multi Polarized data
- Improved geolocation accuracy
- MSSR mode
Ice Monitoring

Key Improvements
- Tasking & delivery enhancements
- Multi Polarized data
- Improved geolocation accuracy
- MSSR
Maritime Surveillance: Polarimetric Marine Target Analysis

Ship Dominant Scattering Mechanism
Trihedral, Cylinder, Dipole

Iceberg Dominant Scattering Mechanism
Trihedral, Cylinder
Key Improvements

- Higher spatial resolution
- Polarimetric capability
- Tasking & delivery enhancements
INSAR Techniques

Key Improvements

- Orbit knowledge and control of RADARSAT-2.
- High resolution data
- Multi Polarized data
  - Polarimetry may shorten the time required to acquire a reliable PSINSAR stack, for RADARSAT-1 this is currently 1-year (15 images).
  - Polarimetry provides additional tools for testing the stability of and classifying persistent scatterers
Key Improvements
• Multi Polarized data
• Polarimetry
• Higher spatial resolution
Bus Delivery

- Testing
- SAR Integration
- System Level Test
- Solar Array Integration
- Environment Testing
- Appendage Deployments
- Final Integrated System Test
- Operations Validation
- Pack & Ship to Launch Site
- Launch
- S/C Operational
<table>
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<tr>
<th>Stage</th>
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<td>S/C Operational</td>
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<td>S/C Operational</td>
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The image shows a satellite in an anechoic chamber, which is used for radio frequency testing. This setup is typically part of the environmental testing phase of a satellite's development.
Bus Delivery
Testing
SAR Integration
System Level Test
Solar Array Integration
Environment Testing
Appendage Deployments
Final Integrated System Test
Operations Validation
Pack & Ship to Launch Site
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Appendage Deployments
Final Integrated System Test
Operations Validation
Pack & Ship to Launch Site
Launch
S/C Operational
RADARSAT-2 will operate in an orbit identical as RADARSAT-1 except for a 180° offset in time.

<table>
<thead>
<tr>
<th>ORBIT CHARACTERISTICS</th>
<th>Value</th>
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<tbody>
<tr>
<td>Altitude (average)</td>
<td>798 km</td>
</tr>
<tr>
<td>Inclination</td>
<td>98.6 degrees</td>
</tr>
<tr>
<td>Period</td>
<td>100.7 minutes</td>
</tr>
<tr>
<td>Ascending node</td>
<td>18 hrs (± 15 min)</td>
</tr>
<tr>
<td>Sun-synchronous</td>
<td>14 orbits per day</td>
</tr>
<tr>
<td>Repeat cycle</td>
<td>24 days</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>COVERAGE ACCESS USING 500 KM SWATH WIDTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>North of 70°</td>
</tr>
<tr>
<td>North of 48°</td>
</tr>
<tr>
<td>Equator</td>
</tr>
</tbody>
</table>
Canadian Ground Segment Locations

- **MDA/GSI**
  - Order Handling
  - Vancouver

- **CCRS Prince Albert**
  - Receiving Station

- **CSA/MDA St-Hubert**
  - Mission Control
  - and TT&C

- **CSA Saskatoon TT&C**

- **Gatineau**
  - CCRS Receiving Station and MDA production
Thank You!

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