DEFENCE R&D DÉFENSE

Operational Ship Detection in Canada using RADARSAT: Present and Future

Paris W. Vachon
DRDC Ottawa / RAST / RDE

LCdr Robert Quinn
DG Space, National Defence

20 June 2012

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.

Funding: $64.5 M, DND.

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.

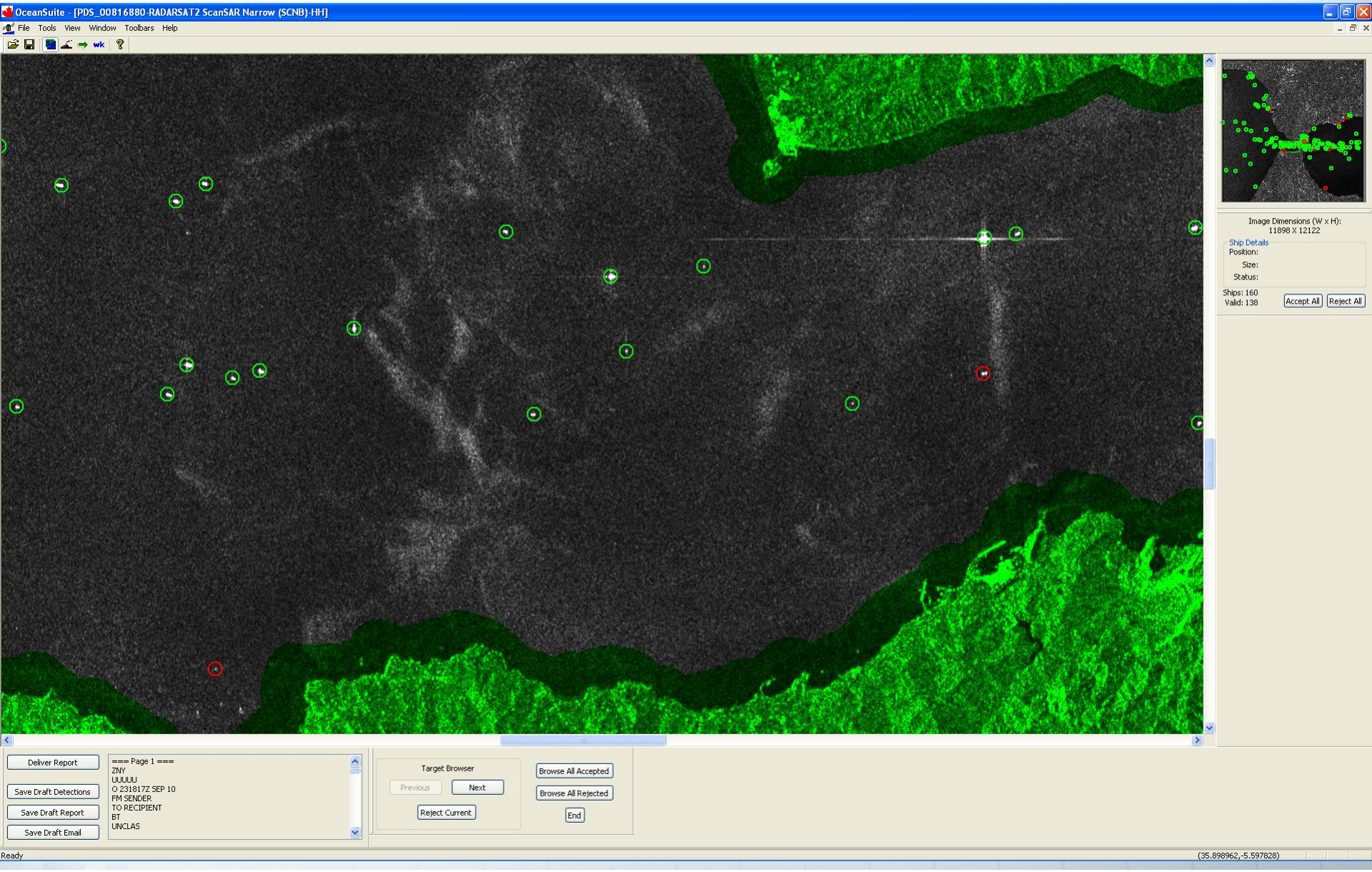
Schedule	IOC	FOC
Arctic Surveillance (Land)	Oct-09	Jun-10
Environmental Sensing	May-11	Apr-12
Near-Real Time Ship Detection	Aug-11	Mar-12
Maritime Satellite Surveillance Radar		Mar-12

NRTSD:
- Reception at Masstown and Aldergrove;
- Processing at Aldergrove;
- OTHGold in < 10 min;
- Automated ingest into RMP.

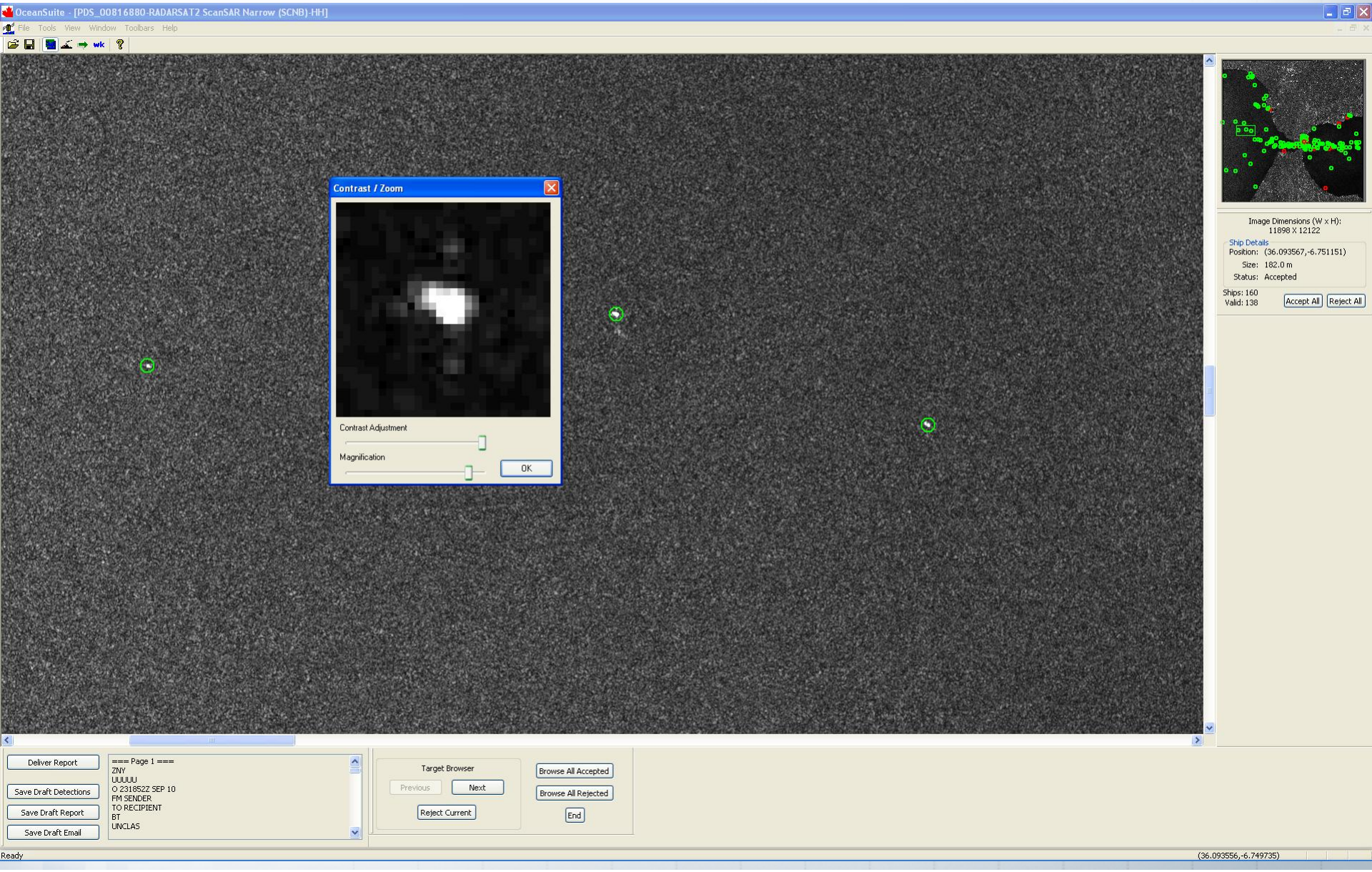
OceanSuite R-2 Exploitation Tool

- Polar Epsilon data exploitation segment:
  - 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;
- Two minutes budgeted for ship detection:
  - Operator in the loop.

OceanSuite – operational ship detection



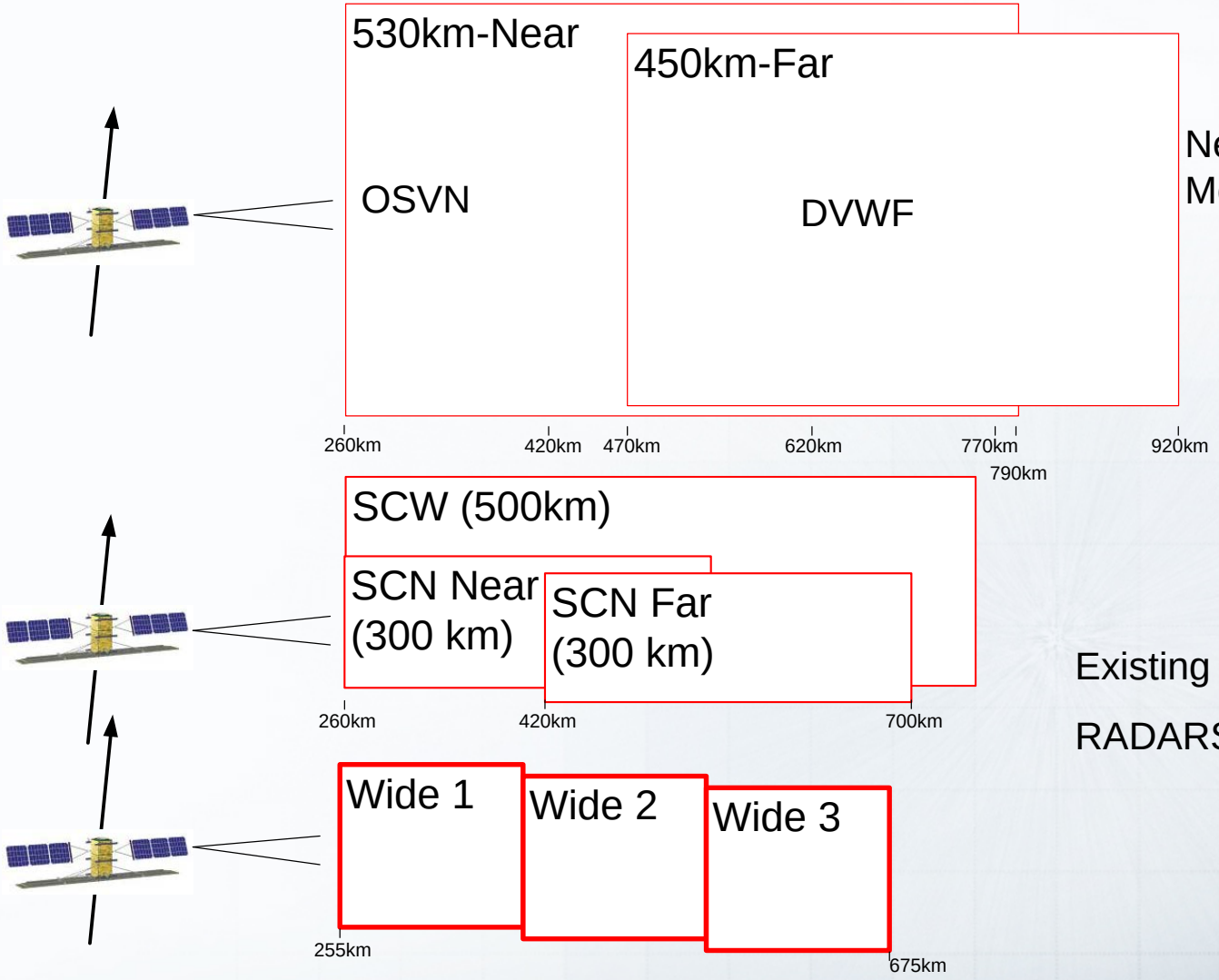
OceanSuite

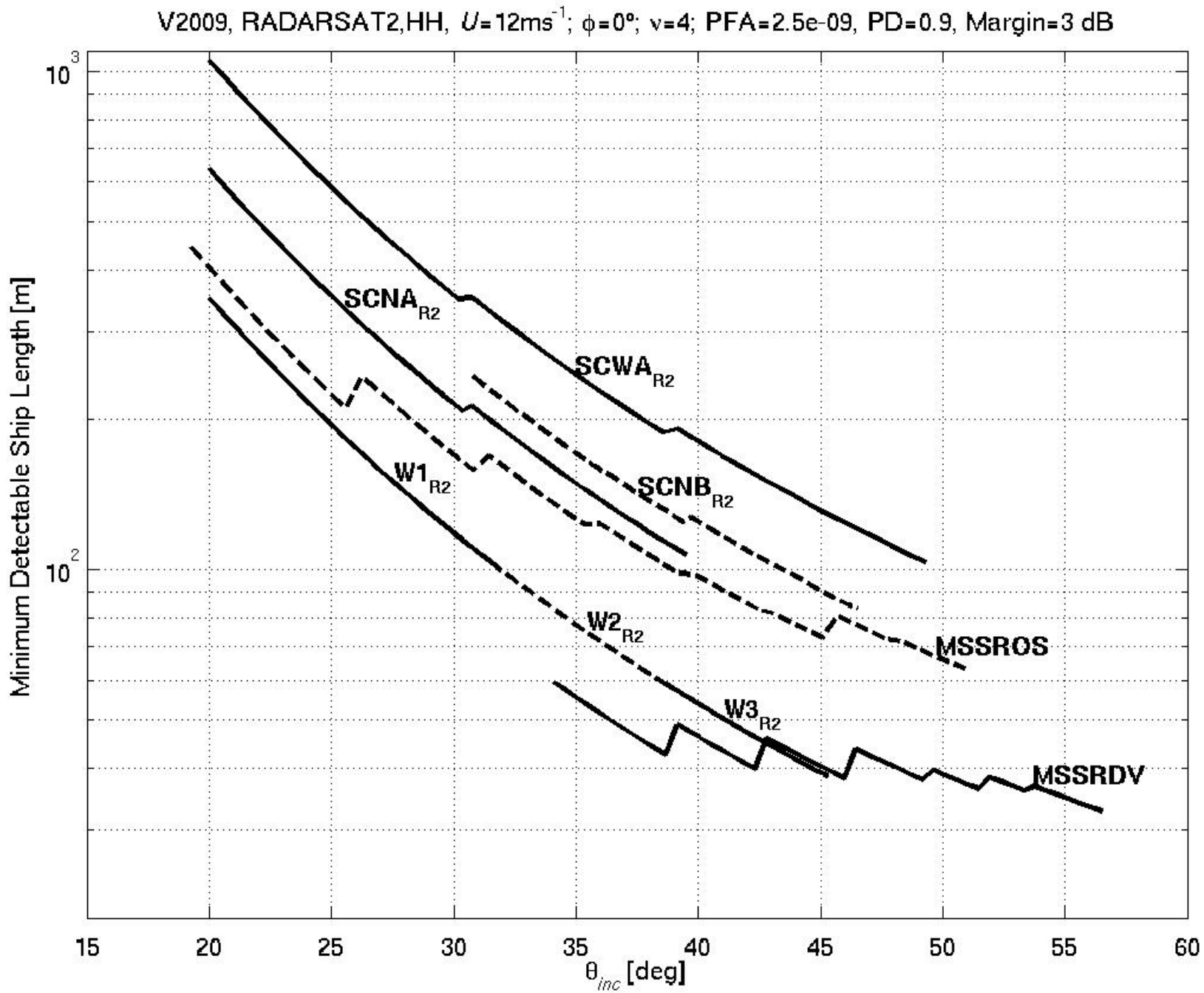


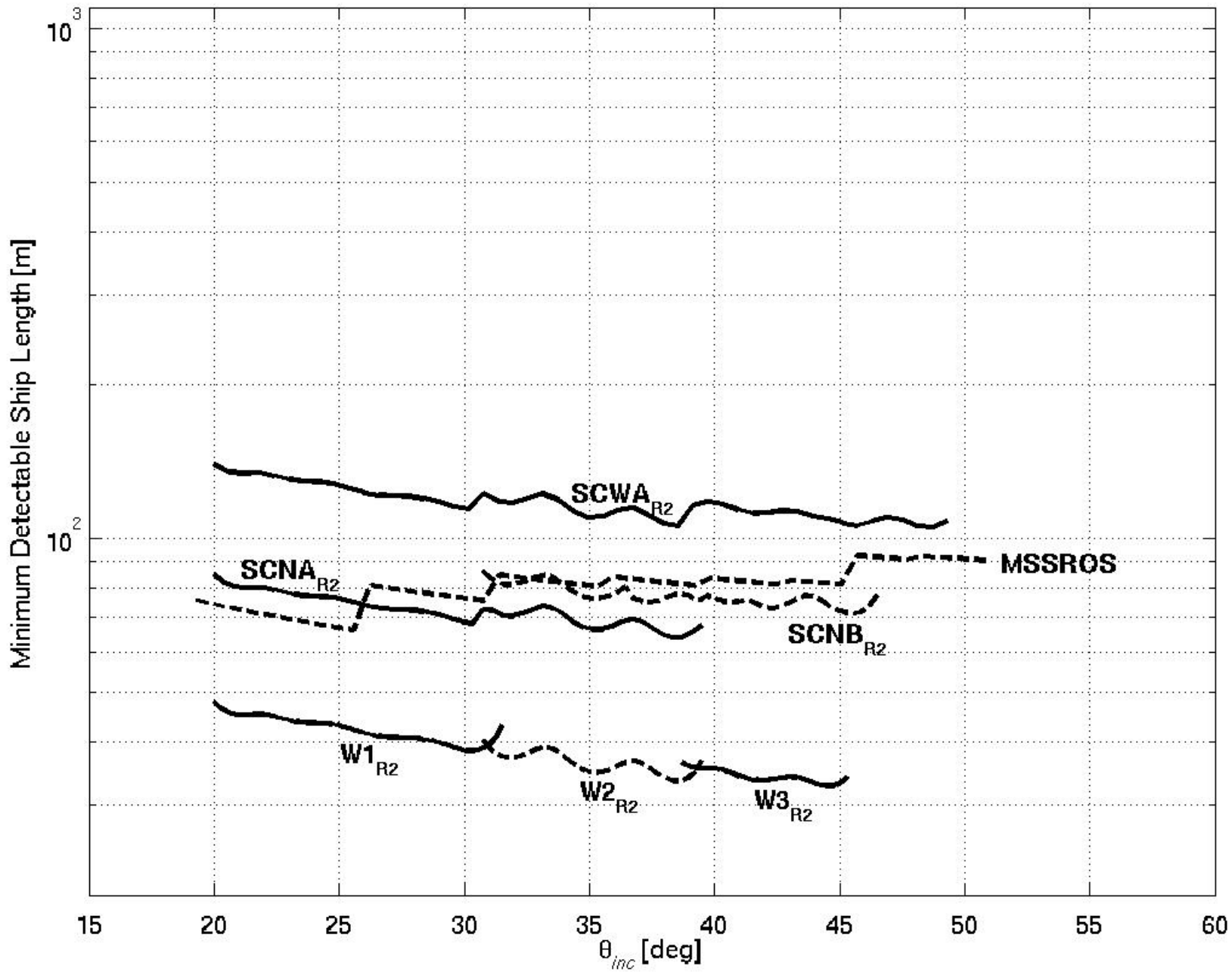
MSSR Modes

- Two new ScanSAR beam modes:
  - DVWF – **D**etection of **V**essels, **W**ide swath, **F**ar incidence:
    - Ship detection optimized;
    - 450 km swath;
    - Single polarization;
  - OSVN – **O**cean **S**urveillance, **V**ery wide swath, **N**ear incidence:
    - Multi-purpose with improved ship detection;
    - 530 km swath;
    - Dual polarization.

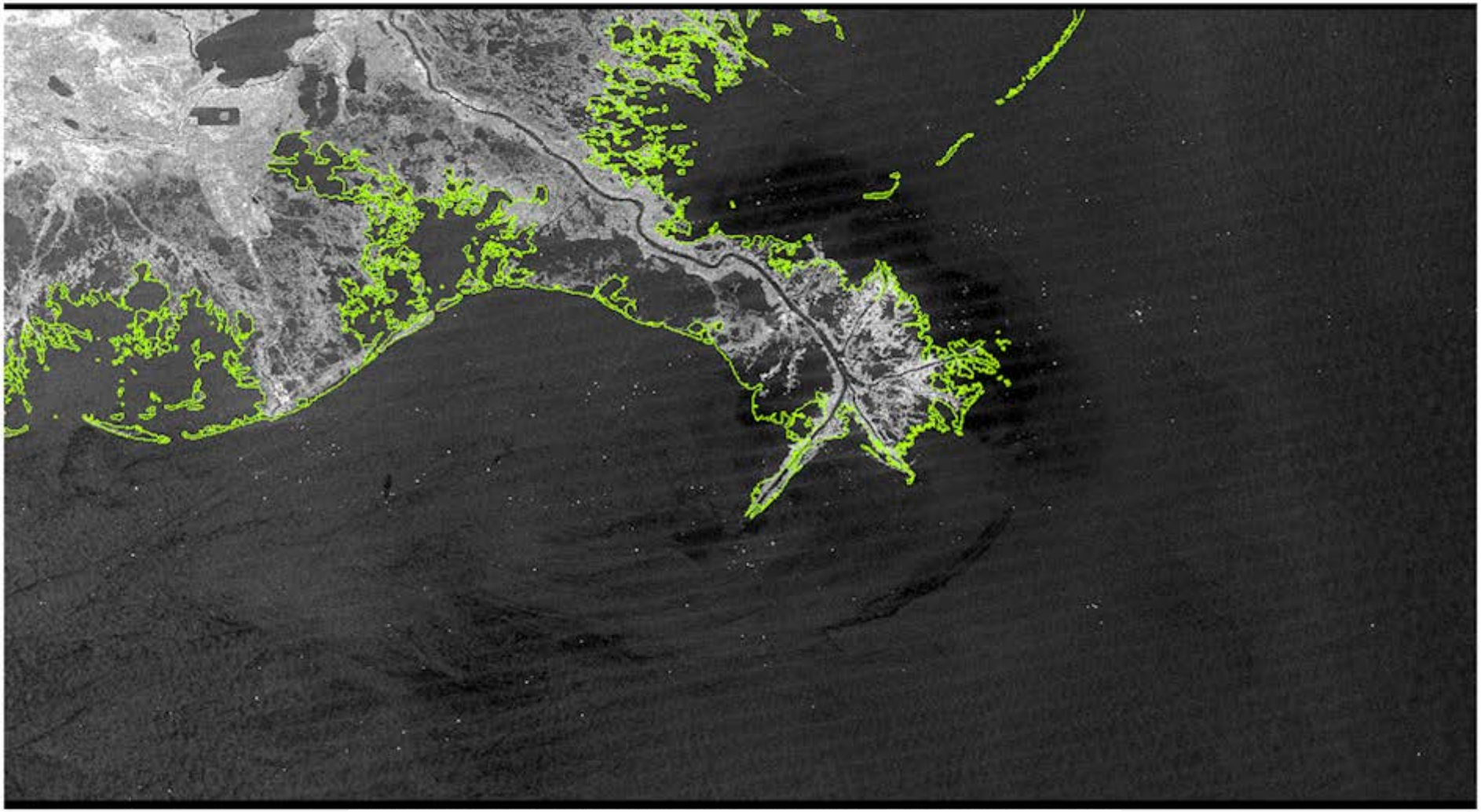
MSSR Modes


530km-Near
450km-Far
OSVN
DVWF
New MSSR Modes
260km
420km
470km
620km
770km
790km
920km
SCW (500km)
SCN Near (300 km)
SCN Far (300 km)
260km
420km
700km
Existing RADARSAT-2 Modes
Wide 1
Wide 2
Wide 3
255km
675km


V2009, RADARSAT2,HH, U=12ms-1; ϕ=0°; ν=4; PFA=2.5e-09, PD=0.9, Margin=3 dB
Minimum Detectable Ship Length [m]
10^3
10^2
15
20
25
30
35
40
45
50
55
60
θinc [deg]
SCNAR2
SCWAR2
SCNBR2
W1R2
W2R2
W3R2
MSSROS
MSSRDV

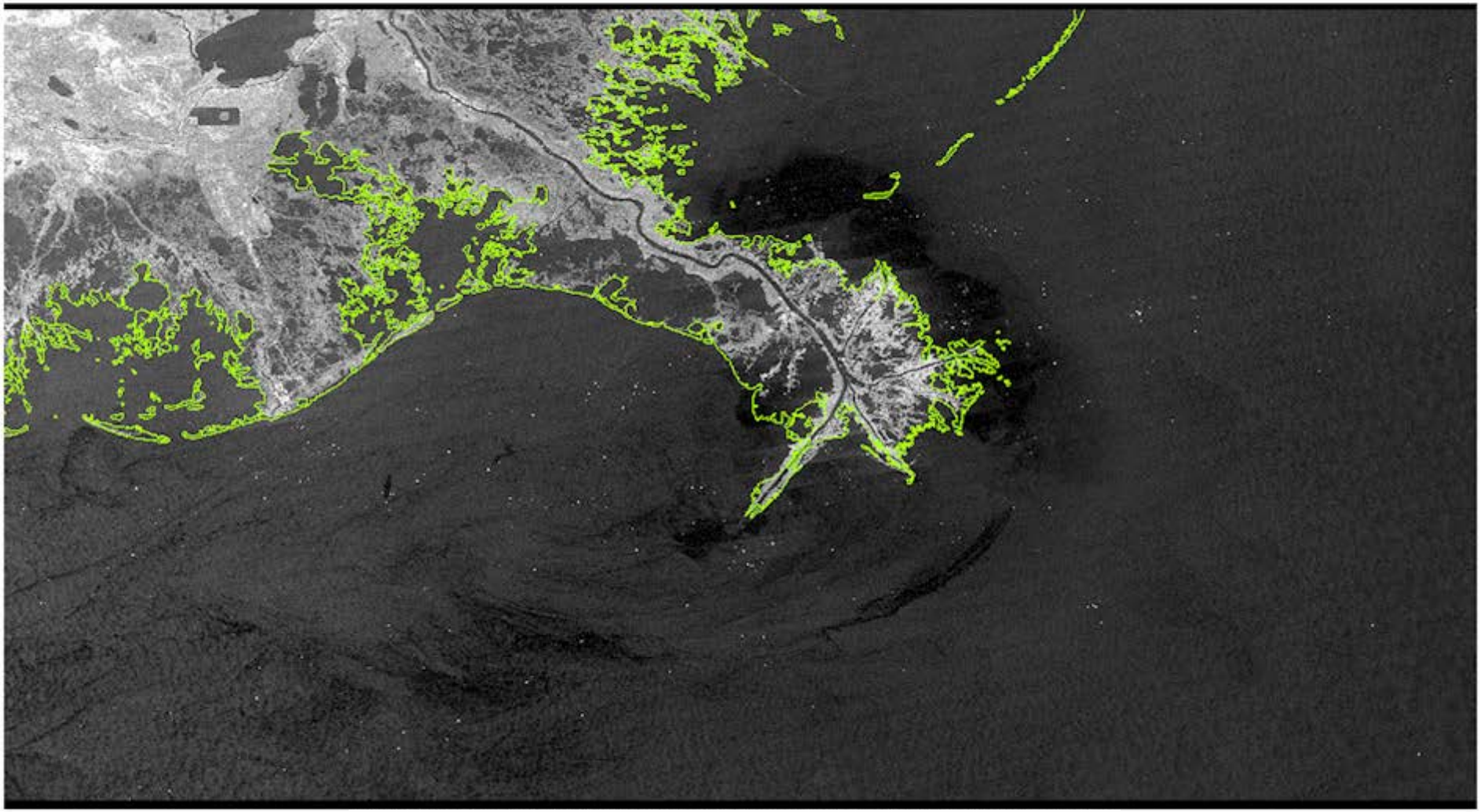

V2009, RADARSAT2,HV, U=12ms-1; ϕ=0°; ν=4; PFA=2.5e-09, PD=0.9, Margin=3 dB
Minimum Detectable Ship Length [m]
10^3
10^2
SCWA R2
SCNA R2
SCNB R2
MSSROS
W1 R2
W2 R2
W3 R2
15
20
25
30
35
40
45
50
55
60
θ inc [deg]

14 Feb, HH, NI, Gulf of Mexico



Canada

14 Feb, HH, NS, Gulf of Mexico



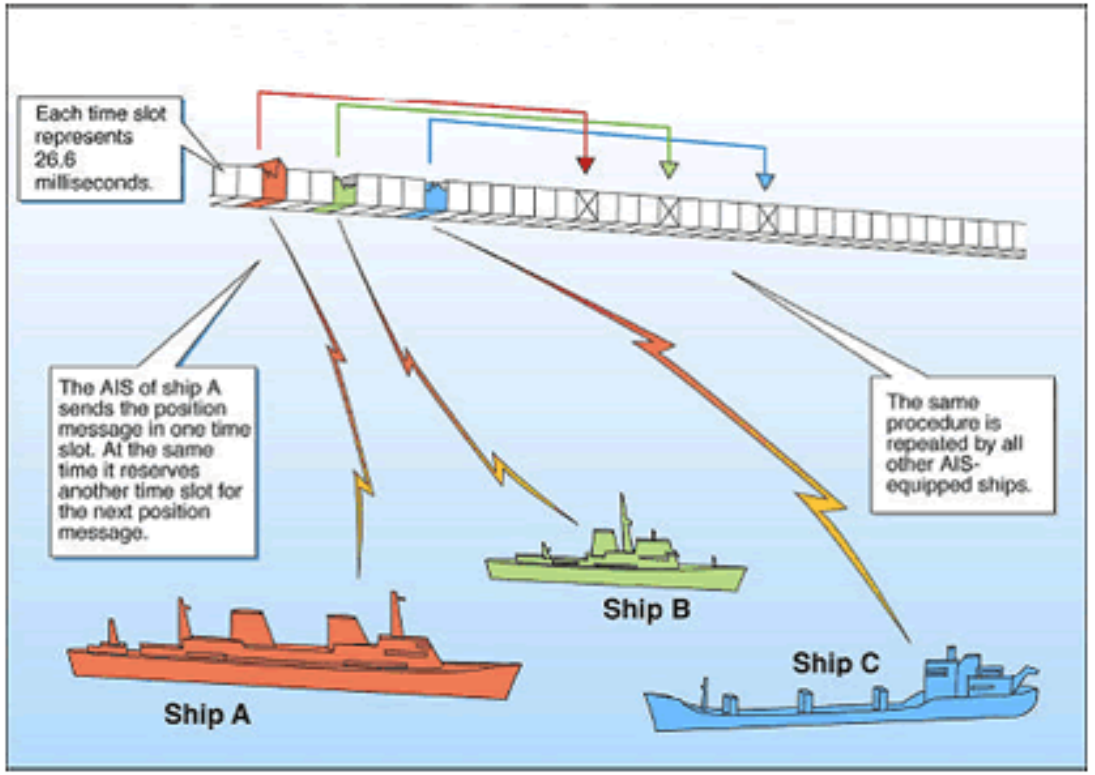
Canada

Automatic Identification System (AIS)

- Ship self reporting system;
- Intended for collision avoidance & vessel traffic services;
- International Maritime Organization:
  - Safety of Life at Sea (SOLAS) convention;
  - Mandated for vessels > 300 gross tons (requirement expanding);
- Maritime VHF band (terrestrial line-of-sight):
  - AIS 1 - 161.975 MHz; AIS 2 - 162.025 MHz;
- Broadcast ship information includes:
  - MMSI
  - Position
  - Heading
  - Time
  - Course
  - Speed
  - Rate of Turn
  - Cargo
- Evolving into a surveillance asset:
  - Coastal, buoy, aircraft, spacecraft.

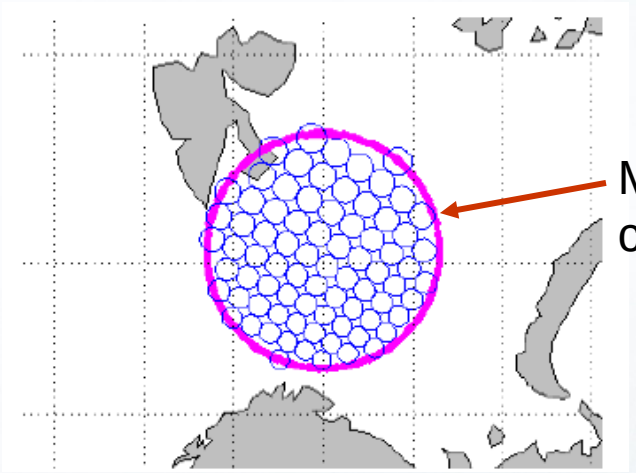
Self-Organized Time Division Multiple Access (SOTDMA)

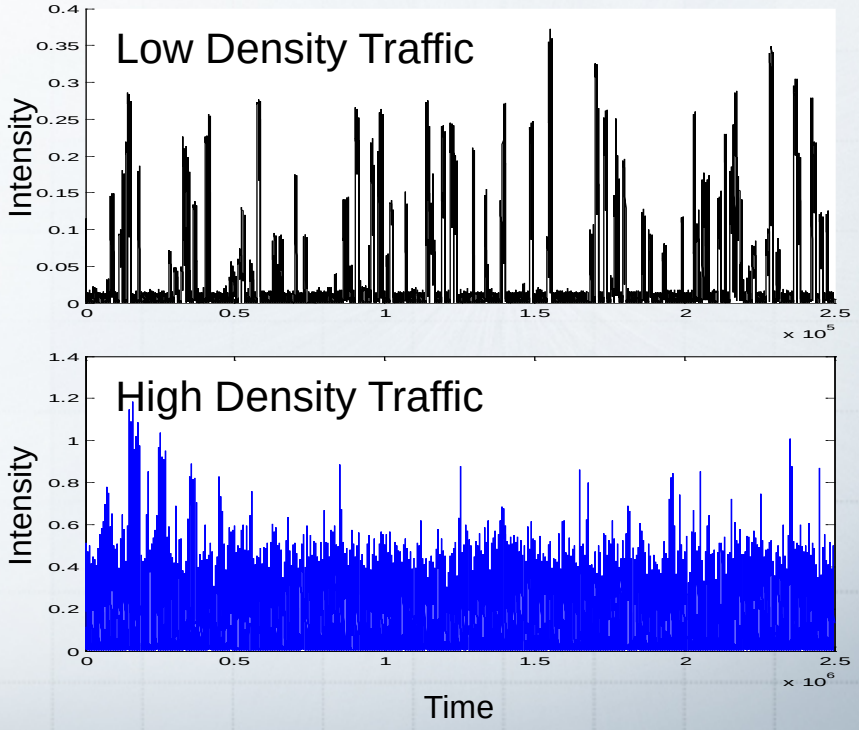
- Terrestrial line-of-sight;
- Future transmission slots reserved;
- Self-organized cells ~ 40 NM in radius;
- Transmissions as frequent as every 2 s;
- 2 channels, each with 2250 slots per minute;
- 27 message types (static and dynamic information);
- > 70,000 Class-A ships;
- **NOT** designed for reception from space.



Space-based AIS

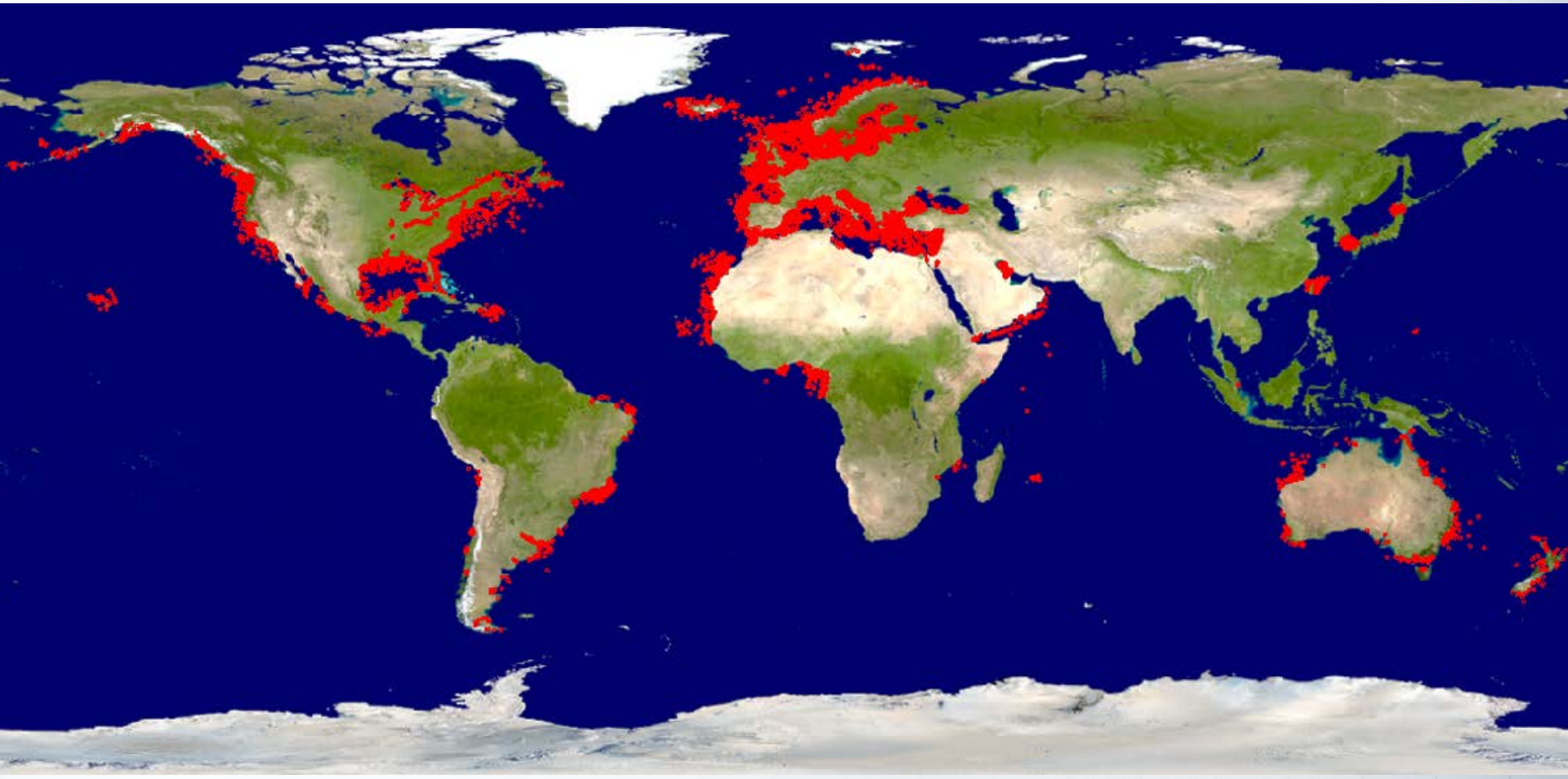
- Field of view is large (~ 5000 km diameter, horizon-to-horizon);
- Observation time up to ~ 12 min;
- Many asynchronous SOTDMA cells in field of view simultaneously;
- Transmissions from different cells overlap;
- Receiver strategies required to deal with **message collisions**.





Global Snapshot Acquired via MSSIS 8-Nov-2011

Number of Unique MMSI's = 27,779

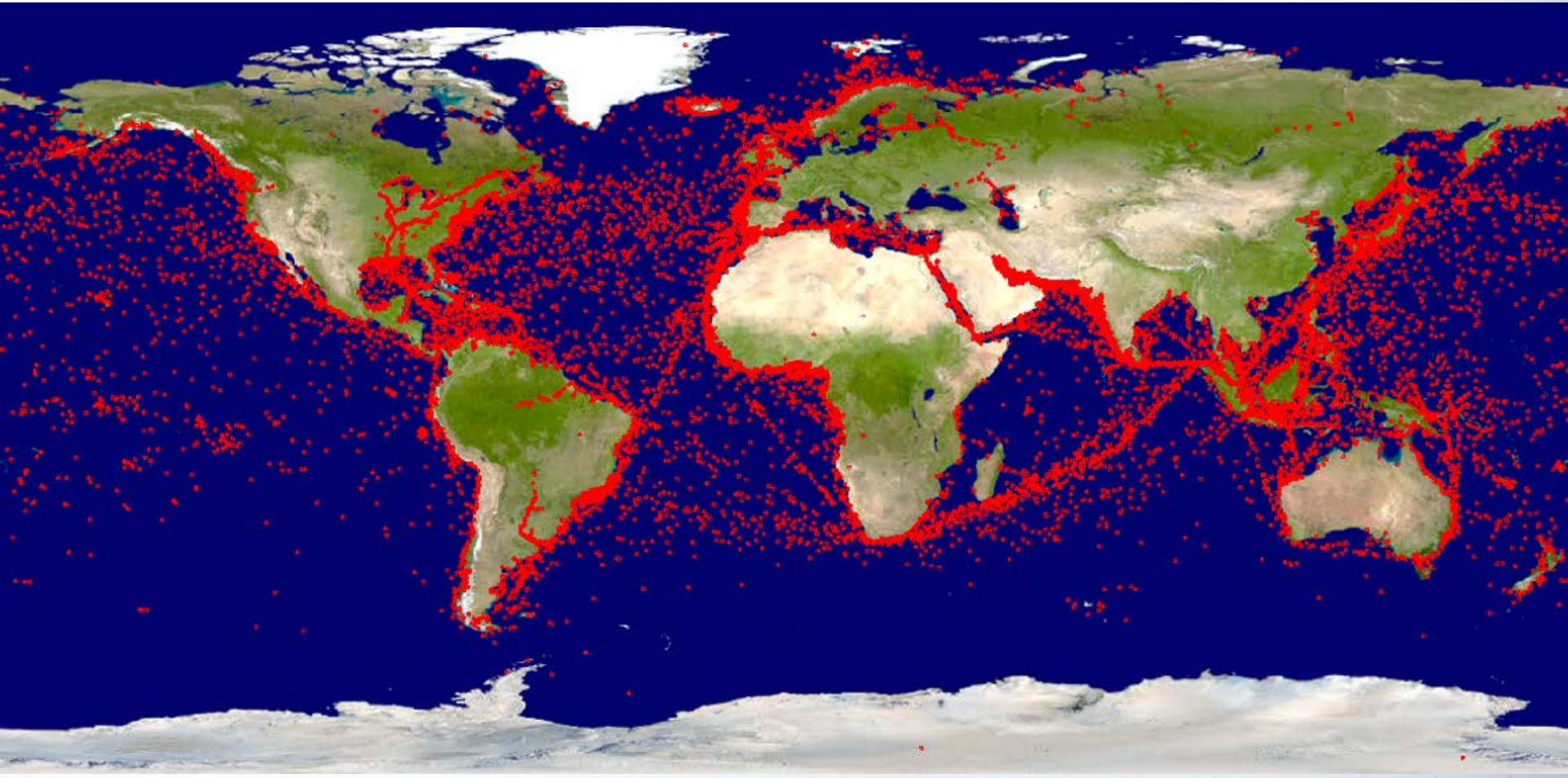


Vessels displayed correspond to the most recent AIS message over a 24 hour period beginning 8-Nov-2011 00:00:00

There are 10,541 vessels common to both MSSIS and Exact AIS Viewer

Global Snapshot Acquired via exactEarth 8-Nov-2011

Number of Unique MMSI's = 29,480



Vessels displayed correspond to the most recent AIS message over a 24 hour period beginning 8-Nov-2011 13:00:00

There are 10,541 vessels common to both MSSIS and Exact AIS Viewer

Polar Epsilon 2: Space-based Surveillance and Reconnaissance Capability

DEFENCE R&D DÉFENSE

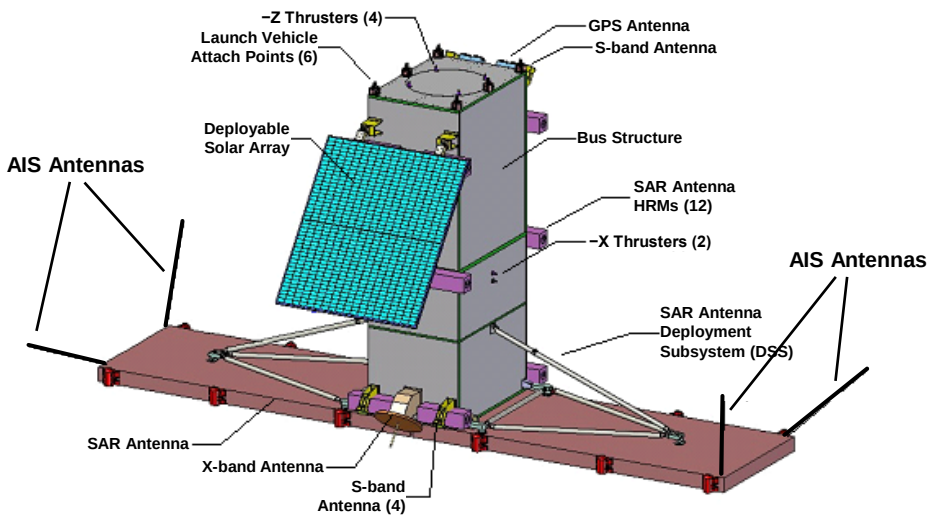
Overview:

Whole of Government approach to delivering more persistent and responsive Arctic, maritime, and deployed ops surveillance & reconnaissance using the RADARSAT Constellation Mission (RCM).

Cost: $184.6M+PO&M @$13.3M/yr (FY19/20).

Project Phase: Definition/Implementation

IOC: late 2016 with RCM 1st launch.



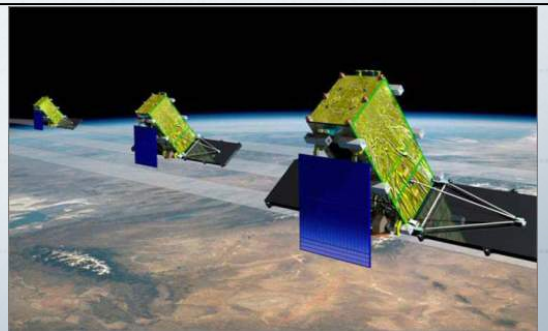
RCM Deployed Configuration

Capabilities:

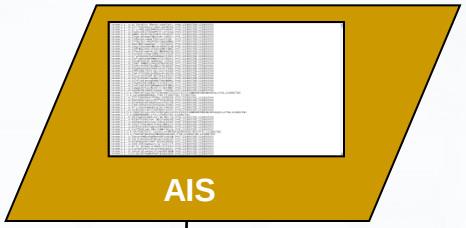
- Global ship identification and tracking;
- Integrated radar and ship identification on the space-segment;
- Daily coverage of the Arctic AOI and Maritime approaches;
- Four-day coherent change detection revisit.

Scope:

- Augment ship identification space segment via DND $56M transfer to CSA to increase RCM utility;
- Upgrade PE ground infrastructure, personnel, exploitation tools, for RCM data;
- Build new infrastructure to ensure sustained operations throughout RCM lifespan to 2023+.



Automation of SAR + AIS Association



Analysts' **D**etection **S**upport **S**ystem (ADSS), DSTO, Australia

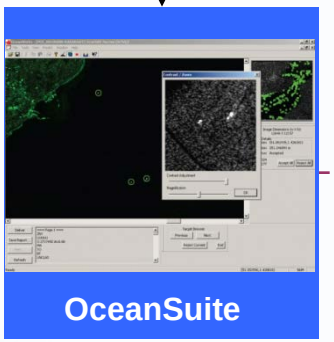
Detect

Predict

$$\begin{bmatrix} \phi(T) \\ \lambda(T) \\ SoG(T) \\ CoG(T) \end{bmatrix}_M$$

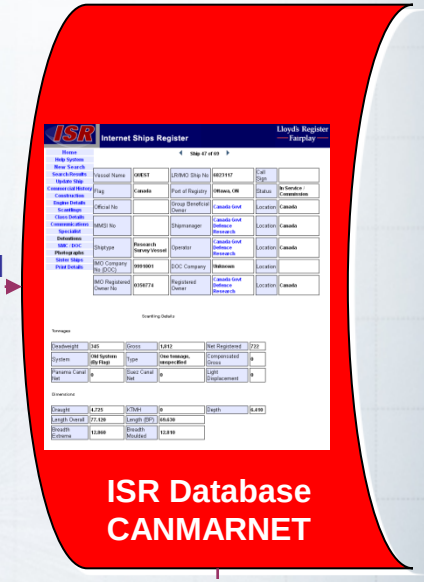
Metadata

MMSI

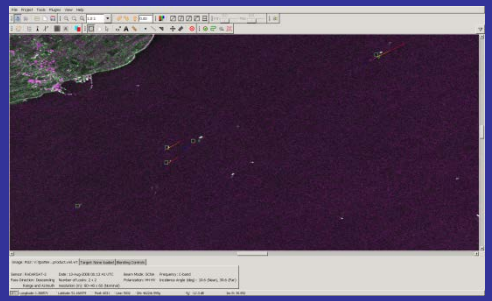


OceanSuite

Proximity Merge



ISR Database CANMARNET

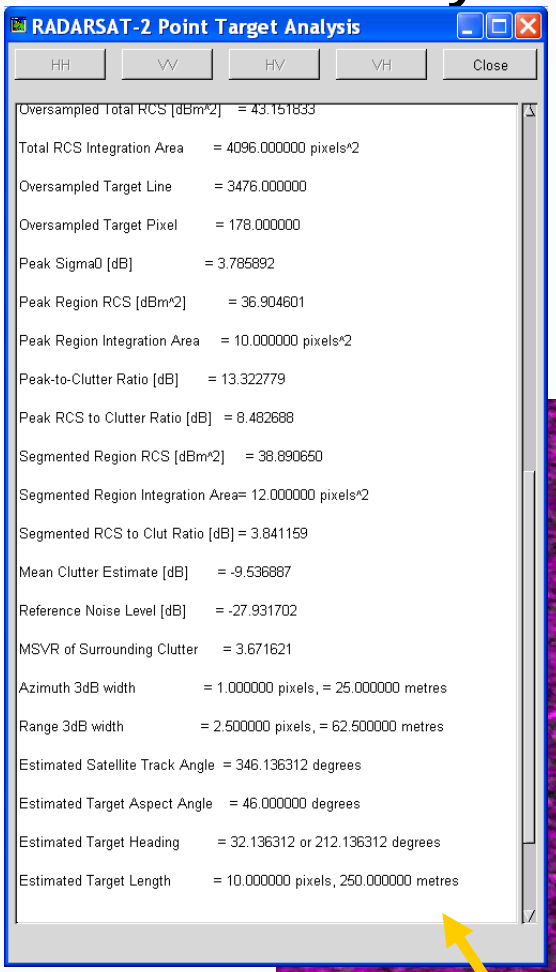


IA Pro

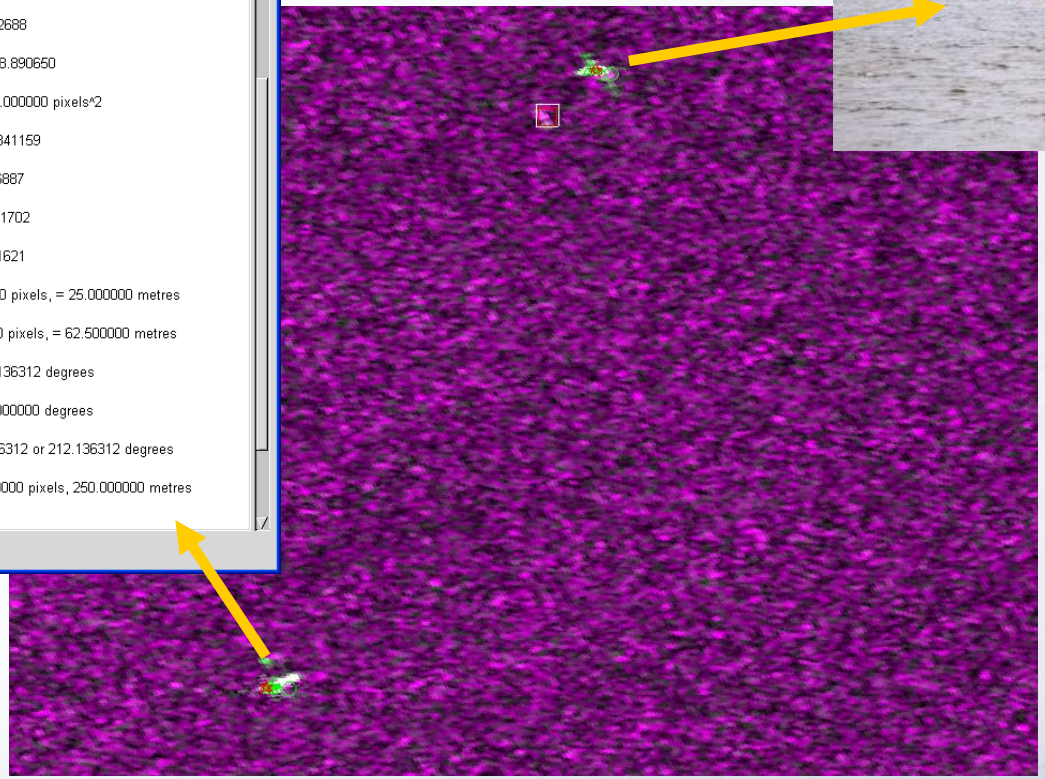
```
CTC/T3828/UNEQUATED-UNKNOWN//SHIP/UNK//NO////18///////
XPOS/14170307Z3/JUN10/LL:685443.97N6-0150353.32E2/AIS////317.6T
/0.0KTS////NTS
RMKS/NAV STATUS:UNDER WAY USING ENGINE
RMKS/RATEOFTURN:0.0 HEADING:214
RMKS/MMSI:XXXXXXXXX
CTC/T3481/UNEQUATED-UNKNOWN//SHIP/UNK//FI////18///////
XPOS/14170307Z3/JUN10/LL:650225.72N9-0243326.25E7/AIS////208.7T
/0.0KTS////NTS
RMKS/NAV STATUS:UNDER WAY USING ENGINE
RMKS/RATEOFTURN:0.0 HEADING:339
RMKS/MMSI:XXXXXXXXX
ENDAT
BT
```

GCCS-M

Declared by R-2, with and without declaration by NTS

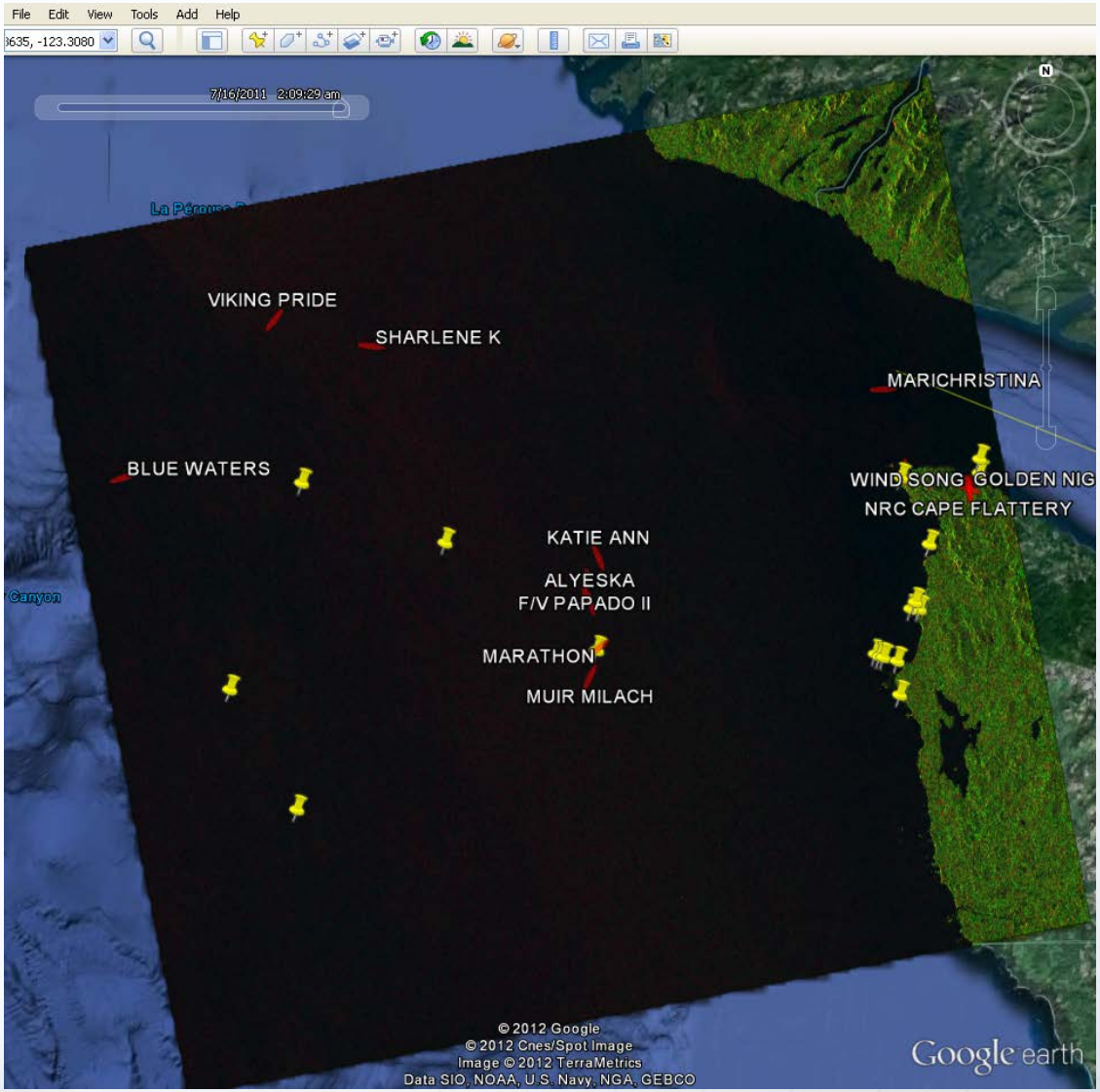


Platform Supply Ship (44 m)



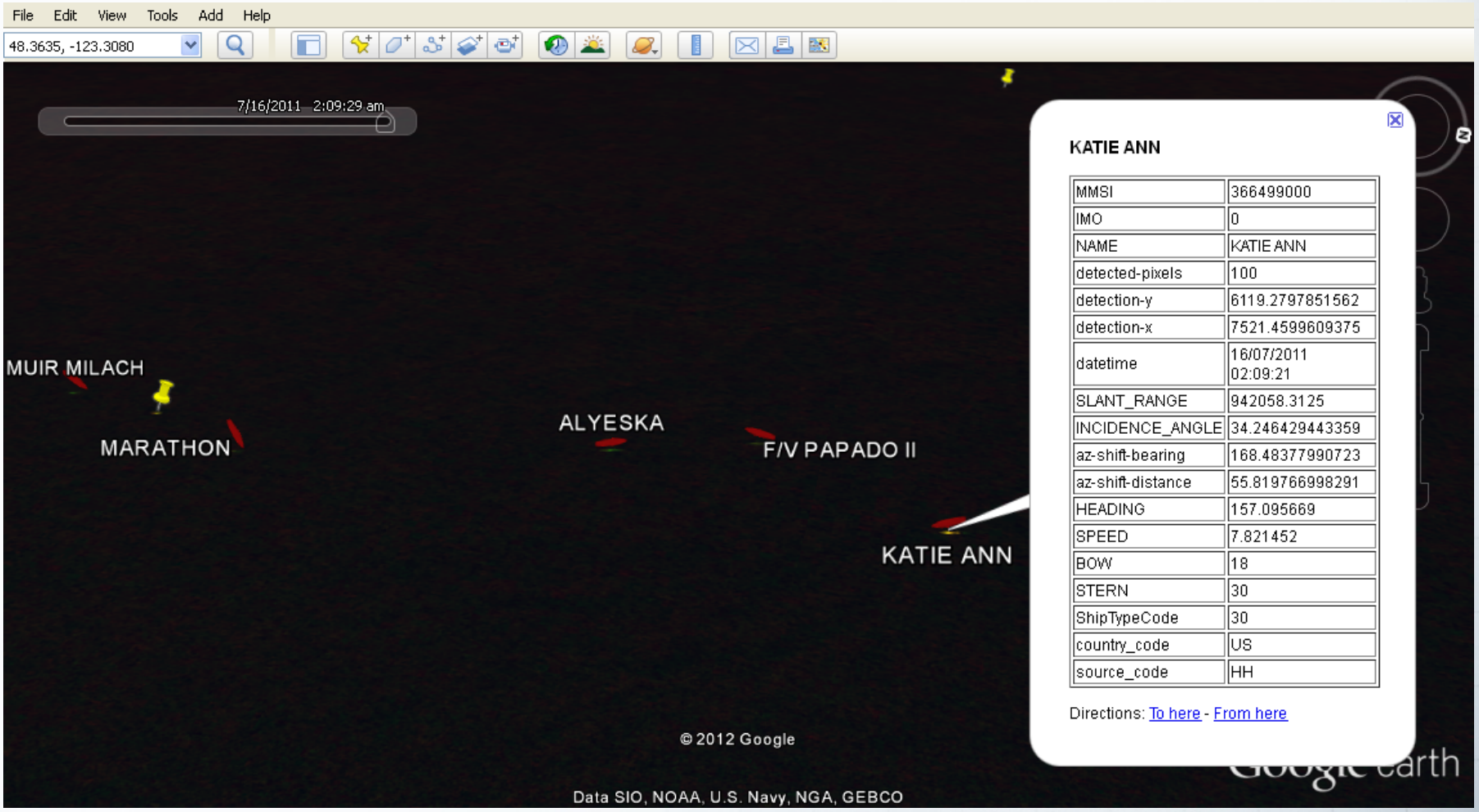
- NTS 1
- NTS 2
- MSSIS
- ADSS_ATA_HV
- ADSS_ATA_HH
- OceanSuite_HH
- ADSS_KCFAR_HH
- ADSS_KCFAR_HV

Approach to Juan de Fuca 2011-07-16



- Red ships are AIS predicted and associated.
- Yellow pushpins are unassociated OceanSuite detections.
- RS-2 S3 HH/HV
  - R: |HH|
  - G: 3|HV|
  - B: 31/255

KML Meta-Data



Summary

- Since March 2012, Polar Epsilon has been operationally using RADARSAT-2 for ship detection;
- In the near future, MSSR modes will be used for maritime order de-confliction within the Government of Canada;
- Space-based reception of AIS permits identification of SAR-detected ships;
- RADARSAT Constellation Mission satellites will include AIS receivers.