RADARSAT Constellation Mission Update

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Canadian Space Agency

POLinSAR 2015 &1st BIOMASS Science Workshop

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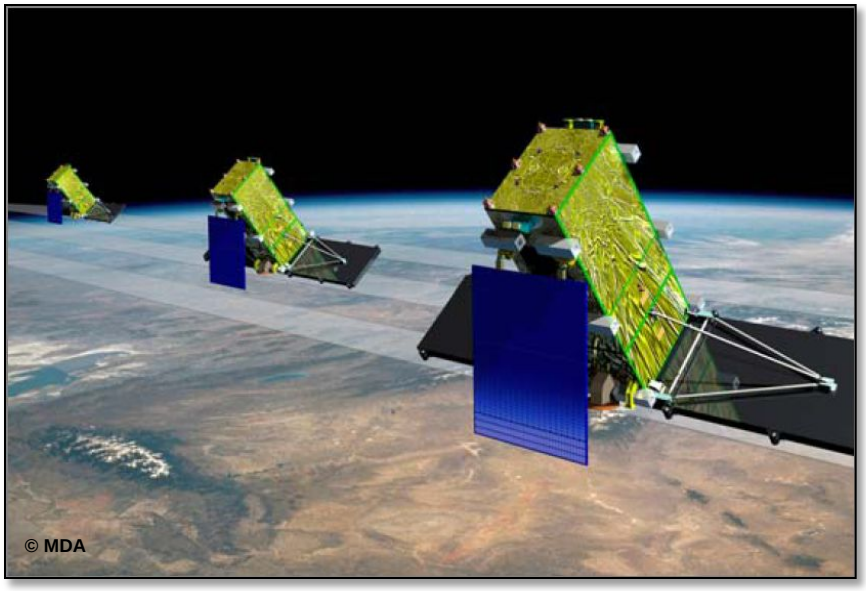
Outline

- ✓ **Mission & Satellite Description**
- ✓ Enhancements
- ✓ Ground Segment
- ✓ Data Products
- ✓ Data Policy
- ✓ Data Acquisition & Capacity
- ✓ Applications



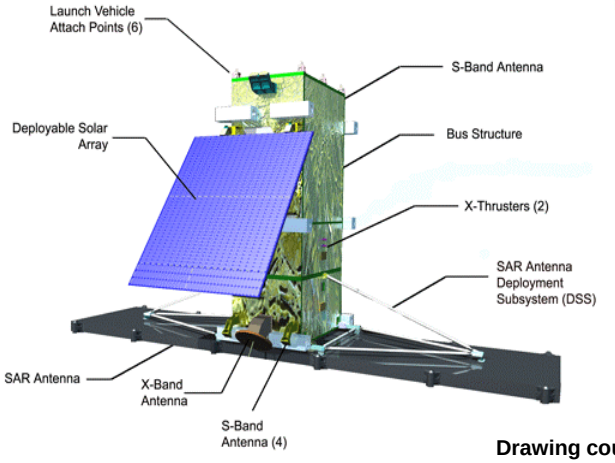
Key Mission Drivers

- 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

The RADARSAT Constellation

System Description

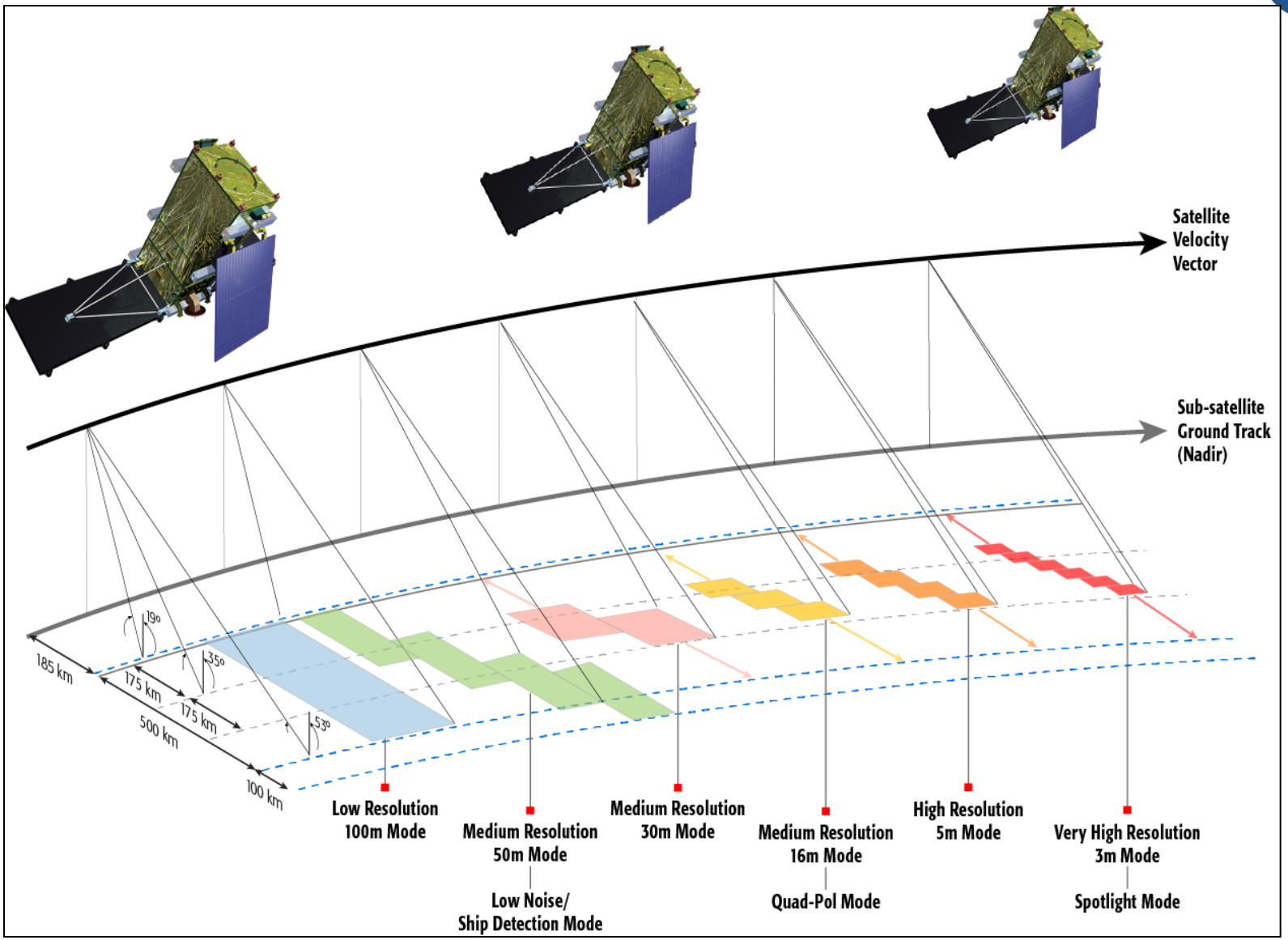
Specifications	
Bus	Canadian Smallsat Bus
Launcher	SpaceX - Falcon 9
Total Mass	1400 kg
Antenna	9.45m^2
Power	<1600 W peak; <220 W average
SAR Frequency	C band – 5.405 GHz
Polarisation	Single Pol / Dual cross selectable pol & Compact polarimetry available on all modes; One fully polarimetric mode
Imaging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



Drawing courtesy of MDA

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

SAR Imaging Modes

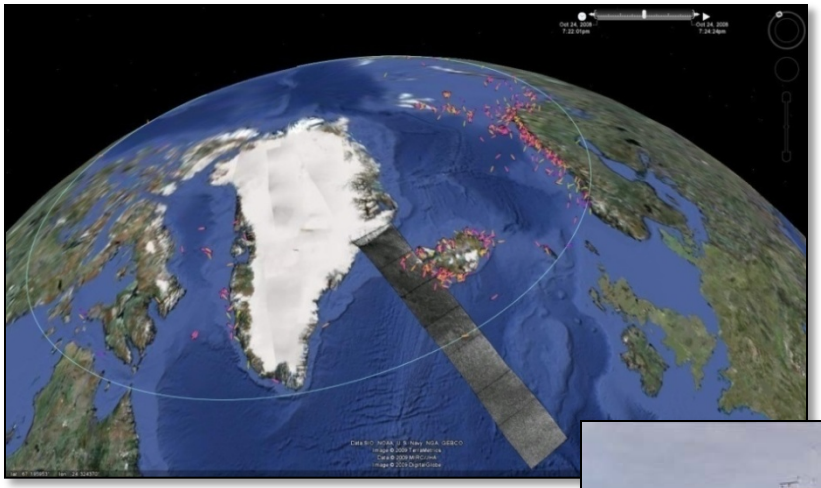


Modes Details

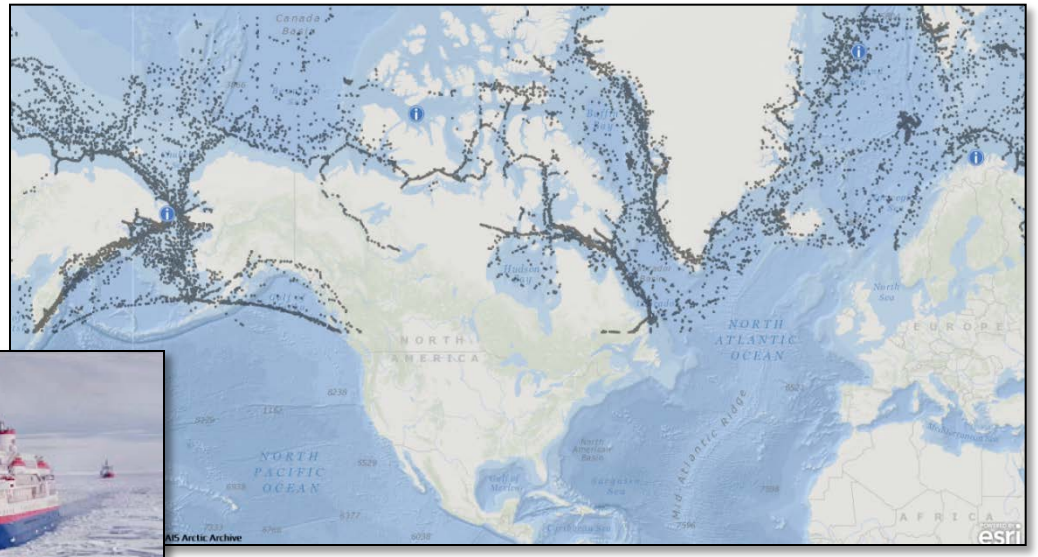
Mode	Res. m	Looks rng x az	Swath Width (accessible) km	Nominal NESZ (dB)	Polarization Options				
					Single	Dual			Quad
					HH, VV, HV or VH	VV or HH +HV	HH+VV	Compact	HH+VV+ HV+VH
Low Resolution	100	8x1	500 (500)	-22	✓	✓	✓	✓	
Medium Resolution	50	4x1	350 (500)	-22	✓	✓	✓	✓	
Medium Resolution	16	1x4	30 (350)	-25	✓	✓	✓	✓	
Medium Resolution	30	2x2	125 (350)	-24	✓	✓	✓	✓	
High Resolution	5	1	30 (500)	-19	✓	✓	✓	✓	
Very High Resolution	3	1	20 (500)	-17	✓	✓	✓	✓	
Low Noise	100	4x2	350 (500)	-25	✓	✓		✓	
Ship Detection	var.	var.	350 (600)	variable	✓	✓		✓	
Spotlight	1 x 3	1	20 (350)	-17	✓	✓		✓	
Quad-Polarization	9	1	> 20 (>250)	-24					✓

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.



Arctic Vessel Positions: July-October, 2011



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.

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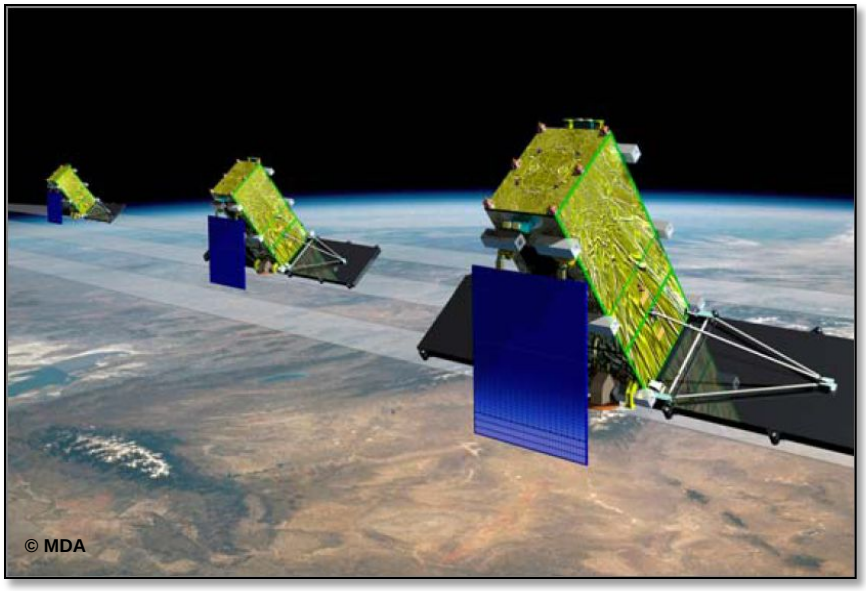
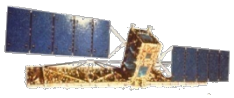
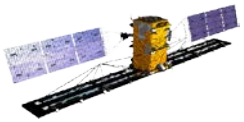
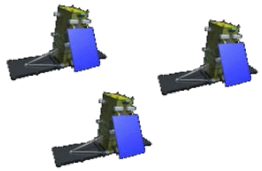


RADARSAT Satellites







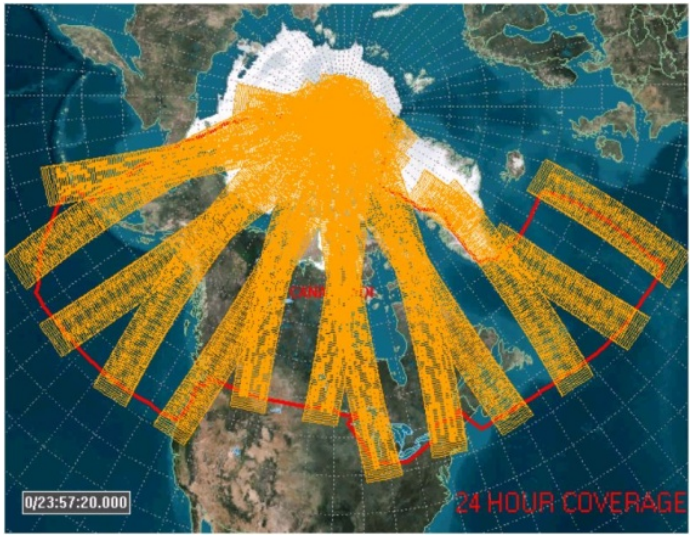
	RADARSAT-1	RADARSAT-2	RCM
Mass	2750 kg	2280 Kg	1400 Kg
Complete Coverage	2-3 days	2-3 days	Daily coverage
Exact Revisit[1]	24 days	24 days	4 days (12/sat)
Imaging time /orbit	28 min	28 min	15 min /sat[1]
Antenna Span	15 m	15 m	6.75 m
Polarization	Single HH	Single, Dual, Polarimetric	Single, Dual, Compact Pol, Polarimetric (exp)
Altitude	800 km	800 km	600 km

(1) Non-eclipse period.

RCM advancement from previous RADARSAT missions

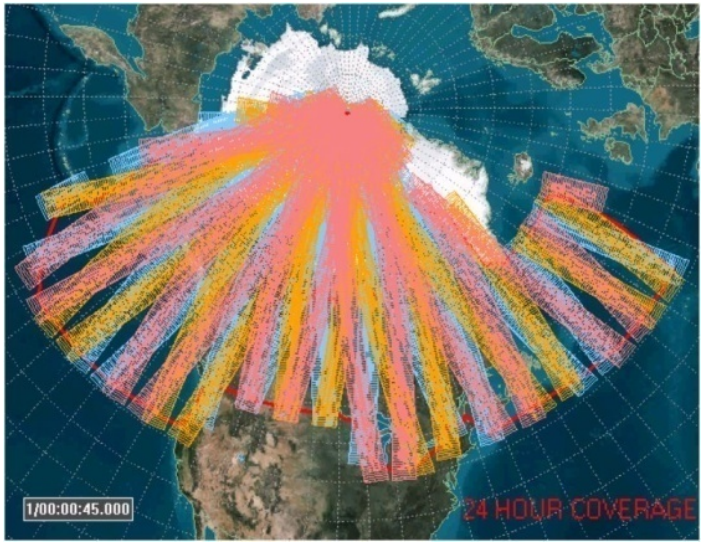
- 3 satellite constellation flying in the same orbit plane equally spaced (32 minutes). Will be controlled to fly in an “orbital tube” of radius 100 meters.
- 4-day displacement detection (CCD using SAR interferometry)
- Multi-polarization including Compact Polarisation.
- Average daily *access* to 95% 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.

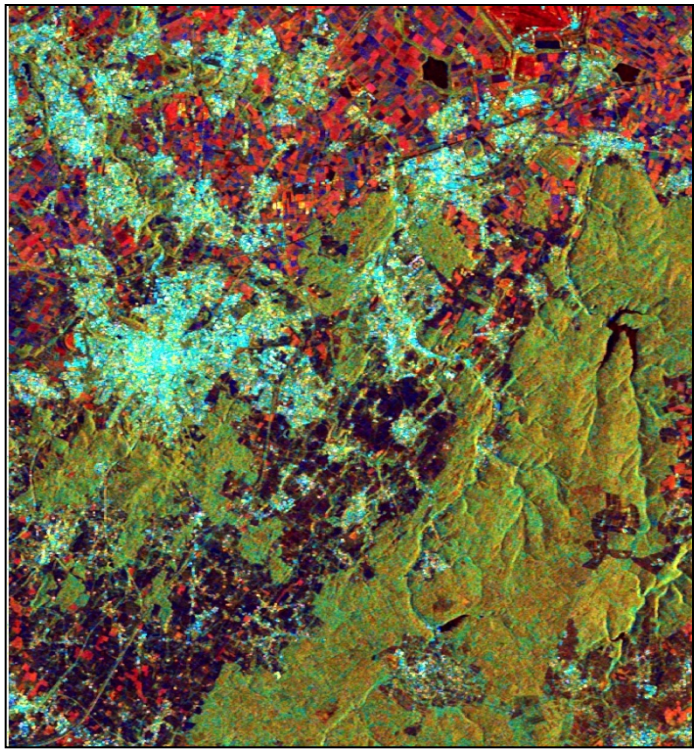


Coverage with RCM

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

Compact polarization

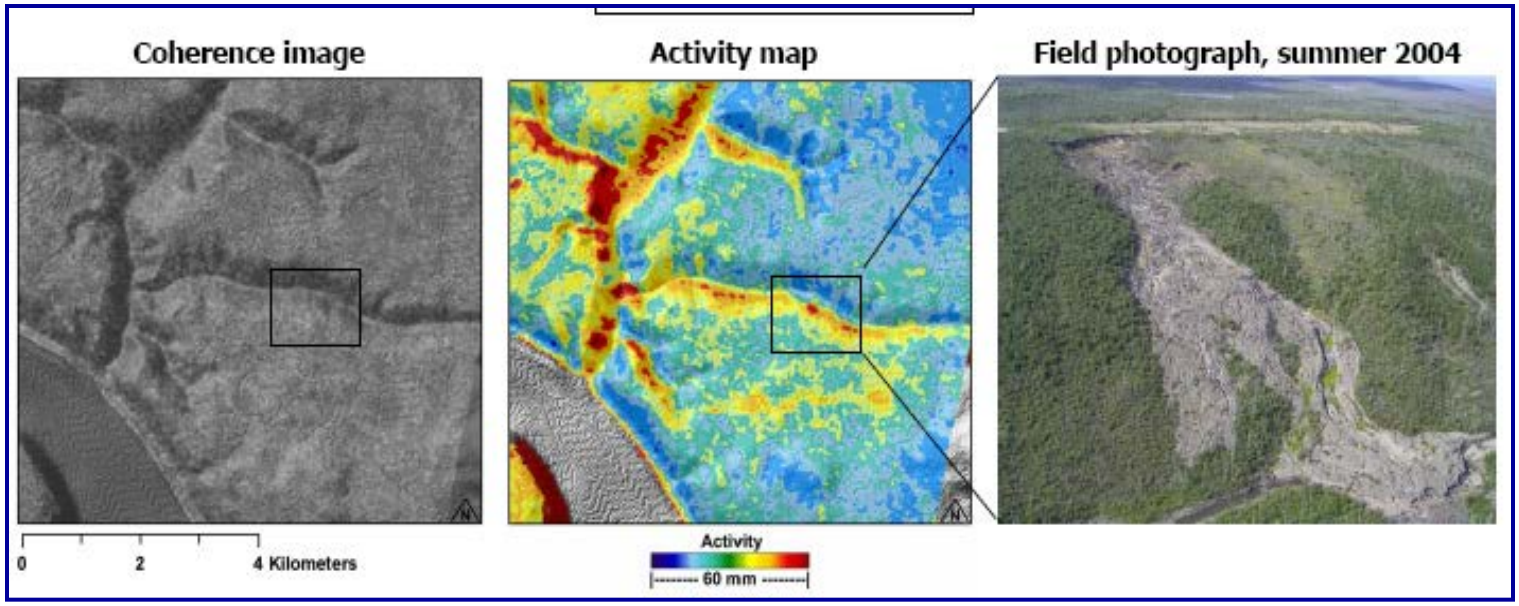
- Quad-Polarization provides full scattering matrix, but with a reduced swath
- Objective of Compact Polarimetry is to realize many (but not all) benefits of quad-polarization, without the reduced swath
- RCM Compact Polarimetry:
  - Transmit circular polarization
  - Receive dual linear H and V



Credit: François Charbonneau, NRCan

Coherent Change Detection (CCD)

- Short-period (4-day)
- ScanSAR (125 km) and Stripmap (30 km) modes optimized for CCD



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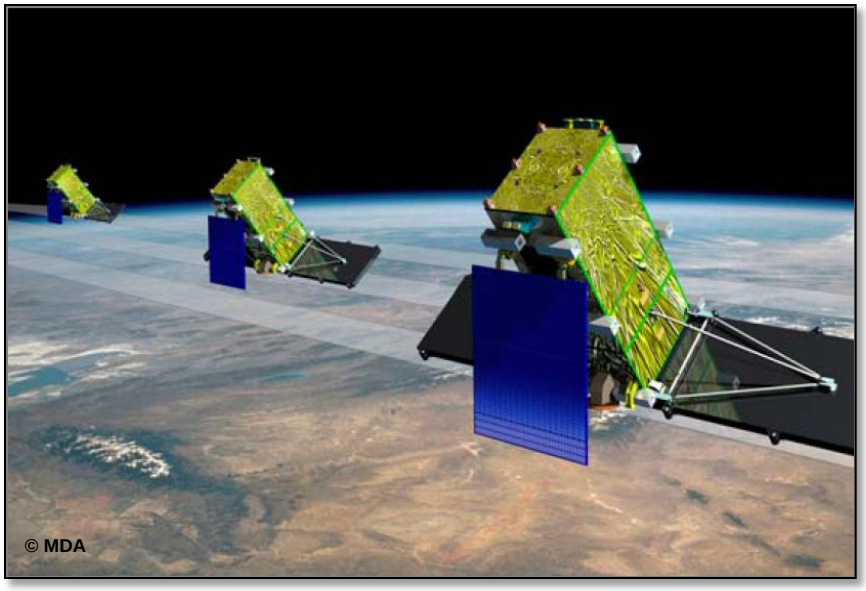
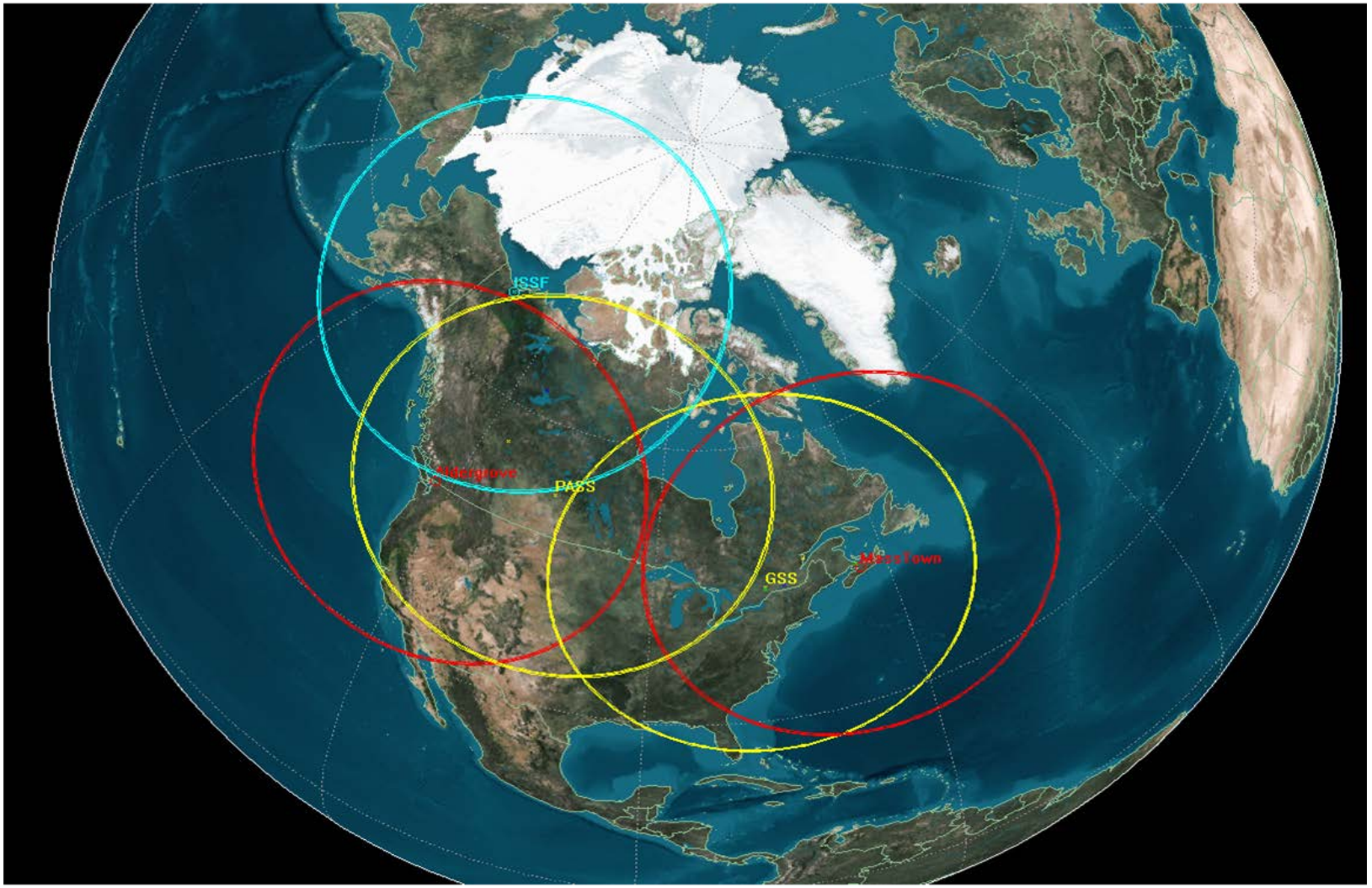


Ground Stations Mask



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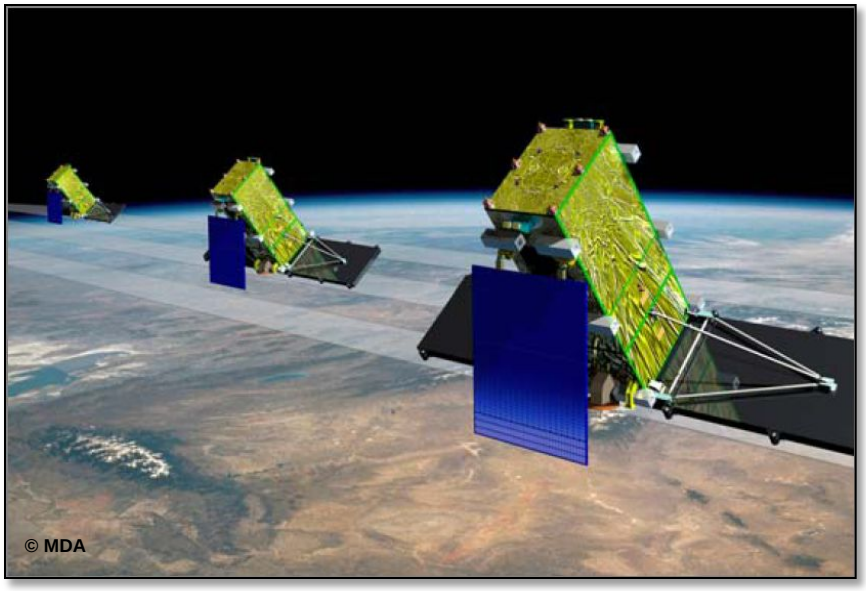

Image Products

Raw Products

- Raw Radar data in Framed Raw Expanded Data (FRED) format

GCC = GeoCoded Complex
GCD = GeoCoded Detected
GRC = Ground range georeferenced Complex
GRD = Ground range georeferenced Detected

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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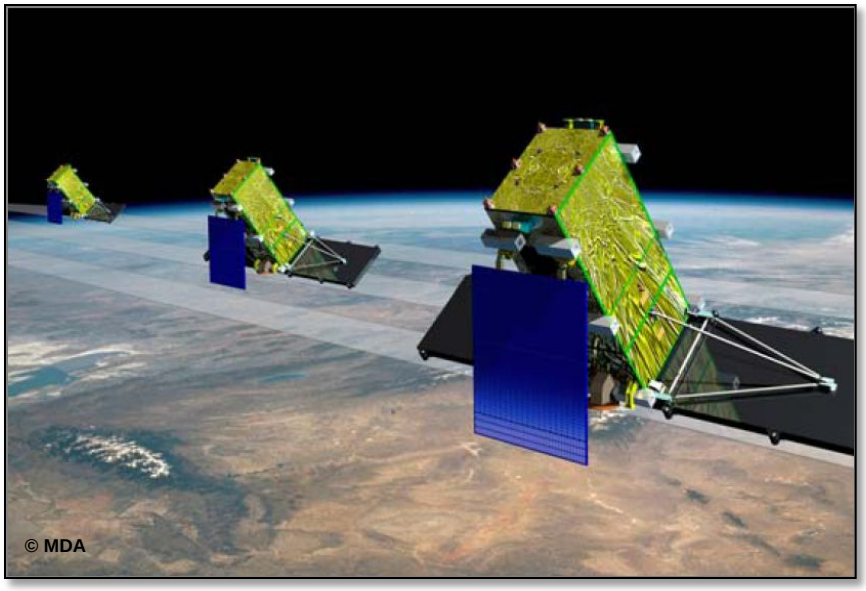

RCM Data Policy Principles

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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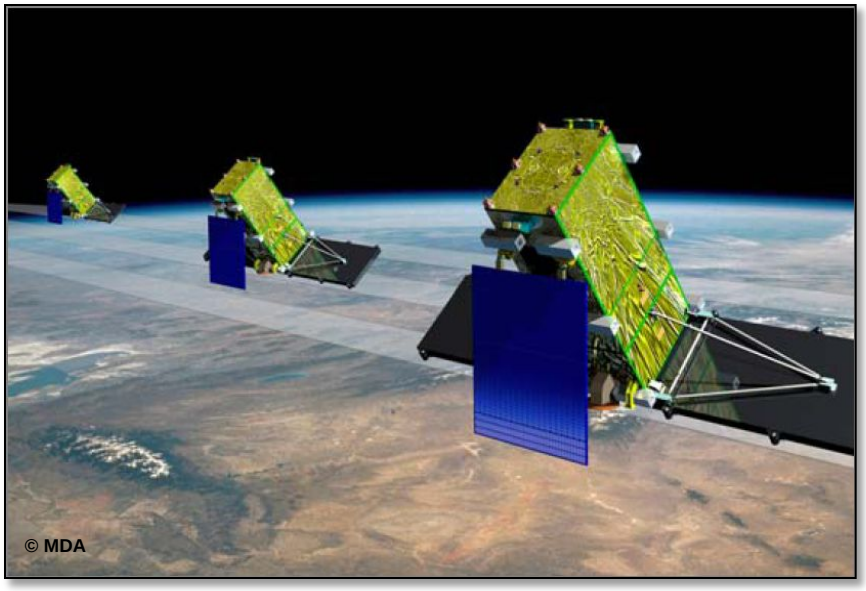


Standard Coverage Concept

✓ **Situation in Canada**

- Large geographic and temporal overlaps in users and applications requirements
- Various preferred imaging modes

✓ **Approach**

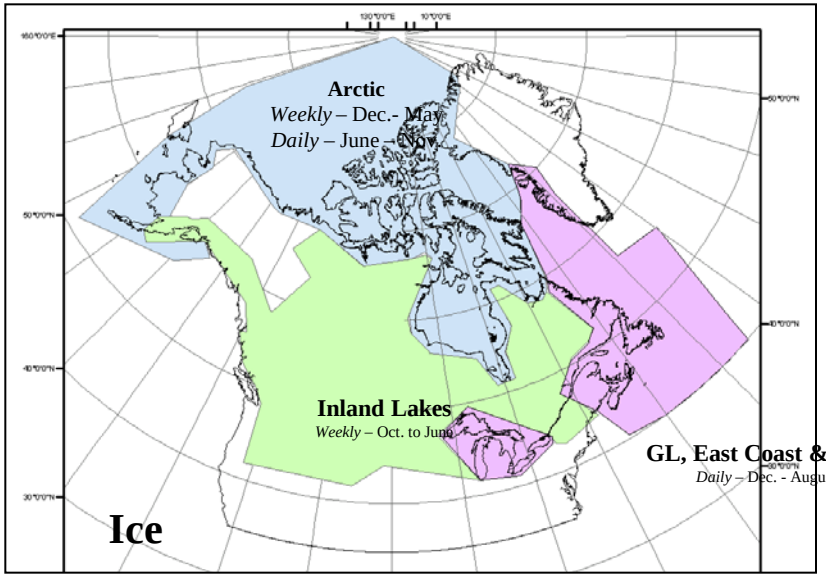
- Analyse user imaging requirements spatially and temporally over the annual cycle to determine a "feasible" imaging scenario, with agreed upon plans in overlapping zones

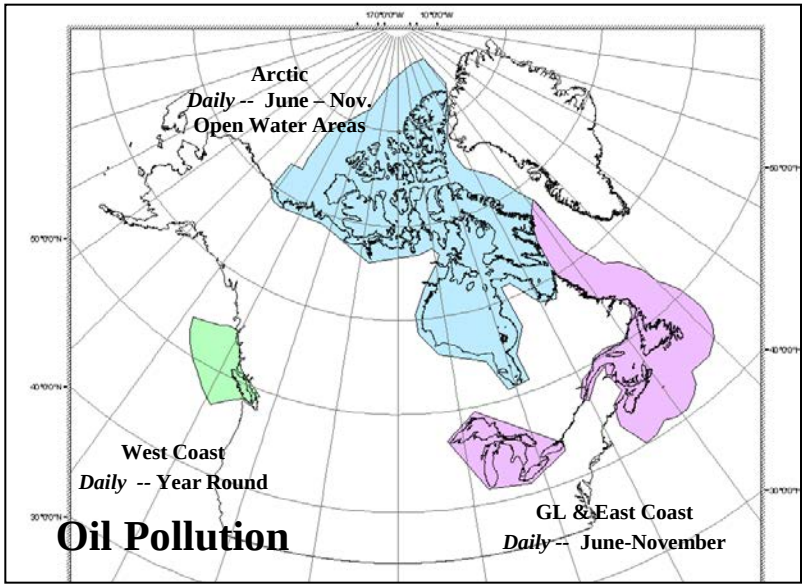
✓ **Result → *Standard Coverage***

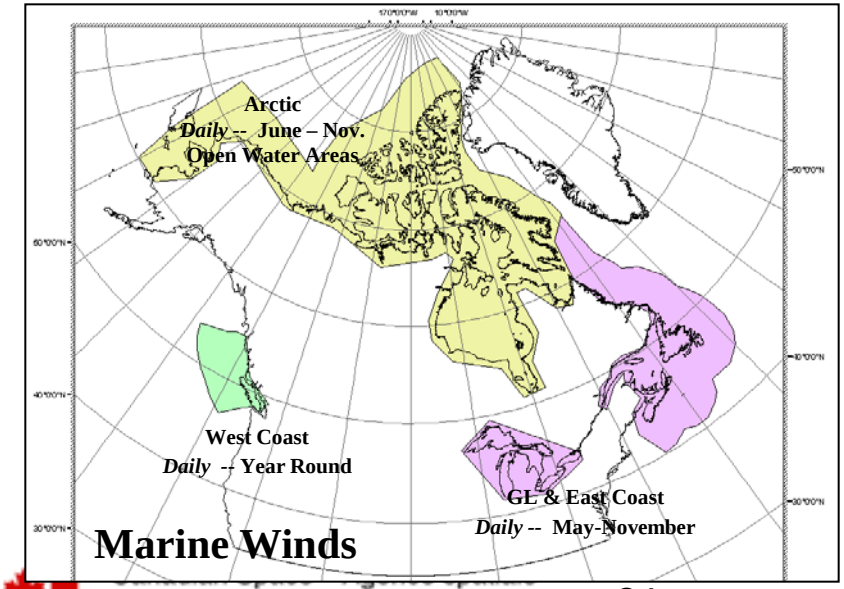
- Collections of data acquired routinely in harmonized and de-conflicted imaging modes intended to optimize and maximize the utility of the data across all User requirements.

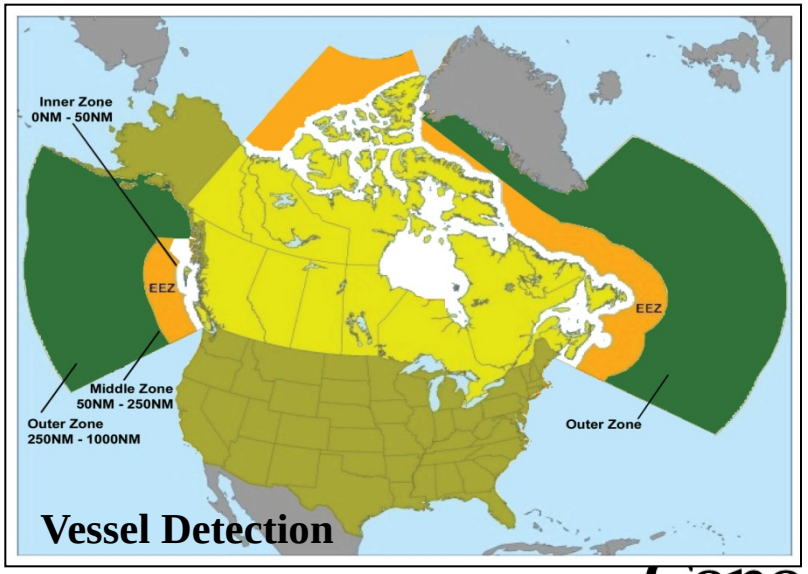
Fast Tasking Capability. If a fast tasking request is received at the command and control centre, it shall be possible to analyze the request, generate commands, contact the satellite, supersede planned operations if necessary and upload request in less than **4 hours**, regardless of where the satellite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

Maritime Operational User Needs Coverage Areas









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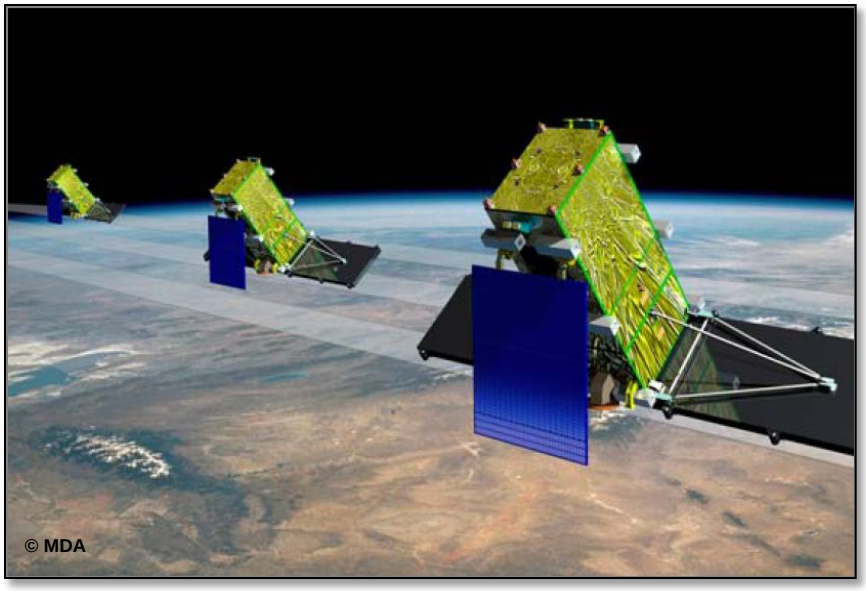
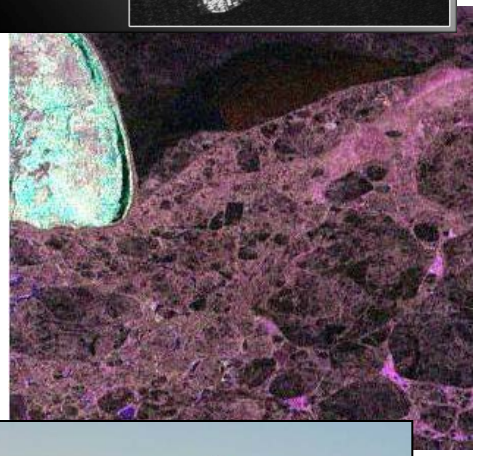


Applications

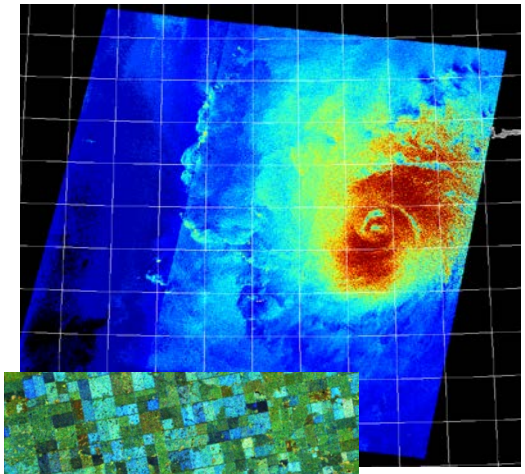


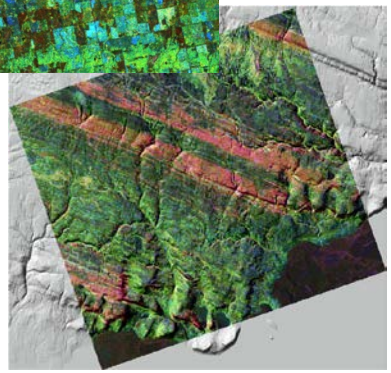
Sovereignty and Security – RCM will provide enhanced coverage of Canada and abroad to assure the safety and security of Canadians to contribute satellite images for international security. Combining space-based radar images and AIS signals will provide a powerful surveillance capacity over Canada's maritime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

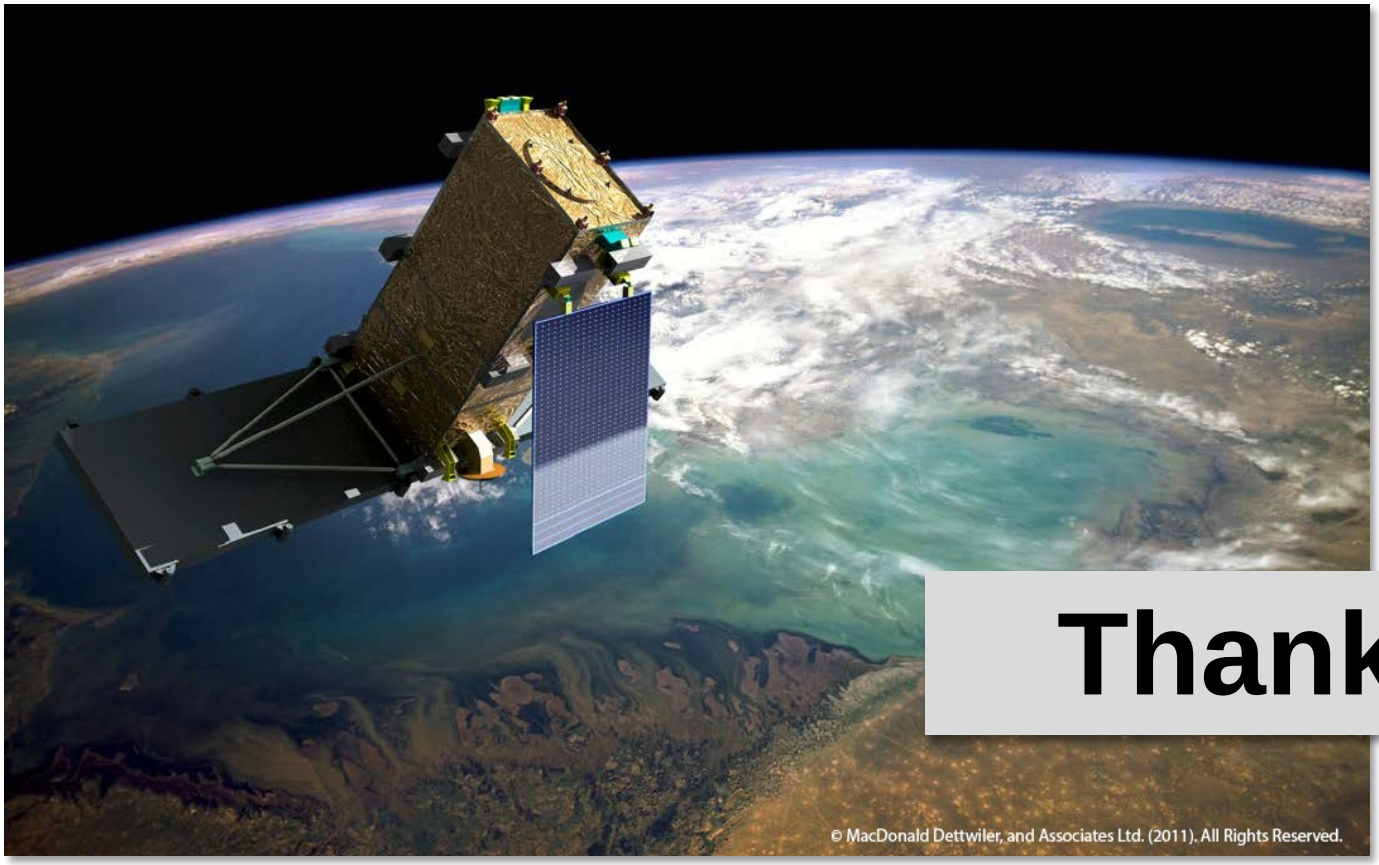
Environmental monitoring - RCM will provide data for wide area change detection. RCM data will contribute to the production of more accurate weather forecasts, marine conditions, ice condition and ecosystems.

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)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