

# RADARSAT-2 Program Update

Luc Brûlé, Daniel Delisle  
Canadian Space Agency  
St-Hubert, Qc, Canada

Hans Baeggli, James Graham  
MacDonald, Dettwiler and Associates  
Richmond, B.C., Canada

**Abstract—** RADARSAT-2 will be the next Canadian commercial Earth observation SAR satellite. The construction of the spacecraft and the development of the ground segment are progressing well. This paper presents an overview of the mission, some featured innovations, imaging capabilities and data distribution aspects.

**Keywords-** RADARSAT-2; mission; satellite

## I. INTRODUCTION

The RADARSAT-2 Mission design and construction represents a significant evolution from RADARSAT-1 with new capabilities designed to ensure Canada's continued leadership in the SAR global marketplace. The development phase of the project is progressing well and the spacecraft is expected to be launched in 2006. The operations phase is designed to last seven years. During that phase, the satellite will provide data for commercial users, as well as for the Canadian Government. This article presents a summary of various elements of the RADARSAT-2 mission, a more complete overview of the mission is found in Reference [1].

## II. MISSION OBJECTIVES

RADARSAT-2 is the follow-on mission to RADARSAT-1 designed to ensure continuity of SAR data and to enhance the ability of the operational users to fulfill their mandates. The primary objective of the RADARSAT-2 mission is the supply and distribution of SAR data and products that will meet the needs of present and future markets, with a commercially viable approach. This is achieved by leveraging the knowledge and experience gained through the RADARSAT-1 mission and taking advantage of newly developed technologies. RADARSAT-2 represents a technological step forward from the very successful RADARSAT-1 mission, and will ensure Canada's continuing global leadership in Radar Remote Sensing.

## III. IMAGING CONFIGURATION AND CAPABILITIES

The RADARSAT-2 SAR will reproduce all RADARSAT-1 beam modes, and will additionally provide selectable polarization options for each of these modes. The full range of signal polarization modes are provided, and can be selected based on optimum performance requirement for a particular application.

The Quad-Polarization mode (polarimetric SAR) will generate images for all polarization combinations: HH, VV, HV, and VH, and the phase difference between them.

RADARSAT-2 will have 3 m resolution capability that advances the state-of-the-art for commercial systems, thus opening up new markets in mapping and surveillance applications. The features of these new beam modes will improve the interpretability of the collected images.

The spacecraft will be able to function routinely in both right looking mode or left-looking mode. Transitions between right and left-looking modes will be achievable in less than 10 minutes.

The SAR will have an accessibility ground swath of at least 500 km on either side of the satellite and a range of incidence angles from 20° to 50° over that swath (800 km and incidence angles of 10° to 60° for extended beams).

The on-board computer will be able to store a command sequence covering 24 hours of spacecraft operations and 500 images. The SAR will be capable of collecting data for a time period of up to a nominal 28 minutes per orbit. On-board data storage, will be provided by two solid state recorders, which will guarantee an end-of-life total capacity of 300 Gb.

The RADARSAT-2 spacecraft will operate in an orbit that is identical to RADARSAT-1's orbit. The orbit will be sun-synchronous, crossing the equator with the ascending node at 18:00 hours local mean time. This orbit will have an altitude of 798 km, an inclination of 98.6°.

Star trackers were added to the spacecraft to improve attitude control and knowledge. The spacecraft orbit control system will be capable of maintaining ground-track repeatability to within at least +5 km, at any point in the orbit. The spacecraft attitude control will have sufficient accuracy and consistency to allow multi-pass interferometry to be performed with the SAR, with passes separated by one orbit cycle of 24 days.

The spacecraft will have an on-board Global Position System (GPS) and will calculate the spacecraft's absolute position in real-time. Using GPS receivers on the spacecraft will improve near real-time orbit knowledge and the geometric accuracy of delivered products.

| Report Documentation Page                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                    |                                     |                                            | Form Approved<br>OMB No. 0704-0188          |                                    |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|-------------------------------------|--------------------------------------------|---------------------------------------------|------------------------------------|
| Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. |                                    |                                     |                                            |                                             |                                    |
| 1. REPORT DATE<br><b>25 JUL 2005</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                    | 2. REPORT TYPE<br><b>N/A</b>        |                                            | 3. DATES COVERED<br><b>-</b>                |                                    |
| 4. TITLE AND SUBTITLE<br><b>RADARSAT-2 Program Update</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                    |                                     |                                            | 5a. CONTRACT NUMBER                         |                                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                    |                                     |                                            | 5b. GRANT NUMBER                            |                                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                    |                                     |                                            | 5c. PROGRAM ELEMENT NUMBER                  |                                    |
| 6. AUTHOR(S)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                    |                                     |                                            | 5d. PROJECT NUMBER                          |                                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                    |                                     |                                            | 5e. TASK NUMBER                             |                                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                    |                                     |                                            | 5f. WORK UNIT NUMBER                        |                                    |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)<br><b>Canadian Space Agency St-Hubert, Qc, Canada</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                    |                                     |                                            | 8. PERFORMING ORGANIZATION<br>REPORT NUMBER |                                    |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                    |                                     |                                            | 10. SPONSOR/MONITOR'S ACRONYM(S)            |                                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                    |                                     |                                            | 11. SPONSOR/MONITOR'S REPORT<br>NUMBER(S)   |                                    |
| 12. DISTRIBUTION/AVAILABILITY STATEMENT<br><b>Approved for public release, distribution unlimited</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                    |                                     |                                            |                                             |                                    |
| 13. SUPPLEMENTARY NOTES<br><b>See also ADM001850, 2005 IEEE International Geoscience and Remote Sensing Symposium Proceedings (25th) (IGARSS 2005) Held in Seoul, Korea on 25-29 July 2005.</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                    |                                     |                                            |                                             |                                    |
| 14. ABSTRACT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                    |                                     |                                            |                                             |                                    |
| 15. SUBJECT TERMS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                    |                                     |                                            |                                             |                                    |
| 16. SECURITY CLASSIFICATION OF:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                    |                                     | 17. LIMITATION OF<br>ABSTRACT<br><b>UU</b> | 18. NUMBER<br>OF PAGES<br><b>3</b>          | 19a. NAME OF<br>RESPONSIBLE PERSON |
| a. REPORT<br><b>unclassified</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | b. ABSTRACT<br><b>unclassified</b> | c. THIS PAGE<br><b>unclassified</b> |                                            |                                             |                                    |

#### IV. SPACECRAFT MAIN SUB-SYSTEMS

##### A. *Spacecraft Bus*

The bus module consists of spacecraft elements that provide general spacecraft support functions such as attitude measurement and control, telemetry and command, data storage and retrieval, power generation and storage, thermal control, and the primary structural support.

The spacecraft bus and solar panels were developed by Alenia Spazio of Italy. Alenia successfully completed the construction of the RADARSAT-2 bus and solar arrays and delivered the components for integration and testing to the David Florida Laboratory in Ottawa, Canada in the Spring of 2004.

##### B. *Payload*

The payload module consists of the SAR antenna, and specific support equipment required to perform such functions as timing and control of the payload, signal distribution, signal detection, thermal control, data storage, and X-band down-link.

The essence of the satellite is an active phased-array synthetic aperture radar operating at 5.405 GHz frequency, the same frequency band as RADARSAT-1, thus maintaining similar radar characteristics. The antenna is composed of two wings, each with two antenna panels containing 4 columns of 32 transmit/receive modules, each driving 20 radiating elements. This results in 512 transmit/receive modules and 10,240 radiating elements for the antenna. Each of the T/R modules can be individually controlled, independently of the others. The aperture of the SAR antenna is identical to that used on RADARSAT-1 but is significantly more flexible because of the phased array technology.

Through the flexible electronic control, proper phasing of the modules produces the numerous different radar beam modes, with varied beam widths and resolutions. The T/R modules have the capability to transmit or receive either Horizontally or Vertically polarized signals, producing the different multipolar beams which will be available with RADARSAT-2.

The SAR antenna and payload electronics are being developed by EMS Technologies in Ste-Anne-de-Bellevue, Canada.

##### C. *Extendible Support Structure*

The SAR antenna itself is supported by the extendible support structure (ESS), which is used to deploy the antenna and to provide a rigid support in the deployed position.

The ESS was developed by AEC-Able in California and was delivered to DFL in October 2003.

##### D. *Assembly, Integration and Testing*

The David Florida Laboratory (DFL) is Canada's world-class spacecraft assembly, integration and testing center, maintained and operated by the Canadian Space Agency. The DFL facilities are used for radio frequency, structural, and

thermal qualification testing of space-bound and terrestrial hardware.

Over the next months, the satellite will be subjected to a series of spacecraft level tests ranging from thermal vacuum/thermal balance, to vibration, radio frequency and mass properties measurements.

The assembly, integration and test (AI&T) plan consists of the following major activities:

Following delivery of the Bus Module in 2004, the Bus was integrated with the SC Control System to establish the compatibility of the Telemetry and Command Subsystem with the Ground Station. Operational Scenario tests were developed and conducted to ensure the spacecraft subsystems were functioning together as required.

Having established a baseline set of test data, a simulated Payload +Y panel was integrated to the Bus to produce a spacecraft thermal test configuration. The spacecraft was then subjected to a full suite of Thermal Balance and Thermal Vacuum tests to verify the thermal model predictions and the performance of the spacecraft (less PL units) over temperature.

The delivery of the SAR Antenna Panel pairs to DFL allowed the extendible support structure to be integrated with the each SAR antenna panel pair to form the two SAR antenna wings.

Following delivery of the payload electronics, mounted to the +Y panel, there is a series of bus to payload interface tests. Following the integration of the +Y panel to the bus, the spacecraft (less SAR wings and solar arrays) will go through further integrated system tests and a second thermal vacuum test.

The SAR wings will be integrated and tested with the spacecraft. The electromagnetic compatibility test and a limited integrated system test will be performed. Finally, the solar arrays will be integrated and the spacecraft assembly completed.

Once the spacecraft is complete the vibration and acoustic tests will be performed. Post environmental testing will take place afterward to ensure that the spacecraft has suffered no damage as a result of the environmental exposures. This includes appendage deployments, a complete integrated system test and the spacecraft operations validation test.

After the conclusion of these tests, the final activities of verification, launch site performance test, final spacecraft build, mass properties testing, final alignments and final propulsion system tests are performed. The spacecraft will then be ready for shipment to the launch site.

The spacecraft will be launched on a Delta II medium class launch vehicle from the Vandenberg Western Range in California. At launch, the spacecraft will weigh approximately 2300 kg and will carry sufficient fuel for a seven year mission.

##### E. *Ground Segment Development Status*

The ground segment systems of RADARSAT-1 and RADARSAT-2 will share the same facilities and TTCS Stations. Parallel systems will be added for order handling,

mission planning and spacecraft control to allow support for RADARSAT-2 without disrupting RADARSAT-1 operations.

Foreign countries may maintain their own SAR data receiving, data processing and archiving facilities. Portable ground stations can also be used for SAR data receiving and processing.

## V. DATA DISTRIBUTION

MDA's RADARSAT International (RSI) will market and distribute RADARSAT-2 data on a commercial basis.

RSI is also actively working to develop new markets through applications research and market development conducted in co-operation with CSA, Strategic Partners, Value Added Resellers and independent organizations.

Provision will be made for the continued distribution of data and products to customers in the traditional forms of CD-ROMs, magnetic tapes, and film products, but the RADARSAT-2 Ground Segment will also provide the ability to link, via CEONet for example, to global distribution networks using the Internet.

## VI. DATA POLICY

RADARSAT-2 will be subject to the Canadian Access Control Policy for commercial remote sensing satellites. The policy balances national security and foreign affairs concerns

on one hand and domestic and international trade policy on the other hand for civilian Earth remote sensing satellites owned and/or operated in Canada. The Canadian Access Control Policy will meet the obligations of all international and domestic laws and the commitments of pertinent UN resolutions and Government-to-Government agreements.

## VII. IN PREPARATION OF RADARSAT-2: SOAR

The Science and Operational Applications Research for RADARSAT-2 Program (SOAR) is a joint partnership program between RADARSAT International and the Canadian Government through the Canadian Space Agency and the Natural Resource Canada's Canada Centre for Remote Sensing. The program provides access to RADARSAT-2 data (once the satellite is launched) for research and testing purposes. The full program document and proposal submission process is available at <http://www.radarsat2.info>

## VIII. REFERECES

- [1] L. C. Morena K. V. James, and J. Beck, "An introduction to the RADARSAT-2 mission", Canadian Journal of Remote Sensing, In press.