PROJECT POLAR EPSILON: JOINT SPACE-BASED WIDE AREA SURVEILLANCE AND SUPPORT CAPABILITY

Major P.J. Butler

Directorate of Space Development, National Defence Headquarters,
101 Colonel By Dr., Ottawa, ON, Canada, K1A 0K2 – butler.pj2@forces.gc.ca

Abstract - Project Polar Epsilon: Joint Space-Based Wide Area Surveillance and Support Capability, a capital project within Canada's Defence program, will use RADARSAT 2 to enable all-weather, day/night persistent surveillance of Canada's Arctic region and ocean approaches. Project Polar Epsilon is a transformational initiative to introduce space-based wide area surveillance to Canadian Government marine surveillance stakeholders. Effort in algorithm development is being undertaken to expand the potential of RADARSAT 2 for the sovereignty and surveillance mission. Capabilities being further developed include: land surveillance of Canada's Arctic Region via change detection techniques; ship detection; environmental sensing and ocean intelligence.

Keywords: RADARSAT 2, Surveillance, Ship Detection, Oil Spill Detection.

1. INTRODUCTION

Coastlines form an important part of international borders and Canada has the longest coastline in the world at 243,772 km and a corresponding marine area of responsibility of over 11 million square kilometers. Therefore, Canada has a formidable surveillance challenge. There are 250 ports in Canada and on a typical day 1700 ships are in our area of responsibility. The goal in marine security is domain awareness: to know what is happening and where it is happening in the marine domain or ocean approaches to our borders so that potential threats can be dealt with as far away from our borders as possible. Given this formidable security challenge, space-based sensors can make an important contribution. In fact, no single sensor is capable of providing complete surveillance or domain awareness; therefore a combination of sensors or capabilities is required. Each capability or sensor has its strengths and weaknesses and the strongest surveillance architecture exists by combining a multitude of sensors in a complementary manner. This paper will discuss the contribution that space-based surveillance can make to domain awareness through project Polar Epsilon and RADARSAT 2.

2. RADARSAT 2

The prime sensor in project Polar Epsilon will be Canada's RADARSAT 2 Earth Observation satellite. Building on the success of RADARSAT 1, the Canadian Space Agency received the mandate to develop a follow-on program to RADARSAT 1 in co-operation with the private sector. RADARSAT 2 will incorporate state-of-the art technology and will provide the most advanced commercially available Synthetic Aperture Radar (SAR) imagery in the world. SAR systems constitute a very powerful tool for Earth Observation as they can acquire images independently of weather and solar illumination. This is particularly useful in Canada's climate and location especially in the Arctic where a significant period is under cloud cover or darkness. Furthermore, as a polar orbiter, RADARSAT 2 passes close to the poles and is therefore ideally suited for Arctic surveillance as well as providing good revisit rates of the Arctic. Furthermore, RADARSAT 2 will detect uncooperative vessels regardless of the absence of emissions in the EM spectrum. Key features of RADARSAT 2 include: all weather, day/night, global reach, polar orbiter ideally suited for Canada's northern latitudes; spatial resolution from 3 to 100 meters; right or left hand imaging capability improving the flexibility of meeting imaging requirements; and multiple polarization modes enabling better discrimination and recognition of objects on the ground and improved classification capability. RADARSAT 2 imaging beams are shown in Figure 1.

3. PROJECT POLAR EPSILON

Project Polar Epsilon will invest in applications and ground segment infrastructure to receive and process RADARSAT 2 information. Polar Epsilon will deliver four main capabilities: near real-time ship detection; arctic land surveillance; environmental sensing; and maritime surveillance radar beam optimization.

3.1 Near Real-Time Ship Detection

The near real-time ship detection capability will include local RADARSAT 2 satellite reception, processing and applications in support of the emerging Marine Security Operations Centres (MSOCs) on both Canada's east and west coasts at or near Halifax and Esquimalt. It is important to note that ship detection information needs to be made available to the recognized maritime picture (RMP) at the MSOCs as fast as possible. This will ensure that the ship detection information is 'value-added' and ready for data fusion with other sensors contributing to the RMP. Furthermore, this will assist with subsequent tasking or cross cueing of other sensors to further classify and identify tracks of interest.

The overall requirement in domain awareness is to detect, classify, identify, track and determine intent. As no single sensor is capable of meeting all of these requirements all of the time, the strongest surveillance architecture exists when the strengths of all available surveillance sensors are used in a complementary manner. Figure 2 depicts the concept

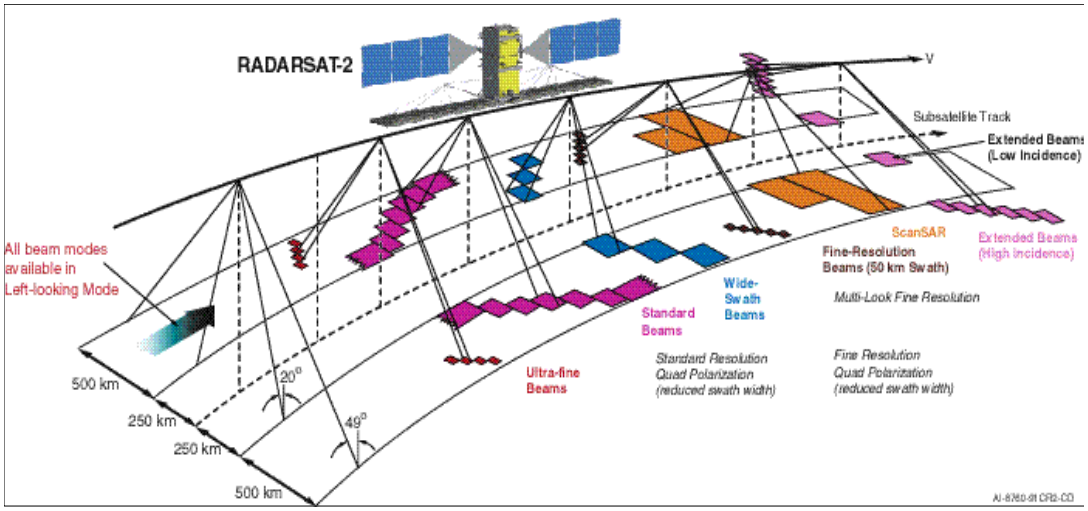

Figure 1. RADARSAT 2 beams (1) **Extended High**: 25 m resolution, 70 km swath; (2) **Extended Low**: 35 m resolution, 170 km swath; (3) **ScanSAR Wide**: 100 m resolution, 500 km swath; (4) **ScanSAR Narrow**: 50 m resolution, 300 km swath; (6) **Wide**: 30 m resolution, 150 m swath; (6) **Standard**: 25 m resolution, 100 km swath; (7) **Standard Quad-Pol**: 25 m resolution, 25 km swath; (8) **Fine**: 8 m resolution, 50 km swath; (9) **Multi-Look Fine**: 10 m resolution, 50 km swath; (10) **Fine Quad-Pol**: 10 m resolution, 25 km swath; (11) **Ultra-Fine**: 3 m resolution, 20 km. Courtesy of the Canadian Space Agency.

of operations for Project Polar Epsilon. RADARSAT 2 is ideally suited as a sensor in remote areas, in all weather conditions and where other sensors do not exist or are unable to operate. RADARSAT 2 is able to generate wide area surveillance using 500-kilometer wide swaths at 7.5 km per second and is therefore likely to be the first sensor of detection. RADARSAT 2 information will be downlinked to the satellite infrastructure provided by Polar Epsilon in support of the MSOCs. With local reception and processing, the information will be processed and automatically formatted into the required messages available for integration to the RMP in 15 minutes. This information can then be available for fusion within the RMP or for cueing to other surveillance sensors or reconnaissance assets such as maritime patrol aircraft, uninhabited aerial vehicles (UAVs), or ships. RADARSAT 2 processors will permit concurrent reception and processing thus significantly improving processing time, unlike the present processors for RADARSAT 1, which must wait for the entire satellite pass to be completed before processing can begin. The provision of local satellite reception facilities in support of the MSOCs is important to provide surveillance information to the RMP as fast as possible, and extend the RADARSAT 2 visibility masks out to 1000 NM from the coastline covering the targeted area of interest. Global surveillance of areas of interest outside the local visibility masks will be achieved by either downlinking the information stored onboard the satellite when the satellite is within connectivity of the local station or other national reception sites.

3.2 Arctic Land Surveillance

The land area of Canada's northern territories is approximately the size of continental Europe and represents 40% of Canada's total landmass. The size of this territory presents a formidable surveillance challenge. Additionally, the sensitive ecosystem, climate change and new discoveries of valuable resources are resulting in increased activity levels in Canada's north. With continued climate change, marine traffic in the North West Passage will undoubtedly increase. RADARSAT 2 is ideally suited for Arctic surveillance both due to its polar orbit and radar characteristics of all weather, day or night sensor capability. Polar Epsilon will assist with Arctic surveillance by exploiting RADARSAT 2 and change detection techniques to monitor activity or changes in the Arctic. This will make a valued contribution to Arctic surveillance given the remoteness of the territory and scarce resources or sensors available for surveillance. Other sensors or assets can then be dispatched for further investigation similar to the maritime concept of operations. In a recent Arctic military exercise in August 2004, RADARSAT 1 was the first among several sensors, both manned and unmanned to detect simulated satellite debris on Baffin Island.

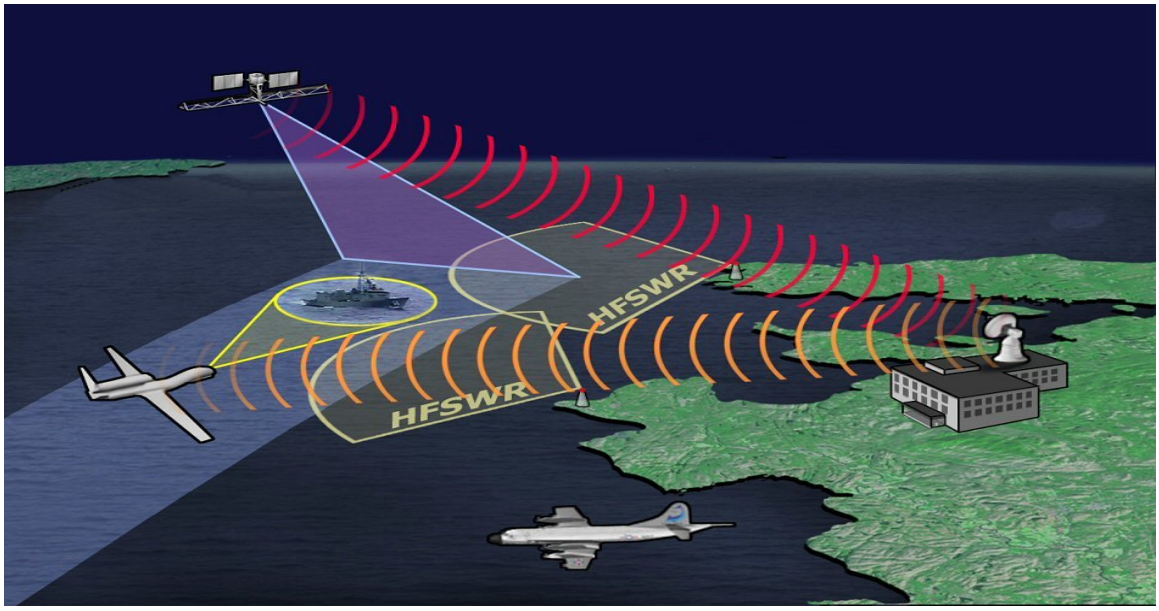

Figure 2. Concept of Operations depicting space, high frequency surface wave radar sites, uninhabited aerial vehicles, maritime patrol aircraft, and the Marine Security Operations Centers with local reception and processing.

3.3 Near Real-Time Ship Detection

Environmental sensing falls into the category of domain awareness or environmental situational awareness. Knowledge of the environment is required to optimally operate reconnaissance assets such as ships, submarines or aircraft and predict or monitor sensor performance such as radar or sonar. Project Polar Epsilon will deliver space-based environmental sensing information to the MSOCs from RADARSAT 2 and the United States National Oceanic Atmospheric Agency satellites carrying Moderate Resolution Imaging Spectroradiometer (MODIS) sensors. The provision of ocean colour information from the MODIS sensors will assist the MSOCs with operational use of maritime patrol aircraft, ships, submarines and sonar performance prediction.

3.4 Maritime Surveillance Radar

The maritime surveillance radar component of Polar Epsilon will consider investment in RADARSAT 2 imaging beams to optimize those beams for marine domain awareness applications. A high assurance of target detection is required given the desire to task reconnaissance assets to detected tracks of interest therefore the highest possible performance of the sensor needs to be achieved. Figure 3 depicts the areas of interest.

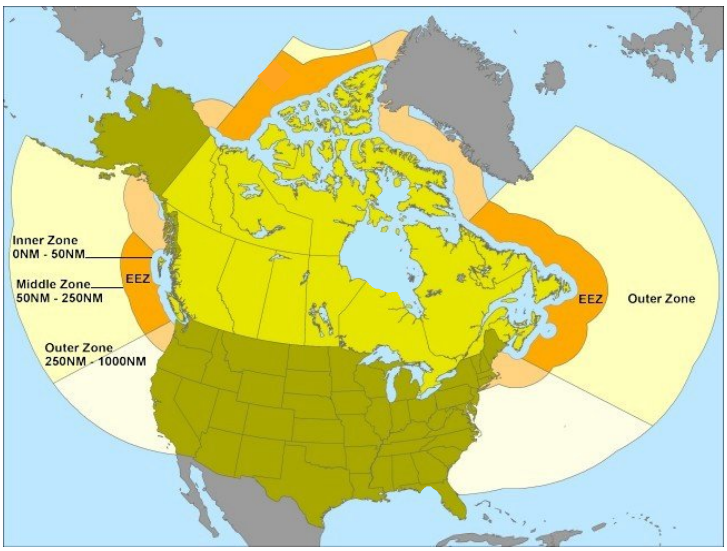

Figure 3. CF Areas of Interest (AOIs): Territorial Waters 12 NM; Economic Exclusion Zone 12 NM – 200 NM; Inner zone: coast – 50 NM, Middle Zone: 50 NM – 250 NM; Outer Zone: 250 NM – 1000 NM.

4. POLAR EPSILON 2: RADARSAT 2 FOLLOW-ON CONSTELLATION (RFC)/AIS

The future is very promising in using space to meet the complete marine domain awareness requirements: detection; classification; identification; tracking; and intent. The International Maritime Organization has mandated carriage of Automated Identification System (AIS) onboard ships. AIS is a mixed ship and shore-based broadcast transponder system, operating in the VHF maritime band, which sends ship identification, position, heading, ship length, beam, type, draught and hazardous cargo information, to other ships as well as to shore. Of significance is that AIS can be monitored from satellites and the fusion of space-based radar detections along with AIS reporting can significantly contribute to the recognized maritime picture. The ability of radar to detect non-cooperative or non-compliant vessels fused with AIS reporting is very significant permitting surveillance operators to suppress known vessels and easily identify unknown tracks or vessels of interest. Figure 4 shows a combined RADARSAT 1 image and AIS information from the English Channel on 27 Jan 05.

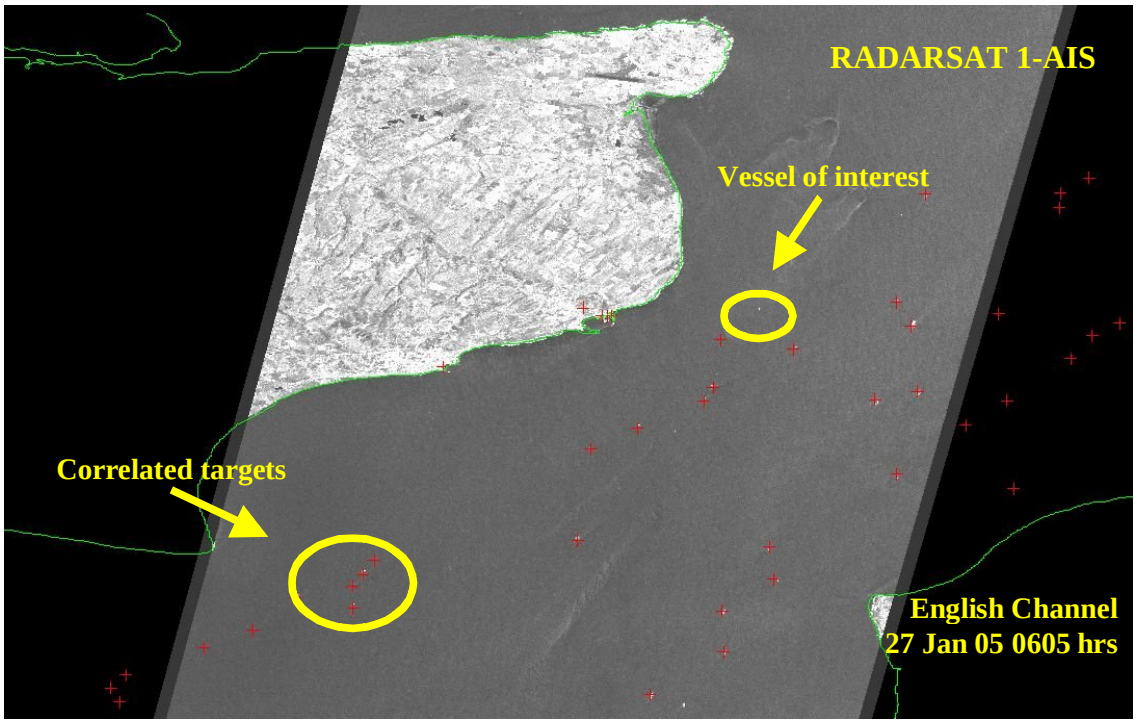

Figure 4. RADARSAT 1 imagery fused with AIS of the English Channel 27 Jan 05 courtesy of Defence Research and Development Canada (Ottawa). The white dots in the English Channel represent detections of ships. The red crosses represent AIS information. The AIS reports and RADARSAT 1 detections are combined.

5. CONCLUSION

Space-based sensors with their unique advantages can significantly contribute to domain awareness. RADARSAT 2's ability to provide surveillance information regardless of target cooperation or environmental conditions will make valuable addition to Canada's surveillance architecture.

6. REFERENCES

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