R&D for Maritime Surveillance of Canadian Coastlines

Doreen M. Dyck
Counsellor Defence R&D
Canadian High Commission
London, UK

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Outline

• Canadian context and challenges
• History of using civilian satellites for maritime surveillance
• Layered approach to surveillance
• Current R&D
Maritime Surveillance Roles

- Surveillance
- Ice & Iceberg Monitoring
- Pollution Monitoring

- Vessel Detection
  - Including AIS
- Marine Winds

Canadian Coastline: 202,080 km
Layered Approach to Maritime Surveillance

- **Territorial & Choke Point Surveillance**
  - Microwave Radar
  - AIS Shore Stations

- **EEZ**
  - Patrollers (air and surface) surveillance & patrol aircraft
  - High Frequency Surface Wave Radar (HFSWR)
  - Space-based AIS

- **International Waters (to 1000/1200 nm)**
  - Space-based AIS
  - Spaced-based Radar
  - Patrollers (air and surface)
History of Civilian Radar Satellites

- 1995 - still operational Government
- 2006 Commercial
- Launch – 2018 Government

- C-Band radars
- Optimised for Wide-Area surveillance
- Hi-Res = ~1m
- Unclassified data
Polar Epsilon: Joint Space-Based Wide Area Surveillance and Support Capability

Overview
Aim: (1) Support to CF operations;
(2) Arctic, maritime domain awareness.
Description: Exploit RADARSAT-2 for DND/CF operational stakeholders.
Project Phase: Implementation.

Capabilities
Arctic Surveillance (Land) (R-2):
• Surveillance of Canada’s Arctic Region;
Environmental Sensing (MODIS):
• Support to CF operations;
Near-Real Time Ship Detection (R-2):
• Surveillance of Maritime approaches;
• Global surveillance (CDI);
Maritime Satellite Surveillance Radar (R-2):
• New beam modes for ship detection and maritime surveillance.

Schedule
<table>
<thead>
<tr>
<th>Capability</th>
<th>IOC</th>
<th>FOC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arctic Surveillance (Land)</td>
<td>Oct-09</td>
<td>Jun-10</td>
</tr>
<tr>
<td>Environmental Sensing</td>
<td>May-11</td>
<td>Apr-12</td>
</tr>
<tr>
<td>Near-Real Time Ship Detection</td>
<td>Aug-11</td>
<td>Mar-12</td>
</tr>
<tr>
<td>Maritime Satellite Surveillance Radar</td>
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<td></td>
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NRTSD:
• Reception at Masstown and Aldergrove;
• Processing at Aldergrove;
• OTHGold in < 10 min;
• Automated ingest into RMP.
R&D Support for Polar Epsilon

Development of Maritime Satellite Surveillance Radar (MSSR) Modes

**SCW (500km)**

**SCN Near** (300 km)

**SCN Far** (300 km)

**DVWF**

**New MSSR Modes**

**Existing RADARSAT-2 Modes**

**Wide 1**

**Wide 2**

**Wide 3**

255km

420km

620km

875km

260km

420km

700km

920km
R&D Support for Polar Epsilon

Development of Ship Detection Algorithms

- Ocean Suites - Operational ship detection based upon bright point-like target signatures
  - Sea clutter modeled with K-distribution
  - Statistical model for ship radar cross section and a set of fuzzy logic rules following target segmentation confirm the detection
R&D Support for Polar Epsilon

Development of Exploitation Tools

• Commercial Satellite Imagery Acquisition Planning System (CSIAPS)
  – Includes all commercial satellites of interest (EO and SAR) & AIS

• Concurrence of AIS and Radarsat-2
  – Crossing orbits:
    • Occasional temporal overlap at high latitudes (depends on orbital altitudes)
  – Minimize time difference between observations:
    • Goal of ±15 minutes

• Image Analyst Pro
  – Visualization testbed
Web based user interface via an internet portal is permitting multiple agency and maritime govt departments all unclassified and sharable data in addition to the maritime COP.
Next Generation Multi-channel Spaceborne SAR R&D

• Moving Target Indication
  – Augment capability in challenging clutter environment (higher sea states, near range, ice-infested waters)
    • Speed and heading estimation
    • Ship-iceberg discrimination
    •Resolve ambiguities in littoral zones

• Wide-swath and high resolution

*RADARSAT-2 antenna structure is very flexible (& programmable) and has been a useful tool for research*
NextGen Multi-Channel SAR & Exploitation

**General Objective:** Transfer GMTI expertise into next generation systems to fill identified capability gaps, e.g. implementing advanced modes on RCM and RNG

**Maritime Applications**

Augment projects PE, PE2

Courtesy Space-based Radar Group, DRDC Ottawa
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Source: Canadian Ice Center

Courtesy Space-based Radar Group, DRDC Ottawa
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Courtesy Space-based Radar Group, DRDC Ottawa
NextGen Multi-Channel SAR & Exploitation

Velocity info overlaid on SAR image

Courtesy Space-based Radar Group, DRDC Ottawa
Radarsat Constellation Mission

- CSA-led project, GoC-owned
- Three radar satellites
- Maritime surveillance Cdn AOR imaged 1 x daily, Arctic 2-4 x daily (detects ≥ 25m ships)
- Data latency ~ 15-30 min
- Ship ID using Space-Based AIS
- Global access w/ 24 hrs
- Hi-Res: ~1m x 3m
- 4-day CCD using SAR Interferometry
- CSA-ESA discussions on-going to explore synergies and interoperability between Sentinel-1 and RCM
Polar Epsilon 2: Space-based Surveillance and Reconnaissance Capability

Overview:
Whole of Government approach to delivering more persistent and responsive Arctic, maritime, and deployed ops surveillance & reconnaissance using the RADARSAT Constellation Mission (RCM).
Project Phase: Definition/Implementation
IOC: 2018 with RCM 1st launch.

Capabilities:
• Global ship identification and tracking;
• Integrated radar and ship identification on the space-segment;
• Daily coverage of the Arctic AOI and Maritime approaches;
• Four-day coherent change detection revisit.

Scope:
• Augment ship identification space segment via DND transfer to CSA to increase RCM utility;
• Upgrade ground infrastructure, personnel, exploitation tools, for RCM data;
• Build new infrastructure to ensure sustained operations throughout RCM lifespan to 2023+.
Major Shipping Routes

Drug Smuggling Routes

Human Smuggling Routes

Major Piracy Areas
R&D to Support Polar Epsilon 2

• Continued improvement of exploitation tools
• Compact polarimetry
  – Transmission of circular pol, and dual reception of H and V
  – Investigation of benefits of using this mode
• M3MSat
  – R&D microsatellite for testing AIS Receiver strategies required to deal with *message collisions*
  – Launch date of Q3 2013
  – Support risk-reduction activities for RCM
• Information and Knowledge Management
  – Growing volumes of data and information is a challenge to analyse and assess
  – Trust in information
  – Balancing need-to-know with need-to-share
M3MSat - Concept of Operations

TDP trials, demonstrations, and R&D

Spin-off ARPs

RJOC Atlantic

RJOC Pacific

AIS Database

Scheduler

Mission Planning System (MPS)

Advanced AIS Signal Processor (GSA)

Telemetry (encrypted) (S-Band)

Tele-commands (encrypted)

Science Data (encrypted) (C-band)

Dielectric

AIS Signals

LDRS Signals

DRDC Atlantic
R&D to Support to Layered Surveillance Concept

- High Frequency Surface Wave Radar (HFSWR) – Surveillance of EEZ
- Northern Watch Technology Demonstration – Arctic Surveillance
- Airborne Surveillance (cued from space or HFSWR)
Persistent Active Surveillance of the EEZ (PASE) Technology Demonstration

- Demonstrate next-generation HFSWR technology that:
  - meets Industry Canada guidelines for operation on a Non-Interfering Basis/Non-Protected Basis
  - operates with minimal risk of causing harmful interference that would result in a complaint
  - maintains acceptable surveillance performance

HFSWR Characteristics:
- Persistent surveillance
- Estimates course and speed
- Poor range resolution and high Doppler resolution
- Tracks targets
- Detection of anomalous vessel behaviour
- Vessel detection to 200 nm (reduced at night, or with smaller vessels)
- Blind zone 1 – 30 nm
- Cost effective
- HFSWR and RCM are complementary
Northern Watch Technology Demonstration

- Objective: To identify and characterize combinations of systems for cost-effective surveillance of Canada’s high Arctic
  - Wide Area Approach Surveillance
  - Choke-point Surveillance
  - Information Compilation and Sharing
Northern Watch Concept

Based on data integration and fusion within a services oriented architecture

- UAV
- SPACE
- AIS

Surface Based Sensors (RF, EO, ELINT, etc.)

RDS

Services Oriented Architecture

Future Capability 1
Future Capability 2
Future Capability 3
Airborne Surveillance

Support to CP-140, JUSTAS (UAV acquisition), and next generation Canadian Multi-mission Aircraft

• Based on X-band experimental radar carried on National Research Council Convair aircraft
• Moving Target Indication
• Autonomous Sensing
• Data Management
• Near-realtime target detection and dissemination of information to ground-based operators
• AESA imaging radar demonstration
• High Altitude, High Grazing Angle Target Detection
Conclusions

• Use of commercial satellites are key to Canada’s maritime domain awareness
• Polar Epsilon (Radarsat-2) is now operational in DND
• Layered surveillance architecture is best for Canada’s unique maritime surveillance requirement