Canadian Space Agency program update

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RADARSAT-2: CURRENT OPERATIONAL LEO SATELLITE SYSTEM
radarsat constellation mission (rcm):
upcoming operational leo satellite system

• rcm is the evolution of the radarsat program with the objectives to:
  – ensure data continuity
  – enhance use of sar data
  – improve system resilience and reliability

• rcm is government-owned, tailored to respond to government needs, namely in the areas of:
  – maritime surveillance;
  – disaster management; and
  – ecosystem monitoring.
RCM Improvements Over Previous RADARSAT Systems

- Daily coverage of any point over Canada
- Capability to potentially access daily any point on the Earth (except around the South Pole)
- 4-day exact repeat (as opposed to 24 days with RADARSAT-1 and 2) for Coherent Change Detection
- Circular Compact Polarization for better detection, measurement, and discrimination of surface features and characteristics.
- Automatic Identification System (AIS) for ship detection and identification.
RCM Data to be Fully Integrated in Government of Canada Service Delivery

- Ice
  - Ice & Icebergs
  - Ice data Assimilation
  - Ice Dynamics

- Environment
  - Integrated Satellite Tracking of Pollution (ISTOP)

- Winds
  - National SAR Winds
  - Wind Data Assimilation

- Ecosystem
  - Arctic Coastline
  - Wetland monitoring

- Land
  - Land Surface & Water Extent

- Agriculture
  - Crop Inventory

- Security & Defence
  - Ocean Features
  - Maritime Surveillance

- Monitoring
  - INSAR
    - Hazards Deformation Infrastructure Glacier

- Emergency
  - Emergency Geomatics Service

- Products
  - Value Added Products
    - Filtered Orthorectified Pol. Decomp.

- R&D
  - Compact Pol CCD
  - Geohazards
  - Wetlands
  - Security & Defence
RCM SAR Data Policy Objectives

- Sustain and enhance operations and services that support government priorities;
- Expand the use of RCM Data by Government of Canada;
- Continue to contribute to international efforts to manage disasters and assist in other international humanitarian efforts;
- Stimulate economic growth;
- Enhance Canada’s access to satellite data of other countries;
- The Government of Canada to retain ownership of all RCM Data;
- The Government of Canada to preserve all RCM Data;
- Make RCM Data available, accessible, and affordable to the broadest extent possible: the SAR data acquired by the Government of Canada to be made available in their originally ordered processed formats, at no cost, subject to the following considerations:
  - Legislation, regulations and policies
  - Sensitivity of data
  - Within technical capabilities
Projected Timelines

Successfully Progressing Towards RCM Launch and Operations!

- **Q1/Q2 2017**: Bus and Payload Assembly, Integration and Test
- **Q3 2018**: Completion of Ground Segment
- **Q3 2018**: Launch
- **Q4 2018**: Commissioning (up to 3-6 months)

RCM Routine Data Collection and Distribution
1st RCM Spacecraft Being Prepared for Testing

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CURRENT R&D SATELLITES

- MOPITT – launched in 1999 (on Terra). Nadir, column CO
- OSIRIS – launched in 2001 (on Odin). Limb Scatter, vertical profiles: O3, NO2, BrO, aerosols
  - Extensively used by atmospheric science and climate communities:
  - ESA and NASA-led activities to generate Essential Climate Variable products for Ozone and Aerosols
  - WCRP/SPARC activities related to ozone trends and chemistry-climate model evaluations
- CASSIOPE – launched in 2013. ePOP space weather payload
  - Suite of eight scientific instruments, including plasma imagers, radio wave receivers, magnetometers and camera
- EFI (Canadian Electric Field Instrument) on ESA’s three Swarm satellites (launched in 2013)
PLANNED R&D SATELLITES AND PAYLOADS

• Contribution to the NASA/CNES Surface Water Ocean Topography (SWOT) mission;
• SAR Data Continuity initiative: planning for the RCM replacement in 2025 horizon;
• Small/Microsatellite program: space weather, atmospheric composition, and water quality mission concepts for LEO under investigation;
• PHEOS (Polar HEO Science) payloads: space weather and atmospheric composition science payloads for HEO and GEO
• Spatial Heterodyne Observations of Water (SHOW): payload development and demonstration/validation via balloon flights
Contribution to Global Observing System

- **World Weather Watch:**
  - Ocean surface winds (RS-2, RCM)
  - GPS RO

- **Global Atmospheric Watch:**
  - GHG (SCISAT, MOPITT, OSIRIS, GHGSat...)
  - Air quality (SCISAT)

- **Hydrological Global Observing System**
  - Altimetry (SWOT)
  - Water quality (WaterSat/COCI)

- **Global Cryosphere Watch**
  - Cryosphere monitoring (RS-2, RCM)

- **Space Weather Watch:**
  - Plasma imagers, radio wave receivers, magnetometers and cameras (CASSIOPE)
  - Electric field instruments (SWARM)
Suggestions for Vision 2040

• Consider 3 drivers for the vision:
  • Requirements/capability gaps
  • Emerging technologies
  • Emerging business models

• Consider to have analyses of hydrometeor profiles/a more advanced description of cloud fields supported by some expansion of active instrumentation (lidars). At least moderate statements on better description of 3-d cloud fields should be added.

• Consider more insisting on absolute calibration missions as was planned by CLARREO.

• Consider a more specific statement: “A reference radiance calibration system in space, with appropriate spectral coverage and resolution, would have the advantage of providing a single reference for other satellites on a global scale” (p.6 of the current draft)
Back-up
RCM Mission Facts

- Constellation of 3 satellites, evenly spaced on same orbital plane
- 600 km / sun-synchronous orbit
- Orbit maintained within 100 m orbital tube
- 96.4 minutes orbital period
- 12 days repeat cycle per satellite (4 days for constellation)
- SAR Duty cycle: 15 minutes of imaging time per orbit on average outside eclipse season
- C-Band SAR – 5.405 GHz
- Automatic Identification System (AIS)
- Launch scheduled for 2018
- 7 years design life
RCM SAR Imaging Modes
RCM SAR Image Products

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.*

- Includes a “Doppler Grid” with 2 km spacing

- Same format as RADARSAT-2: GeoTIFF images with XML meta-data + NITF 2.1 format.

GCC = GeoCoded Complex
GCD = GeoCoded Detected
GRC = Ground range georeferenced Complex
GRD = Ground range georeferenced Detected
RCM Automatic Identification System (AIS)

- Each RCM satellite will include a receiver for AIS transmissions from vessels.
- Navies, port authorities, civilian ships, coast guards, and other marine authorities use AIS data for tracking and to enhance maritime situational awareness.
- Using AIS in conjunction with radar data will allow improved detection and tracking of vessels of interest.
- AIS is a DND sensor with access limited to the Government of Canada and their partners.

Space-Based AIS allows detection of vessels beyond coastal range or terrestrial antennas!