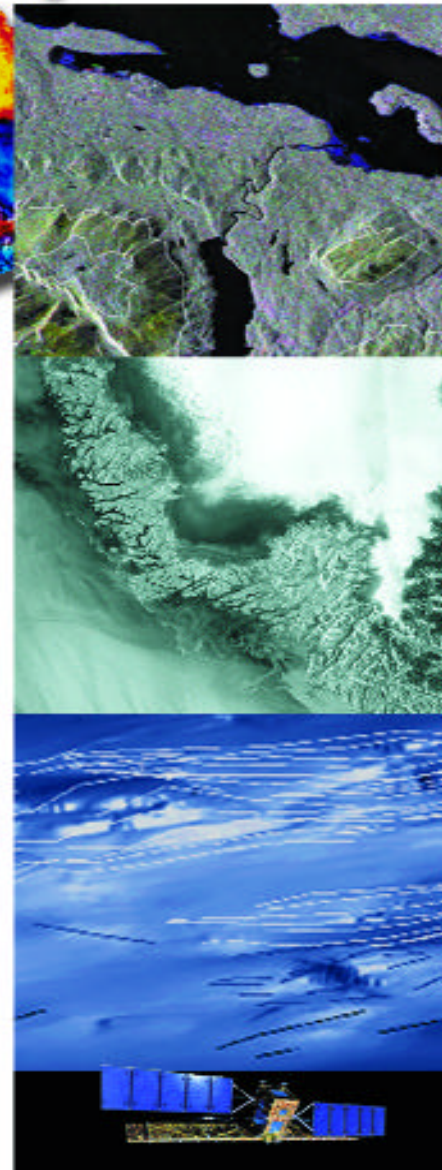
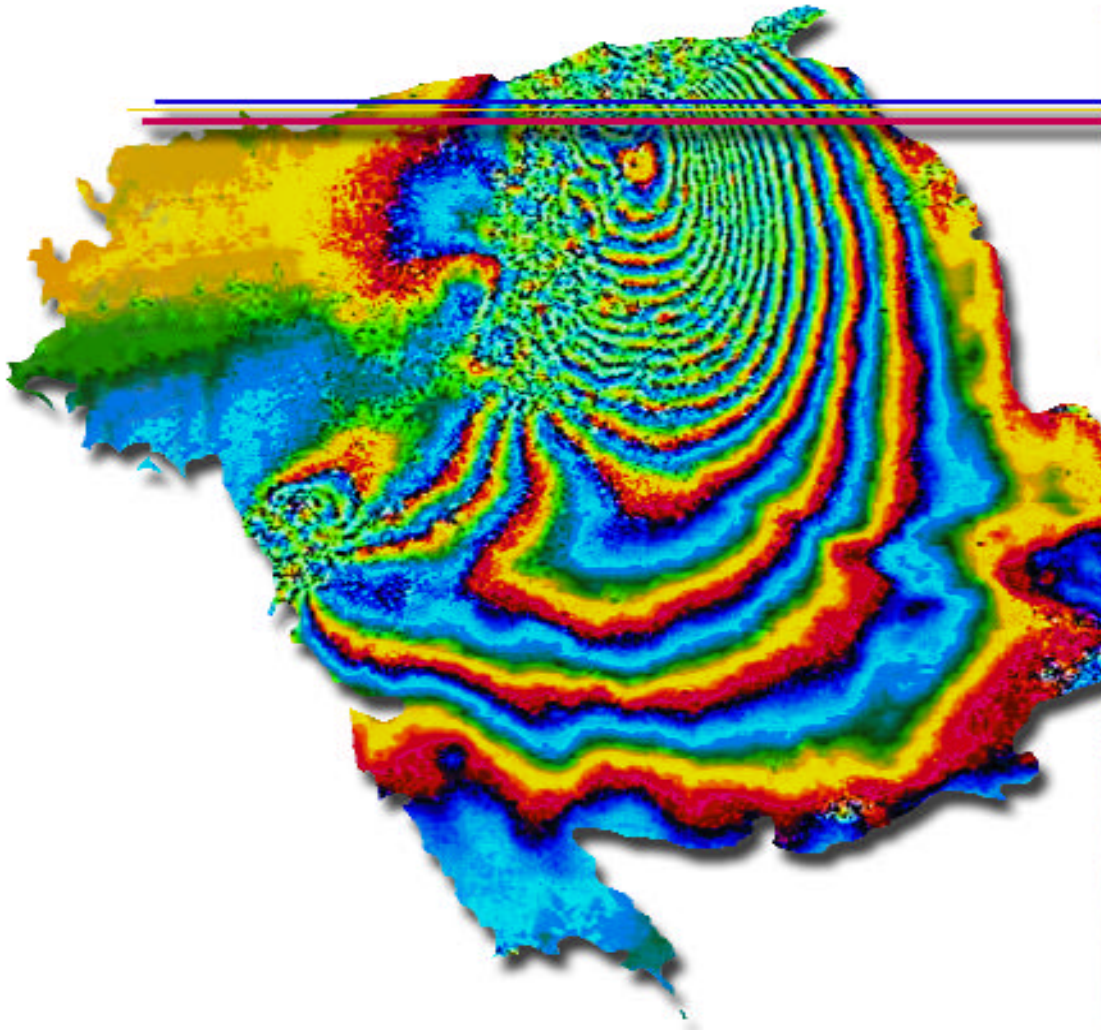


# RADARSAT



ANNUAL REVIEW  
**1998/99**



Canadian Space  
Agency

Agence spatiale  
canadienne

Canada



### ***Mission***

***The Canadian Space Agency is committed to leading the development and applications of space knowledge for the benefit of Canadians and humanity.***

***To achieve this, the CSA will promote an environment where all levels of the organization will:***

- ***pursue excellence collectively;***
- ***advocate a client-oriented attitude;***
- ***support employee-oriented practices and open communications;***
- ***commit to both empowerment and accountability, and;***
- ***pledge to cooperate and work with partners to our mutual benefit.***





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*Front cover: These images have been selected from the four award-winning ADRO projects announced at the Final ADRO Symposium. See page 8 for article.*

*RADARSAT Fine 5 interferometric data of Piton de la Fournaise, an active volcano on l'Île de la Réunion.*

*RADARSAT data © Canadian Space Agency 1998. Enhanced and provided by the Centre National d'Études Spatiales (CNES). Project sponsored by the Application Development and Research Opportunity (ADRO # 389, PI Philippe Durand).*

*RADARSAT Standard 4 multi-temporal imagery of old growth forests near Port McNeill, Vancouver Island, Canada.*

*RADARSAT data © Canadian Space Agency 1996, 1997. Enhanced and provided by the Faculty of Forestry, University of British Columbia. Project sponsored by the Application Development and Research Opportunity (ADRO #384, PI Peter Murtha).*

*RADARSAT ScanSAR Wide 1 image of sea ice in the Cape Farewell area, Greenland.*

*RADARSAT data © Canadian Space Agency 1997. Enhanced and provided by the Danish Meteorological Institute. Project sponsored by the Application Development and Research Opportunity (ADRO #503, PI Rashpal S. Gill).*

*Interpreted RADARSAT ScanSAR Narrow 1 image of natural oil slick in Foz do Amazonas basin, Brazil.*

*RADARSAT data © Canadian Space Agency 1997. Enhanced and provided by the Remote Sensing Laboratory de PETROBRAS/CEGEQ. Project sponsored by the Application Development and Research Opportunity (ADRO #132, PI Fernando Pellon de Miranda).*

*Unless otherwise stated, all images presented in this annual review were received by the Canada Centre for Remote Sensing, and processed and distributed by RADARSAT International Inc.*



# STRENGTHENING THE RADARSAT NICHE

## MESSAGE FROM W.M. (MAC) EVANS - PRESIDENT, CANADIAN SPACE AGENCY



*In 1995, RADARSAT-1 was launched into an Earth observation community developing in expertise and brimming with potential. Since then, the Satellite Operations Directorate of the Canadian Space Agency has managed and operated a growing RADARSAT-1 system and fostered associated data utilization to meet the needs of this global community.*

*The number of individuals and organizations who are benefiting from the use of Canada's industry-leading Earth observation satellite continues to increase as RADARSAT data becomes further entrenched in current methods of natural resource management, coastal surveillance and disaster mitigation efforts. By far the biggest beneficiary is the planet itself - now being monitored by advanced Canadian space technology.*

*As this year's review so clearly depicts, the Application Development and Research Opportunity (ADRO) Program has been instrumental in stimulating the use of RADARSAT-1 and, in turn, the long-term success of the satellite system. The strong results illustrate how the inventiveness of the ADRO projects has won new operational and scientific users from around the world.*

*The past three years have seen a sharp transition from R&D into the commercial arena as a result of initiatives led by RADARSAT International (RSI), the Canada Centre for Remote Sensing (CCRS), Natural Resources Canada and the Canadian Space Agency (CSA). We are now seeing an operational robustness in the satellite system, innovative products and services using RADARSAT data, and better educated clients. Here again, the payoff has been new business opportunities, helping to make RADARSAT-1 the decisive choice among users worldwide.*

*Looking beyond, the new millennium brings with it a new satellite - RADARSAT-2, a follow-on system at half the cost of its predecessor with even more advanced remote sensing technologies. Above all, it will allow Canada to continue fulfilling its unwavering commitment to protecting and monitoring the Earth's precious resources and the environment.*



# OPERATIONAL MATURITY DELIVERS RESULTS

## MESSAGE FROM ROLF MAMEN

### DIRECTOR GENERAL, SPACE OPERATIONS, CANADIAN SPACE AGENCY

*As the only fully operational civilian SAR Earth observation spacecraft, RADARSAT is demonstrating maturity well beyond its three years of operations thanks to the efforts of CSA's Satellite Operations Directorate and the RADARSAT program partners. Major gains have been made this year in RADARSAT's global coverage, operational performance, demonstrated commercial results and responsiveness to a wide variety of application needs - especially as a valuable source of information in support of disaster management.*

*Combined, RADARSAT network stations now offer coverage of nearly all of the Earth's landmass, expanding RADARSAT-1's operational capacity and enabling real time downloading of data worldwide. In addition, new coverage and timeliness opportunities are being discovered using transportable stations.*

*Customer demands for enhanced data turnaround and application-specific services are helping RADARSAT achieve new milestones in system performance. Moreover, faster data delivery continues to be realized through increased use of the Internet.*

*The generation of value-added products and services, through CSA, CCRS and RSI applications development programs, is building remote sensing expertise in Canada and abroad and earning RADARSAT an integral role in many information solutions. This year's Final ADRO Symposium, sponsored by program partners CSA, NASA and RSI, showcased some of RADARSAT's most promising projects to date, including interferometry, an application whose potential is surpassing preliminary expectations. Together with RADARSAT's unqualified success in the 1998 MARCOT exercise, the satellite system is performing extremely well, firmly proving its strength as a responsive and versatile system.*





# SERVICE TO CLIENTS : BUILDING ON PARTNERSHIPS

As part of CSA's Space Operations sector, the Satellite Operations Directorate manages the RADARSAT-1 Program. Led by Director Surendra Parashar, Satellite Operations ensures that the Program objectives, which are multi-dimensional and encompass science, technology, operations and commercialization, are met in collaboration with the Program partners. In this review period, the Directorate focused on completing the ADRO project, instituting the Disaster Watch service, fostering data utilization and marketing, and enhancing the operational service delivery to clients through an expanding network of data receiving stations.

The Satellite Operations Directorate comprises four main groups - System Operations, Operations Planning, Data Management, and Data Utilization/Business Development - and carries out the following activities:

- plans, implements and operates the RADARSAT system,
- provides service to RADARSAT customers for acquisition, reception, processing, archiving, cataloguing and delivery of data,

- maintains the satellite orbit and the health and safety of the satellite,
- controls image quality and certifies network stations,
- develops and implements the Background Mission and projects such as ADRO to foster data utilization,
- supports development of markets for the commercialization of RADARSAT data, and
- extends satellite operations support to national and international cooperating agencies.

The Satellite Operations Directorate brings together a world-class team from industry, government and the scientific community to deliver the internationally recognized RADARSAT-1 Program. The table below highlights the roles of the Program partners.

Canadian Space Agency Space Operations Satellite Operations Directorate	Owns and operates RADARSAT-1 Controls RADARSAT-1 in space, plans SAR data acquisition and delivery, and tasks RADARSAT-1 ground systems Conducts commercialization programs Supports commercial and government clients including Ice Services Canada, Department of Fisheries and Oceans, and the Department of National Defense
Natural Resources Canada Canada Centre for Remote Sensing	Operates Canada's two RADARSAT receiving stations Oversees pre-processing, recording and archiving of RADARSAT data Conducts applications research
RADARSAT International	Processes, markets and distributes RADARSAT-1 data commercially through distributors and network stations Owns and operates the Canadian Data Processing Facility (CDPF)
National Aeronautics and Space Administration (NASA) / National Oceanic and Atmospheric Administration (NOAA)	Launched RADARSAT-1 Distributes RADARSAT-1 data to the United States government through the Alaska SAR Facility
Canadian Provinces	Contributed Program funding Pre-purchased RADARSAT-1 data
Canadian Industry	Designed and built the RADARSAT-1 satellite and ground system Contractually supports RADARSAT-1 operations and maintenance Develops RADARSAT-derived products and services



# SYSTEM ENHANCEMENTS : BOOSTING OPERATIONAL CAPABILITIES

In 1998, the Satellite Operations Directorate implemented several major enhancements to the RADARSAT system. Key among these was the complete upgrade of the hardware and production software of the Mission Management Office Data Base Management (MMO/DBM) planning system, resulting in a faster and more powerful system. The MMO/DBM is now accessible 24 hours a day for request transmittal and tracking to the eight international network stations and five order desks - up from 12 hours a day in 1997.

Due to the growing interest in using RADARSAT for emergency response, the MMO established a new service called "Disaster Watch" under which CSA acquires, but does not process, RADARSAT data on a speculative basis on disasters occurring in Canada and abroad. This is creating a valuable data base of SAR observations from around the world on a wide variety of disasters. In addition to providing routine operations service, the MMO also acquired and delivered data in support of special projects, such as the 1998 MARCOT exercise (see page 7).

1998 acquisition requests: 22,362

1998 emergency requests: 13

1998 estimated minutes of data: 41,901

1998 orbits: 5,217

1998 estimated OBR imaging requests: 6,704

Minutes of on-time per orbit: 32

Average system performance: 96%

Number of playbacks per day: 3.5

Total acquisition requests: 51,567

Total emergency requests: 45 (since November 1995)

Total estimated minutes of data: 99,837

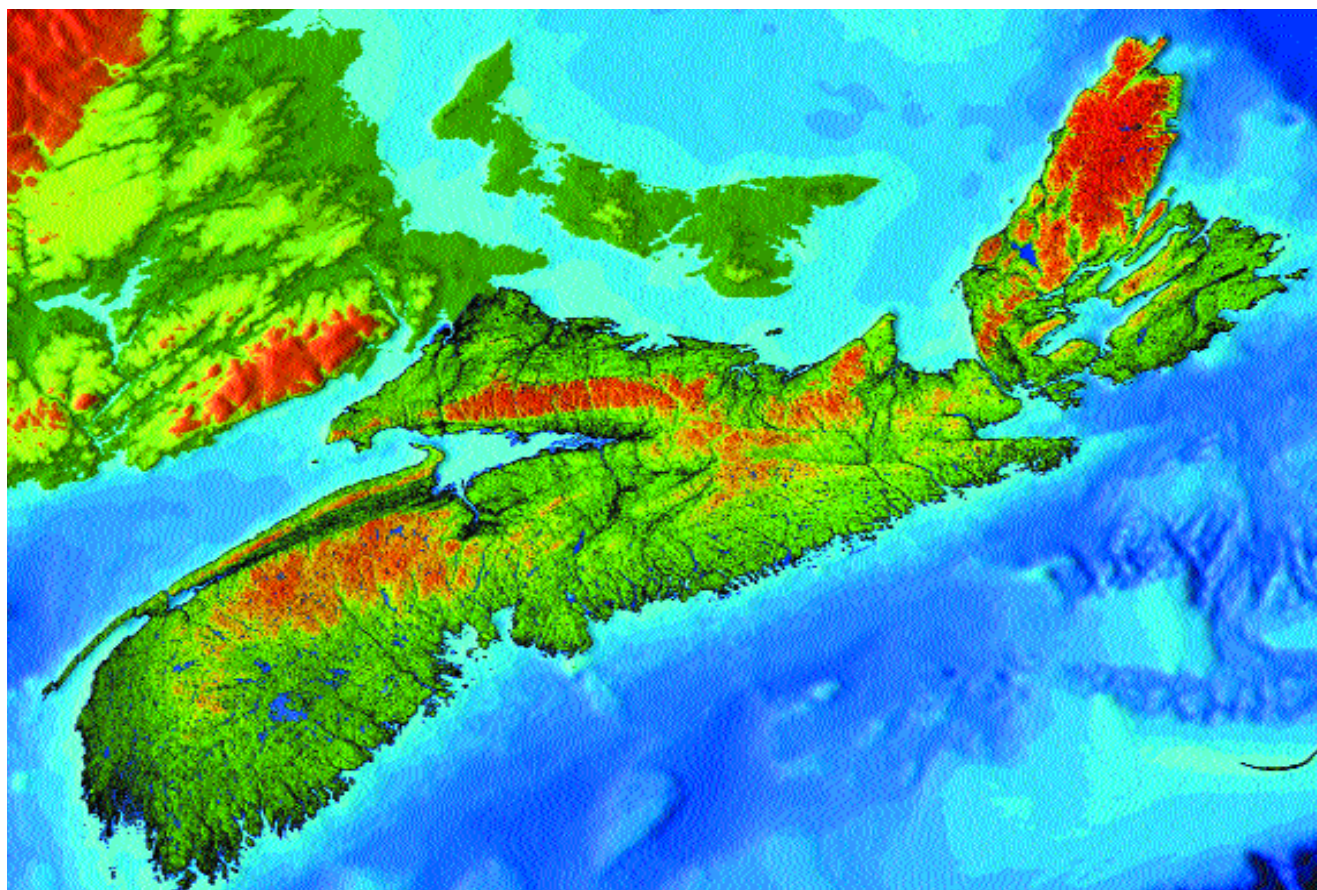
Total orbits: 17,768

Total estimated OBR imaging requests: 28,463

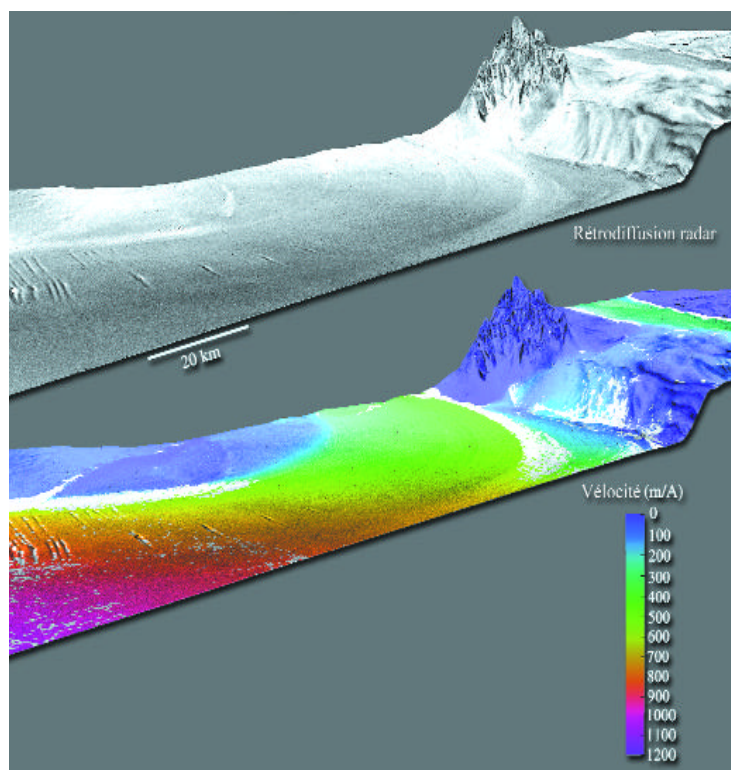
***Nova Scotia is shown here in a 3D mosaic of 17 orthorectified Standard 7 scenes acquired in descending orbit (best viewed with Chromadepth 3D glasses). The data was corrected to 1:50,000 base information and relief distortions and displacements were corrected based on a 50-metre DEM derived from the 1:50,000 contours.***

RADARSAT data © Canadian Space Agency 1996 - 1998.

Imagery enhanced and provided by the Centre for Geographic Sciences (COGS), Nova Scotia Community College.







**CCRS scientists have devised a method to map ice movement in Antarctica using RADARSAT data. In this image, the Slessor Glacier, located to the left of the Shackleton mountain range, flows into the large floating Filchner Ice Shelf in the foreground to the left. Colour has been added to show ice motion; purple indicates slow speeds, changing to blue, green, yellow, with red and violet indicating speeds of more than one kilometre per year. This information helps researchers in measuring and understanding changes in global sea levels related to regional or global warming.**

RADARSAT data © Canadian Space Agency 1998.

Received by the Alaska SAR Facility. Enhanced and provided by the Canada Centre for Remote Sensing.

## Monitoring Image Quality

The RADARSAT calibration maintenance program was fully operational throughout 1998. The radiometric calibration of each calibrated beam was monitored regularly and adjustments in processing parameters were made as needed. In early 1999, the four ScanSAR imaging modes were radiometrically calibrated.

An extensive data base of image quality parameters was developed in 1998, as were visualization tools for meaningful image quality relationships and their evolution over time. Resolution-related measures have been better than specifications, and location accuracies are deemed excellent.

## Achieving Operational Maturity

RADARSAT-1's attitude control continued to perform well throughout 1998. Operations continued during the summer eclipse season without outages - a first since launch. This was accomplished without any changes to the flight software.

During the past year, the spacecraft experienced certain anomalies. However, virtually all of these were related to the SAR payload, and workaround operational solutions were developed and applied to minimize any data loss resulting from these anomalies.

The satellite control system, plant support facilities and lifecycle support systems have continued to evolve. The telemetry, tracking and command antennas were overhauled and additional spares purchased. In addition, a major project to ensure overall system readiness for the millennium change was initiated, and the first phase is expected to be completed by April 1999.

## Antarctic Mapping Mission 1: Update

During the past year, the Alaska SAR Facility processed more than 6,000 images for NASA from the RADARSAT Antarctic Mapping Mission 1 conducted by Satellite Operations in the fall of 1997. Although processing is expected to continue until June 1999, preliminary analyses have generated some exciting new maps and scientific findings including:

- the first synoptic map of all the Antarctic ice streams,
- the discovery of new ice stream systems in East Antarctic,
- the first radar-derived map of ice divides and catchment areas,
- the discovery of extensive mega-snowdune fields, and
- the production of interferometrically-derived ice velocities, which are important in determining if the Antarctic ice cap is shrinking and in understanding global climate changes.



# BACKGROUND MISSION: UPDATE

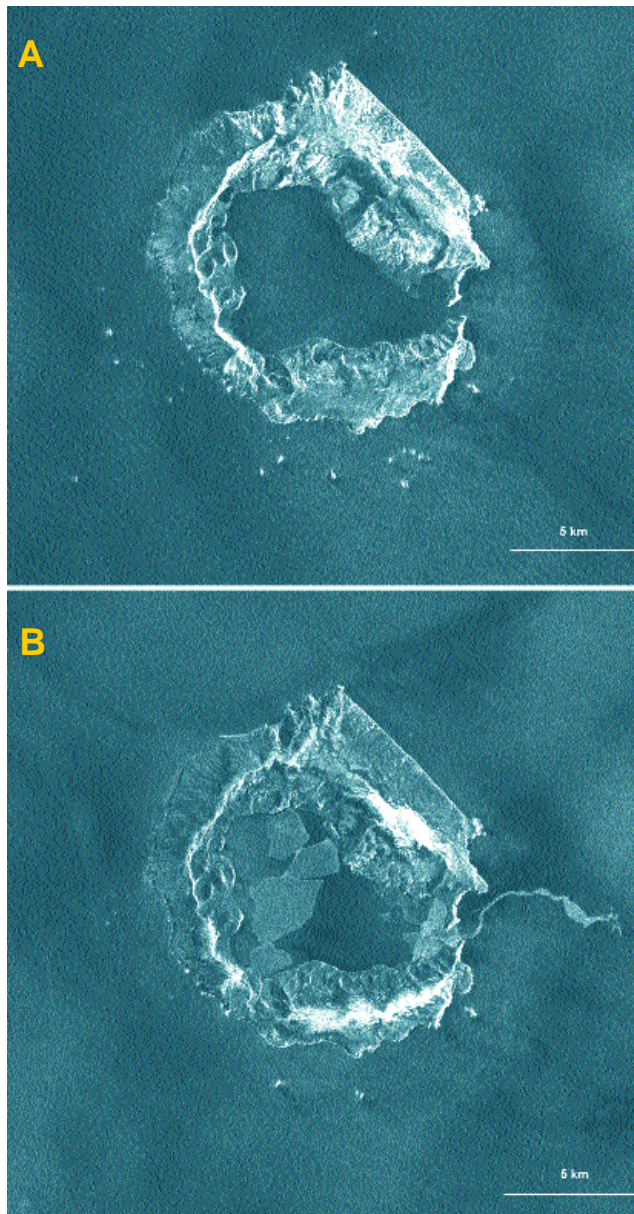
Building on the success of last year's ScanSAR coverage of the world's continents, continental shelves and polar caps, the RADARSAT-1 Background Mission has launched a second continental coverage program as the next step in creating an archive of seasonal RADARSAT data. During 1998, North America, Europe and Australia were imaged using ScanSAR Narrow in seasons different from those covered by ScanSAR Wide in 1997.

The stereo data set of the world's landmass continues to grow. Now available are highly coherent Standard 7 and 2 beam pair stereo data for all of North America and Western Europe. In addition, Standard 7 coverage of Indo-China and Australia is complete, while Standard 7 coverage of China and South America is well under way. The beam pair stereo data can be exploited for generating DEMs (digital elevation models) and producing maps.

Most of the Earth's oceanic islands have now been imaged with RADARSAT's Standard 5 beam- the first coverage of its kind. Furnishing multi-step imagery of these small oceanic entities, which are particularly sensitive to the effects of climatic factors and anthropogenic activities, will yield valuable data for global change detection.

Fine beam coverage of the world's capital and major cities began in April 1998. With nearly 100 cities imaged, an estimated 50 cities remain to be imaged in 1999. These data can be used by urban planners and public utility operators.

In addition to supplying uniform global SAR coverage, the Background Mission is proving to be an important source of reference data when natural disasters, such as floods, landslides, earthquakes, and volcanic eruptions, occur. By providing data that pre-dates these catastrophes, the mission's archives offer disaster management agencies vital information for use in comparing and reckoning the impact of natural disasters.



***The RADARSAT-1 Background Mission has provided temporal coverage of climatically sensitive islands in the remote polar regions of the world. These Standard 5 images are autumn (A) and spring (B) views of the peri-Antarctic Deception Island with its large central caldera filled with water and sea ice (spring image). The horseshoe-shaped island has been the site of numerous volcanic eruptions in the recent past.***

RADARSAT data © Canadian Space Agency (CSA) 1998.  
Enhanced and provided by CSA.



# RADARSAT RECEIVING STATIONS: UPDATE

## Canada

A new wide area network installed by CCRS in 1998 now transfers low resolution RADARSAT imagery from the two RADARSAT receiving stations located in Gatineau, Québec and Prince Albert, Saskatchewan to Ottawa, Ontario where it is placed on a web-accessible browse and catalogue service. In addition, CCRS has implemented a new RADARSAT raw data archive system.

## International

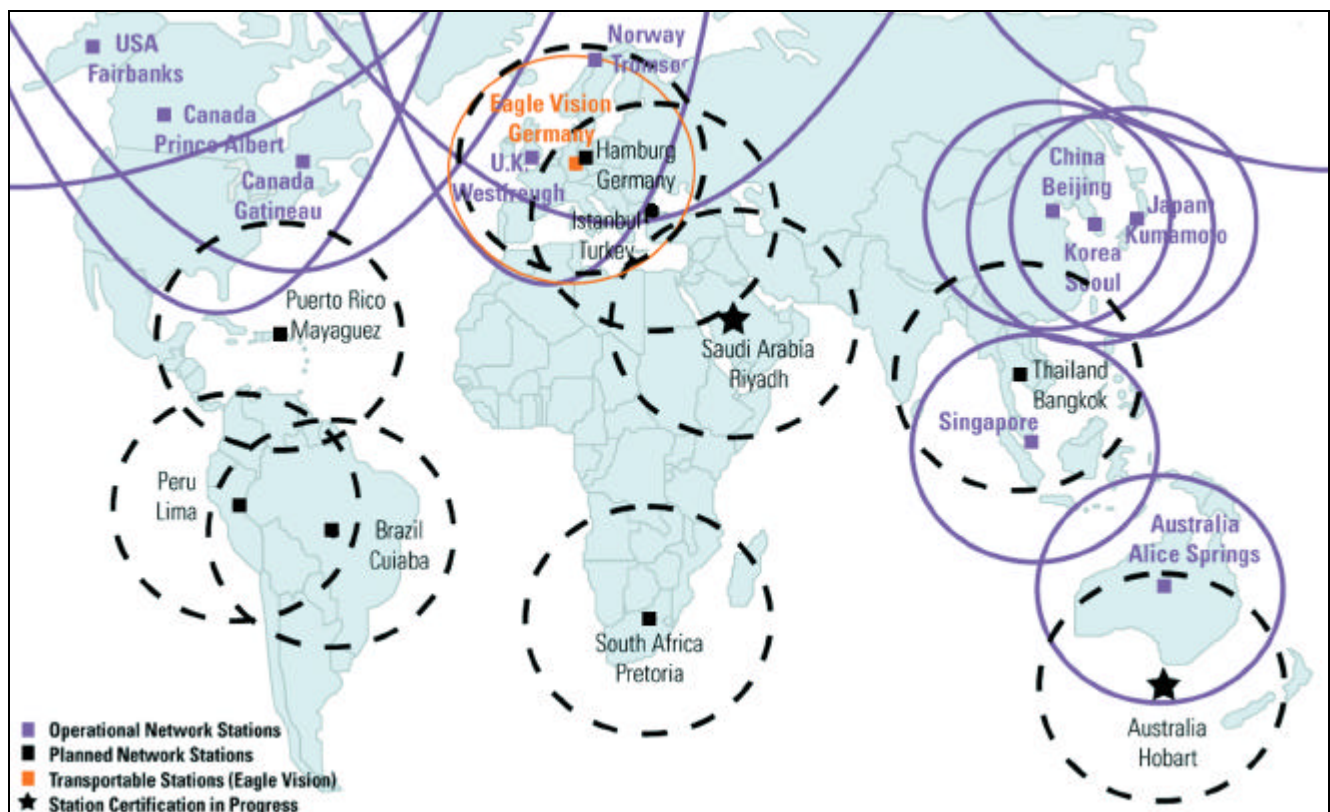
In 1998, network stations in Australia and Japan achieved both operations and product certification; South Korea and Saudi Arabia achieved operations certification. Combined with stations in Canada and the United States, the RADARSAT network stations, which also include already operational stations in China, Norway, Singapore, and the United Kingdom, provide coverage of virtually all of the Earth's landmass.

New coverage opportunities are emerging with the advent of transportable ground stations. Canada's SENTRY system, developed by IOSAT Inc., and the Eagle Vision system in the United States are demonstrating the capability of portable stations to receive and process RADARSAT data. In 1998, SENTRY was successfully deployed in an operational demonstration during Exercise MARCOT/UNIFIED SPIRIT '98, which took place in Nova Scotia, Canada. MARCOT is Canada's largest annual joint military training exercise, and as UNIFIED SPIRIT '98, one of the premier annual training events for NATO.

The use of the portable station gave Canadian defence personnel experience with real time delivery, processing and interpretation of RADARSAT-based surveillance data. As noted by D.E. Miller, Rear-Admiral, Commander, Maritime Forces Atlantic, Department of National Defence, "During Exercise MARCOT 1/98, MARLANT was able to make use of RADARSAT imagery processed through the IOSAT transportable ground station (SENTRY). I was impressed with the technology, the talented individuals operating the systems, and the results obtained."

***Combined, the RADARSAT network stations now provide coverage for nearly all of the Earth's landmass.***

Network station visibility mask provided by RADARSAT International.





# ADRO: ADVANCING RADARSAT APPLICATIONS

The RADARSAT Application Development and Research Opportunity (ADRO), managed by Satellite Operations, has been instrumental in advancing the state-of-the-art for radar applications as well as enhancing the ordering and delivery process for all RADARSAT users.

The program's activities culminated in the highly successful Final ADRO Symposium held October 13 - 15, 1998 in Montréal, Québec. Representatives from industry, government and academic organizations presented their project findings of the subprograms that were initiated by ADRO's sponsors - CSA, NASA and RSI, with support from CCRS - following the launch of RADARSAT-1 in 1995.

Attracting 300 attendees from 39 countries, the Symposium highlighted the final results from nearly 200 projects, providing an ideal forum for exchanging ideas, examining the challenges ahead and showcasing ADRO's capability in promoting application-specific uses of RADARSAT, supporting new applications and processing, furthering the understanding of the Earth's processes, and collecting technical information for use in future programs. As noted by Symposium participant Mr. Michael Kirby of SAR Corporation - Canada, "It was an excellent overview of the RADARSAT research to date...I found the proceedings and events that I attended...quite worthwhile in terms of content and participation."

Hydrology, monitoring and surveillance, agriculture, environmental, and mapping applications figured prominently among ADRO's operational and scientific projects. One of the unexpected benefits identified by the ADRO projects is that quality interferograms can be generated from virtually all RADARSAT beams, including ScanSAR.

Over the past three years, ADRO projects have investigated activities such as:

- measuring the deformation of the Earth's surface,
- detecting oil seeps and slicks,
- measuring forest clearings more accurately,
- monitoring violent storms,
- mapping floods more accurately,
- measuring and assessing crops,
- detecting global climate changes, and
- mapping ocean currents.

From these, four projects won distinction for their excellence in meeting or surpassing their respective sponsor's objectives, as shown in the table below.

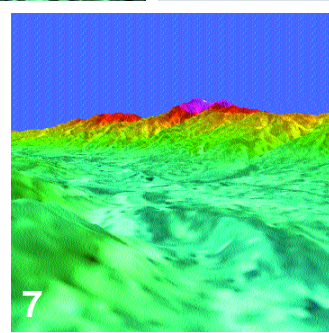
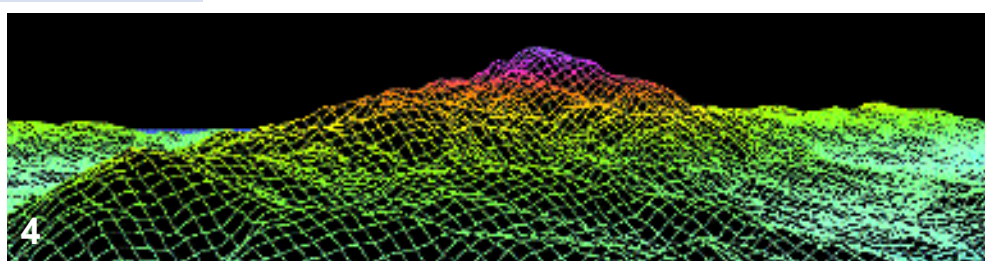
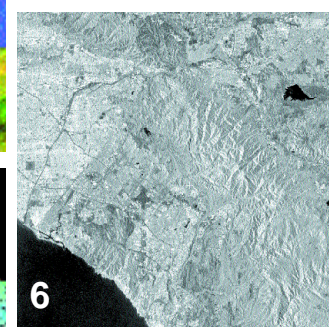
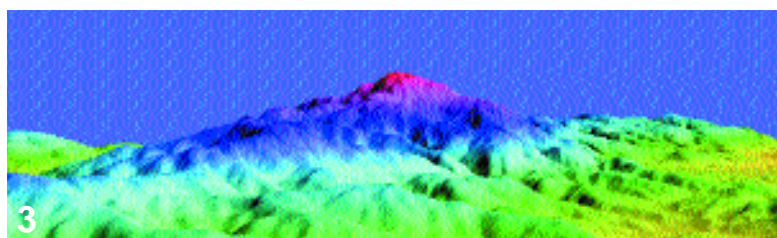
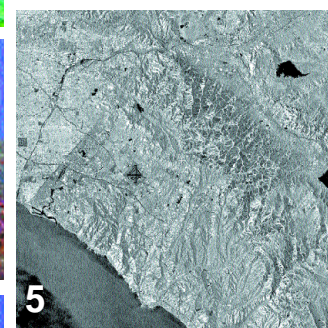
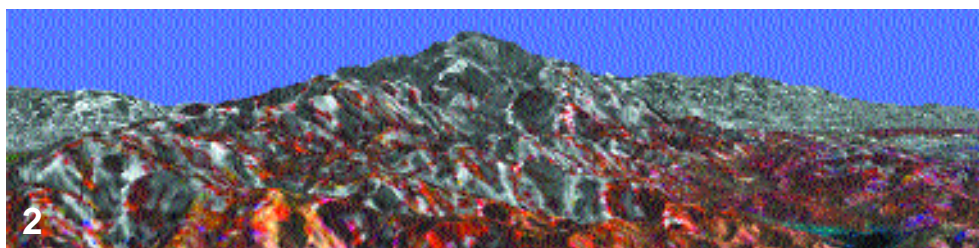
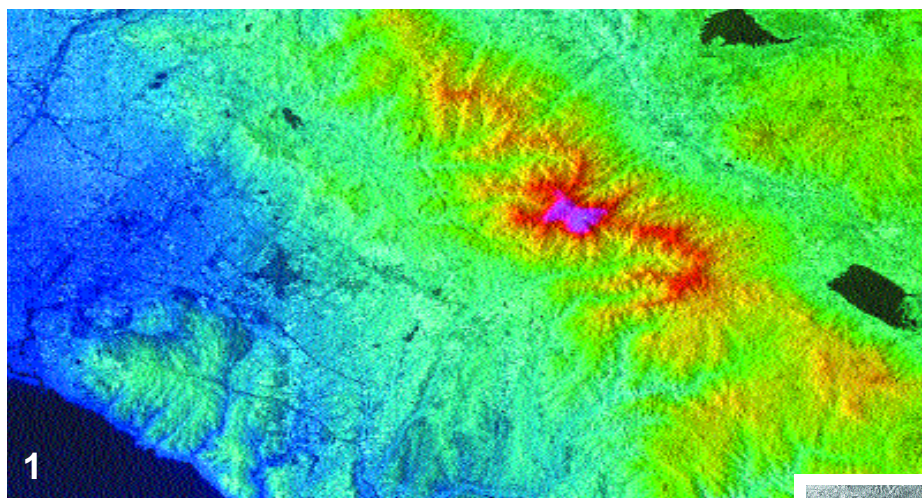
With the publication of the Symposium's proceedings, ADRO is now focused on:

- evaluating projects with specific commercial promise,
- determining the feasibility of a second ADRO program,
- following up on promising opportunities in data utilization, and
- ADRO CD-ROM.

Put simply by ADRO Principal Investigator Dr. Jim Garvin: "Keep that RADARSAT satellite running. It's been a delight to work with and I look forward to another ADRO and a RADARSAT-2."

ADRO Award	Award Winning Organization	Project Distinction
CSA Award for Technical Demonstration	Centre National d'Etudes Spatiales (Toulouse, France)	Although RADARSAT was not designed for interferometry, this volcano monitoring project showed how RADARSAT might be used more effectively for differential interferometric applications.
RSI Award for Commercial Demonstration	Danish Meteorological Institute (Copenhagen, Denmark)	Demonstrated the utility of RADARSAT ScanSAR Wide data to monitor sea ice on a year-round, operational basis.
CSA Program Manager's Award	Forest Resources Management, University of British Columbia (Vancouver, Canada)	Regularly apprised the ADRO Coordination Office on the project's progress; provided constructive feedback; generated various technical publications based on this forest monitoring and mapping project.
RSI Award for Most Promising New Application	PETROBRAS (Rio de Janeiro, Brazil)	Successfully used RADARSAT Wide and ScanSAR Narrow data to detect natural offshore oil seeps; developed classifications to enhance oil seep data; ascertained RADARSAT's cost-effectiveness for operations.





*This collage of Irvine, California comprises a stereo-extracted DEM with a Standard 6 image fused with pseudo-colour (1); a Landsat 4,3,2 image fused with a Standard 2 image draped over a stereo DEM (2); an arbitrarily pseudo-coloured stereo DEM perspective (3); a wireframe DEM perspective (4); an orthorectified Standard 2 image using a stereo DEM (5); an orthorectified Standard 6 image using a stereo DEM (6); and a DEM and Standard 6 image fused and draped over a DEM (7).*



# DISASTER MITIGATION: DEVELOPING AN EFFECTIVE RESPONSE

Uniquely capable of responding to disasters around the world, the RADARSAT system can support the operational mapping and monitoring of natural disasters in four critical ways:

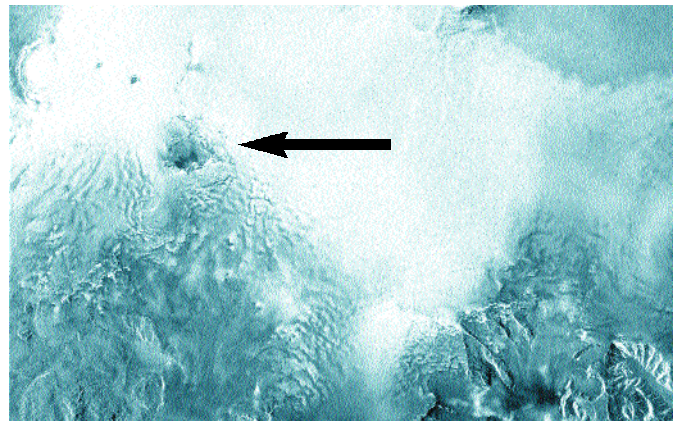
**Prevention:** Gathering baseline data, identifying potential hazardous sites and assessing the availability of facilities and equipment needed to assist in emergency response activities.

**Preparedness:** Monitoring high risk areas in order to provide an early warning of potential disasters.

**Emergency Response:** Identification of locations, assessing the extent of the disaster and short-term monitoring of the event.

**Recovery:** Monitoring affected areas for damage assessment and monitoring the environmental impact for the reconstruction and rehabilitation of disaster areas.

The table below summarizes the features and benefits of the RADARSAT system in mapping and monitoring disaster events.



*A view of the subglacial volcanic eruption in the Grimsvotn region of Iceland is shown in this Standard 5 image. Monitoring regions such as these can help provide an early warning of potential disaster and aid in preparing communities for evacuation.*

RADARSAT data © Canadian Space Agency 1998.

Received by Tromsø Satellite Station. Enhanced and provided by CSA.

## Benefit

## RADARSAT Feature

Reliable source of information

The RADARSAT SAR sensor provides all-weather, day or night imaging, producing cloud-free imagery on a reliable basis of any part of the world.

Global coverage

RADARSAT provides worldwide coverage by directly downlinking data to the RADARSAT network stations or by storing data on its onboard tape recorder.

Frequent repeat coverage

RADARSAT can image any location within a 525-kilometre accessible swath during each orbit pass. With 14 orbit passes a day, any location on Earth can be imaged every one to five days, depending on the latitude.

Selectable product scales

RADARSAT's seven beam modes offer geographic coverage from 2,500 to 250,000 km<sup>2</sup>. The choice of beam mode can be tailored to the scale (coverage) of the disaster or level of detail required to capture the features of interest.

Optimizing information content

Because RADARSAT can view the Earth using a range of incidence angles, users can select viewing angles that maximize the information content for a specific disaster application.

CSA RADARSAT Data Policy/Emergency Response

CSA's Satellite Operations Directorate supports emergency management and assigns top priority to a declared emergency after spacecraft health and safety.

Custom urgent response and contingency planning services

RSI's global network of distributors provides customized, region-specific service, facilitating data ordering and data delivery in emergency situations.

Delivery of imagery within hours of acquisition

The RADARSAT system provides near-real processing and electronic delivery of data products to meet the critical timelines of emergency response situations.

## RADARSAT Responds

Since its launch in 1995, RADARSAT has responded to more than 40 emergency requests. In 1998 alone, data was acquired on: Floods, Landslides, Earthquakes, Droughts, Violent storms, Forest fires, Volcanic eruptions, and Avalanches.



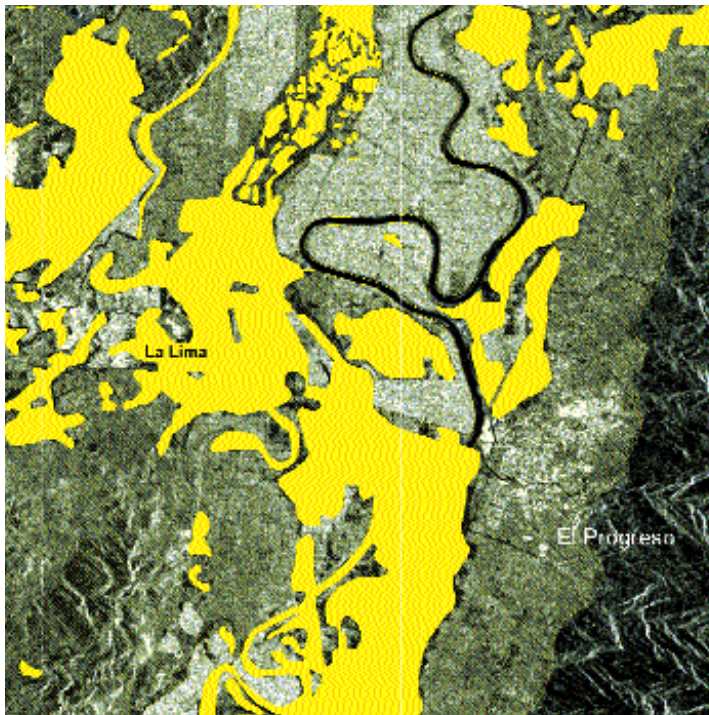
As a member of the Committee on Earth Observation Satellites (CEOS), CSA is participating in the CEOS Disaster Management Support (DMS) Project. This project seeks to support natural and technological disaster management on a global basis by fostering the improved application of Earth observation satellite data.

On October 16, 1998, CSA hosted the DMS Project's seventh meeting and working session. Close to 100 delegates from more than 40 scientific, government and industry organizations gathered to hear presentations by NOAA, CSA, University of Manitoba, KEMSAT, PCI Geomatics Group, CCRS, Université de Sherbrooke, RSI, Vantage Point International, SAR Corporation, and Global Geomatics, Inc. Topics covered RADARSAT's emergency response capabilities, disaster prediction, management and mitigation projects, the role of transportable ground stations, commercial response services, specialized software, and derived information products and services.

To address client needs for dependable delivery of time-sensitive information to respond to and manage disasters, RSI implemented its Emergency Response Service in 1998. As a renewable, 12-month subscription service, it encompasses on-site training, consultation, development of simulation and emergency response scenarios, 24-hour hotline access, 29- to 48-hour lead time programming, near-real time processing, and electronic delivery. This service is available for all RADARSAT beam modes.

CCRS scientists are investigating the use of RADARSAT data to satisfy operational information requirements in managing various types of disasters. In 1998, CCRS developed RADARSAT products for a number of Canadian and international disasters, including the Swissair crash off Nova Scotia and the flooding of China's Yangtze River. Many products were developed in collaboration with CSA, RSI as well as universities and other industry and government agencies.

In response to the severe floods in Canada during recent years, the CCRS Order Desk now routinely monitors all RADARSAT imaging activity over areas potentially affected by spring run-off. In 1998, emergency response services were provided to the St. Lawrence, Chateauguay and Chaudière River floods in Québec.



*This 1:50,000 scale orthoimage was created using RADARSAT Standard 2 imagery acquired during the peak of Hurricane Mitch, as it battered the Sula Valley in north-western Honduras. As one of the most destructive storms to hit Central America, Hurricane Mitch was responsible for more than 7,000 deaths in Honduras.*

*The towns of La Lima (middle) and El Progreso (middle right) appear as bright areas. Three classifications were made: flooded (open calm water with no or little vegetation), partially flooded (partially flooded or very moist ground), and flooded vegetation (completely or partially flooded trees or plantations).*

RADARSAT data © Canadian Space Agency 1998.  
Enhanced and provided by Dendron Resource Surveys Inc.



# WINNING NEW BUSINESS

In the increasingly competitive marketplace for space-based information products, RSI (Richmond, British Columbia) has won roughly 15 percent of the global remote sensing market in just three years. In 1998, RADARSAT commercial data orders grew to more than US\$10.6 million based on approximately 8,800 scenes processed for all clients including the Canadian government. This increase reflects the successful efforts of RSI and its team of 75 international distributors and eight certified network stations to serve 500 clients in 52 countries.

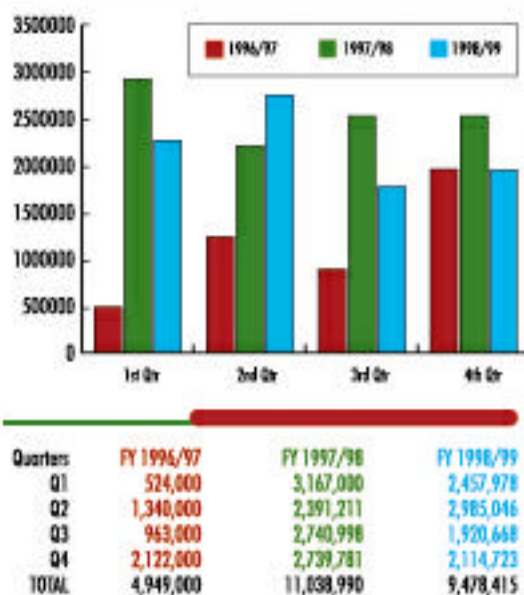
At RSI's 1998 Network Stations' and Distributors' Meetings, the outstanding sales achievements of RADARSAT distributors EarthSat, DERA, RESTEC, PT Bhumi Prasaja, and CIC Geomatica were honoured. Regional distributor meetings in Australia and the Philippines were also held.

Through strategic alliances, cross-licensing and project agreements with value-added companies such as Vexcel Corporation, PCI Enterprises Inc., IMSTRAT, Hatfield Consultants, IOSAT Inc., and Resource GIS and Imaging, RSI continues to develop and introduce new RADARSAT-derived products, including high-value, off-the-shelf products such as mosaics, RADARMaps and DEMs. In addition, RSI offered new custom products such as RADARSAT stereo data for clients who generate DEMs and perform 3D visualizations and feature extractions.

## Top Commercial Applications for RADARSAT

Offshore oil and gas exploration	Oil seep detection
	Ice monitoring
Mapping	DEMs
	Land classification
Defence	Land surveillance
Marine surveillance	Ship detection
Agriculture	Crop monitoring
Disaster management	Floods
	Oil spills
	Coastline mapping
	Forestry

## Total RADARSAT Sales



RSI is also gaining business by offering market-specific subscription services such as the Offshore Exploration Service (OES), the Emergency Response Service (see page 13), and six new and improved programming services. The development of the OES earned RSI and EarthSat, a U.S.-based RADARSAT distributor, the prestigious 1998 Award for Canadian-American Business Achievement. This honour recognized the pioneering efforts of RSI and EarthSat in using RADARSAT to detect marine oil seeps in petroleum exploration, a key commercial market with enormous potential.

Providing faster electronic delivery continues to attract clients. New compression software installed this year at the RSI-managed Canadian Data Processing Facility in Gatineau, Québec has enabled RSI to deliver full RADARSAT scenes via the Internet - often in a matter of minutes rather than hours.

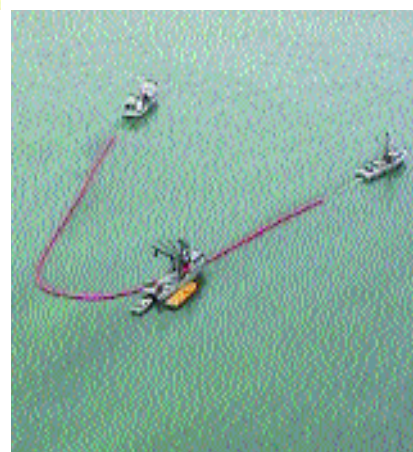
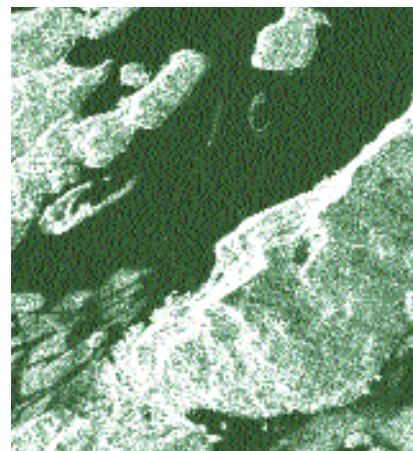
Educating existing as well as the next generation of remote sensing users is crucial to RADARSAT's long-term success. This goal is being realized through RSI initiatives such as the RADARSAT Resource Centres in Argentina, Australia, Canada, China, France, Indonesia, the Netherlands, Thailand, and the United States, which deliver regional radar remote sensing workshops and training. RSI is also a major sponsor of Vancouver's Pacific Space Centre, which works with educators and students to raise the awareness of Canadian space programs.



Since the Exxon Valdez ran aground in 1989, the crude oil industry in Alaska has conducted an annual oil spill drill to train personnel and validate response procedures. For the 1998 drill, SONS '98, Space Imaging and RADARSAT International were invited to showcase RADARSAT's operational responsiveness.

This capability was clearly demonstrated during the simulation when a RADARSAT Extended Low subscene of Orca Inlet was successfully delivered electronically to the SONS '98 headquarters only one hour and 15 minutes after acquisition. The subscene shows ships which participated in the exercise and the deployment of their booms (similar to that seen in the inset photograph), taken near Seward, Alaska.

RADARSAT data © Canadian Space Agency 1998.  
Provided by RADARSAT International Inc.



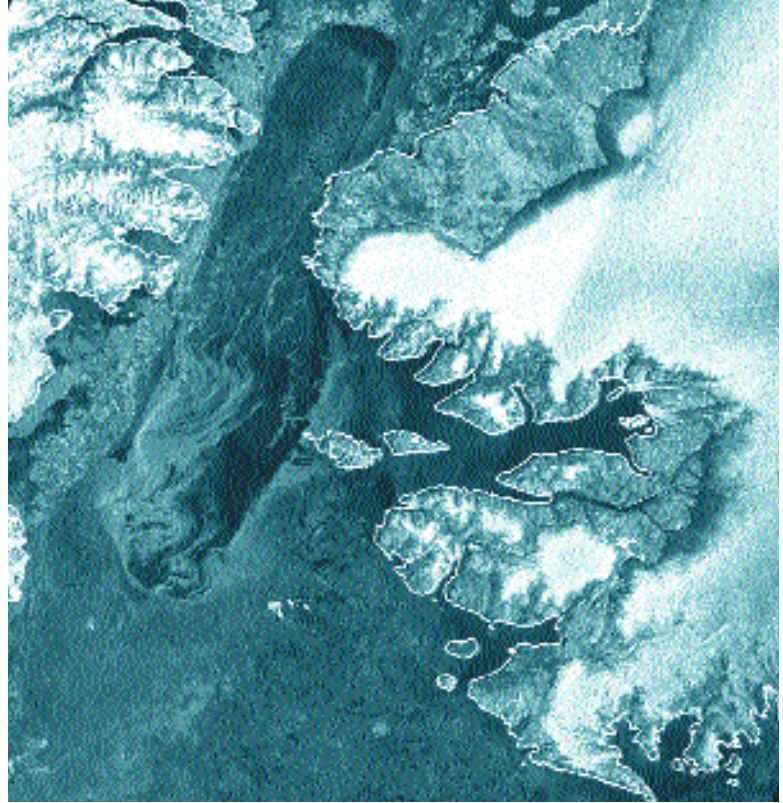


The Canadian Ice Service (CIS) is the world's leading user of real-time RADARSAT data. In 1998, CIS acquired over 4,000 image frames in support of ice monitoring over Canada's offshore areas for marine operators in general, and the Canadian Coast Guard icebreaker fleet in particular. From this data stream, 64,013 image products and 9,209 graphical analyses were delivered. CIS continues to save an estimated \$7 million per year in data acquisition costs through the use of RADARSAT.

Although ScanSAR remains the mode of choice with its superb geographic coverage and revisit capabilities at sufficient resolution for the interpretation of significant ice features, CIS acquisitions of single scene, higher resolution imagery grew for applications such as detailed ice surveillance, oil spill detection and environmental monitoring.

Some of the RADARSAT ScanSAR data acquired by CIS in 1998 was used to support the North Water Polynya (NOW) project, a multi-disciplinary study taking place in northern Baffin Bay. The data was used to develop an animation of the polynya's lifecycle over a year. In turn, the animation will provide a dynamic view of the environment in this area and help scientists analyze the development and maintenance of the polynya.

CIS, in collaboration with CCRS, also investigated the use of RADARSAT data to identify and track atmospheric phenomena over open waters. CIS ice analysts have consistently noticed the reflection of various atmospheric phenomena, particularly mesoscale polar lows, frontal systems, and convective clouds on the ocean surface in RADARSAT images. Many of the images show dramatic imprints of the overlying state of the atmosphere on the ocean surface. RADARSAT may have an untapped potential as a tool for monitoring weather systems over oceans, where conventional weather observing network sites are uncommon.



***A well-developed North Water Polynya in northern Baffin Bay is shown in this ScanSAR Wide image. Heavy, thick ice surrounds the polynya with much thinner, new ice growing on the water as it is pushed southward by winds and water currents. Typically occurring in the same area and at the same time every year, polynyas are extremely productive biologically and, due to of their northern location, are expected to be sensitive to global climate changes.***

RADARSAT data © Canadian Space Agency 1998.  
Enhanced and provided by the Canadian Ice Service.



# DEVELOPING NEW APPLICATIONS, PRODUCTS AND SERVICES

## RADARSAT User Development Program (RUDP)

As RUDP enters its last year, the program continues to assist Canadian companies in developing new RADARSAT products and services. Final RUDP contracts are expected to be awarded in spring 1999.

The favourable introduction of two image products supported revenue growth in 1998. Orthoengine RE, developed by PCI Geomatics Group (Richmond Hill, Ontario), produces orthoimages from RADARSAT imagery and corrects for distortions caused by the satellite, cartographic projections, and Earth terrain and curvature. These in turn are used to generate stereo-assisted DEMs. Multi-date RADARSAT imagery is being used by Tecsalt Foresterie Inc. (Québec City, Québec) to generate land use maps of cloud-covered tropical areas in Africa.

RUDP projects are stimulating other work for contract winners. Both Dendron Resource Surveys Inc. (Ottawa, Ontario) and R.J. Burnside International Limited (Orangeville, Ontario) started new flood mitigation and infrastructure building work in Honduras as a result of RUDP projects. (See page 13 for Dendron image product.)

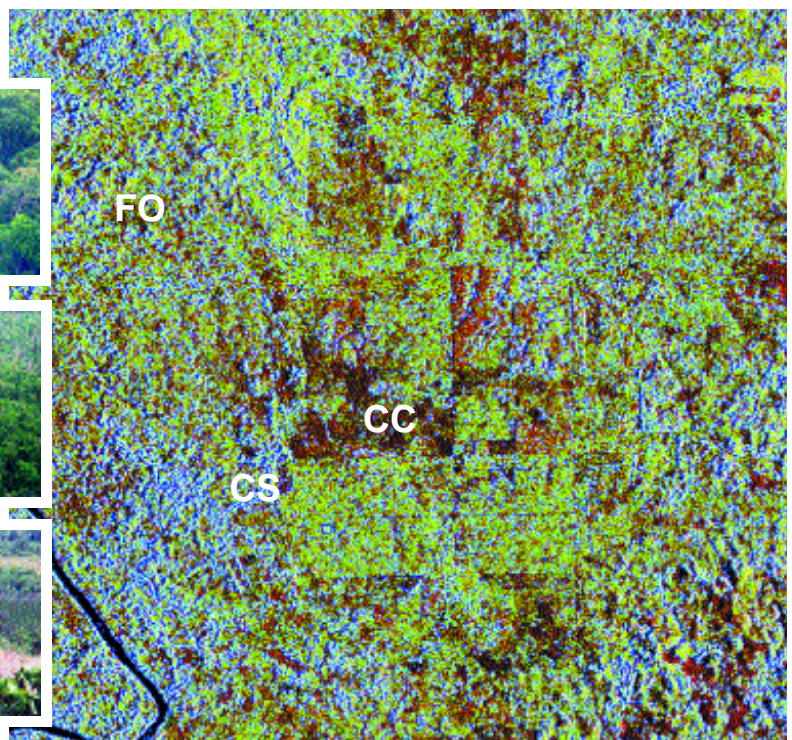
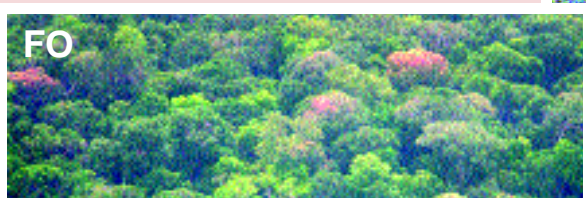
RUDP Milestones (1995 – 1999)	
Total contracts:	37
Value of contracts:	\$11.4 million
Products and services generated:	21
Total products and services revenues:	\$14 million (excl. data sales)
Leveraged RADARSAT data sales:	\$3 million (est.)

A significant highlight was the development of the IOSAT transportable ground station (SENTRY), which is partially funded by RUDP. In June 1998, SENTRY was successfully utilized for operational maritime surveillance in support of Exercise MARCOT/UNIFIED SPIRIT '98 (see page 7).

As a centre of excellence in the use of Earth observation data, Canada continues to advance the development of new RADARSAT applications and derived products and services. Collaborating with industry, government and scientific organizations around the world, CSA/CCRS supports RADARSAT applications research and manages the following CSA-funded programs.

***The potential of RADARSAT data for land use mapping in the Ivory Coast is highlighted in this composite. It was produced from two RADARSAT scenes acquired in different seasons and a texture analysis was applied. Shown are moist evergreen or mature secondary forests (FO), cultivation (CC) and mature or young forests with cultivation (CS).***

RADARSAT data © Canadian Space Agency 1998.  
Enhanced and provided by Tecsalt International Limitée.





# DEVELOPING NEW APPLICATIONS, PRODUCTS AND SERVICES

## Canadian Earth Observation Network (CEONet)

CEONet provides users with real-time Internet access to RADARSAT and other remote sensing satellite databases. Now in its second year, CEONet offers a directory service for government and private sector data and service providers, a map interface, and a distributed search service that connects to remote Canadian and international data sets. By the end of 1998, more than 1,000 suppliers, 4,700 products and 100 services were included in the CEONet database.

RSI's RADARSAT catalogue and browse data is accessible worldwide through CEONet. Access to RADARSAT and other Earth observation data as well as in situ data empowers the Canadian value-added industry to develop new products and services using RADARSAT data and to market these internationally on CEONet.

## Earth Observation Data Sets Program (EODS)

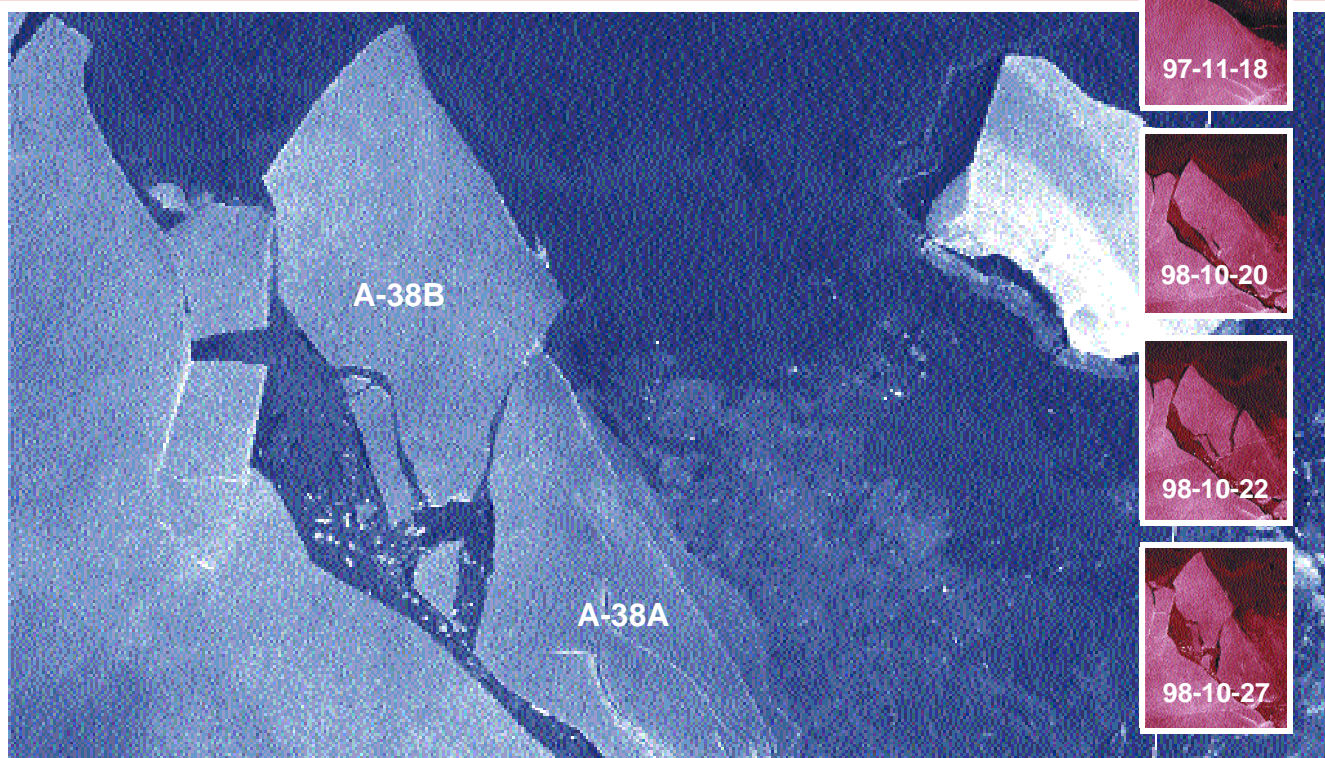
Now in its third year, EODS supplies RADARSAT and other Earth observation data to researchers for the development of new algorithms and the extraction of information from image data products. Successful applicants have two years to report significant research results.

Of the 42 proposals received, 26 are active projects. 1998 project reports include those from the University of Sherbrooke on providing remote sensing tools for quantitative forest management as part of a larger global change program with Natural Resources Canada; the University of Alberta on delivering data fusion algorithms using both optical and RADARSAT imagery with DEMs to predict evapotranspiration, infiltration and interception for land cover; and the Institut National de la Recherche Scientifique-EAU-Québec on using multi-temporal RADARSAT imagery in mapping wetland aerial extent and type for the Québec Ministry of Natural Resources.

***In October 1998, the U.S. National Ice Center (NIC) discovered a massive new iceberg originating from the Ronne Ice Shelf in Antarctica. Named A-38, the 150 x 50 kilometre iceberg subsequently broke up into several pieces, named A-38A, A-38B, etc. This sequence of ScanSAR Wide images, processed from the RADARSAT archive and acquired after the iceberg's discovery, clearly shows the motion and break-up of the large, tabular iceberg. Over the ten-day observation period, the northern section of A-38B drifted 50 kilometres.***

RADARSAT data © Canadian Space Agency 1997, 1998.

Received by the Canada Centre for Remote Sensing (CCRS) and the Alaska SAR Facility (ASF). Processed and distributed by RADARSAT International Inc. (RSI) and ASF.





Other expected contributions for the use of RADARSAT imagery include landscape change detection algorithms, monitoring ice break-up, ship detection algorithms, mapping hidden archaeological sites, algorithms for quantifying coastal zone erosion, and various algorithms for the mapping and delineation of geological structures and mineralization.

## Earth Observation Pilot Projects Program (EOP3)

EOP3, also in its third year, emphasizes the operational use of Earth observation data, especially from RADARSAT, to improve resource management and environmental protection and to assist the Canadian geomatics industry in promoting their products and services. Because bringing new technology to market (or customizing existing technology for new markets) can be a formidable challenge, EOP3 provides scientific and technical advice, as well as partial funding support for pre-operational pilot projects.

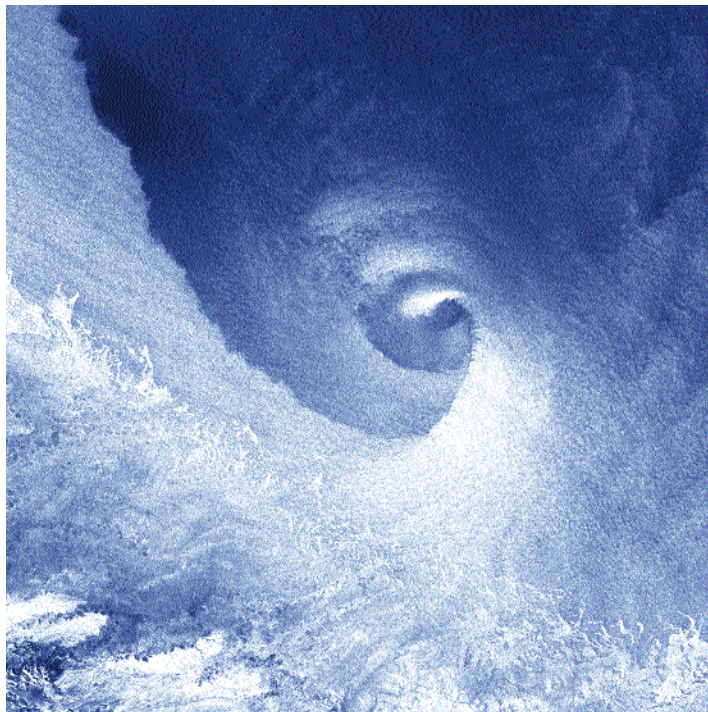
In 1998, EOP3 funded 20 RADARSAT-based projects, supporting applications ranging from topographic mapping in South America to precision farming in Alberta, rice crop monitoring in Vietnam to snow cover measurement in northern Quebec. To ensure a smooth transition from research through development to operational application and user acceptance, EOP3 works closely with other CSA-funded programs. For example, EOP3 partially funded the operational demonstration of the SENTRY transportable station, while the RUDP program partially funded SENTRY's development.

## User Education and Training Initiative (UETI)

The UETI program, now in its third year, has effectively demonstrated the role of remotely sensed data in operational environments. Canadian industry is marketing educational and Earth observation materials and services, developed with co-investment from UETI, and assisting third-party users in developing the required skills to use RADARSAT data. Five UETI projects were completed in 1998, bringing the program's total to 39.

Results from 1998 include the RADARSAT Distance Learning Program (RDLP), a popular and freely distributed CD-ROM developed by Geomatics International (Burlington, Ontario). It covers basic imaging radar theory and RADARSAT application examples in an easy-to-use format suitable for researchers, educators, and Earth and environmental science professionals.

Another highlight was the RADARSAT Lesson Plan for User Education and Training and the Geomatics Education Forum developed by Intermap Technologies Ltd. (Calgary, Alberta). The Lesson Plan introduces RADARSAT to educators and consultants, enabling them to deliver information on the satellite system to students and trainees. The Education



***A polar low pressure system beyond the ice edge off the coast of Labrador, Canada is shown in this RADARSAT ScanSAR Wide image. The atmospheric frontal structure, atmospheric waves and areas of instability are readily apparent in the ocean surface signature patterns created by the surface wind field surrounding this weather system.***

RADARSAT data © Canadian Space Agency 1999.  
Provided by the Canadian Ice Service.

Forum addresses the issues associated with available remote sensing and geomatics resources, the role of industry and others to map future educational needs, centralizing information on the web, and test educator in-service training courses.

A Québec-based company, Groupe Perspective D'Avenir, produced a practical guide (using Canadian examples) for interpreting and integrating remotely sensed data into cartographic applications. UETI also co-funded the first phase of a CD-ROM training tool for wetland sustainability. Developed by IQ Media (Toronto, Ontario), the CD-ROM is designed to be an interactive, environmental conservation product aimed at international development officers.



# DEVELOPING NEW APPLICATIONS, PRODUCTS AND SERVICES

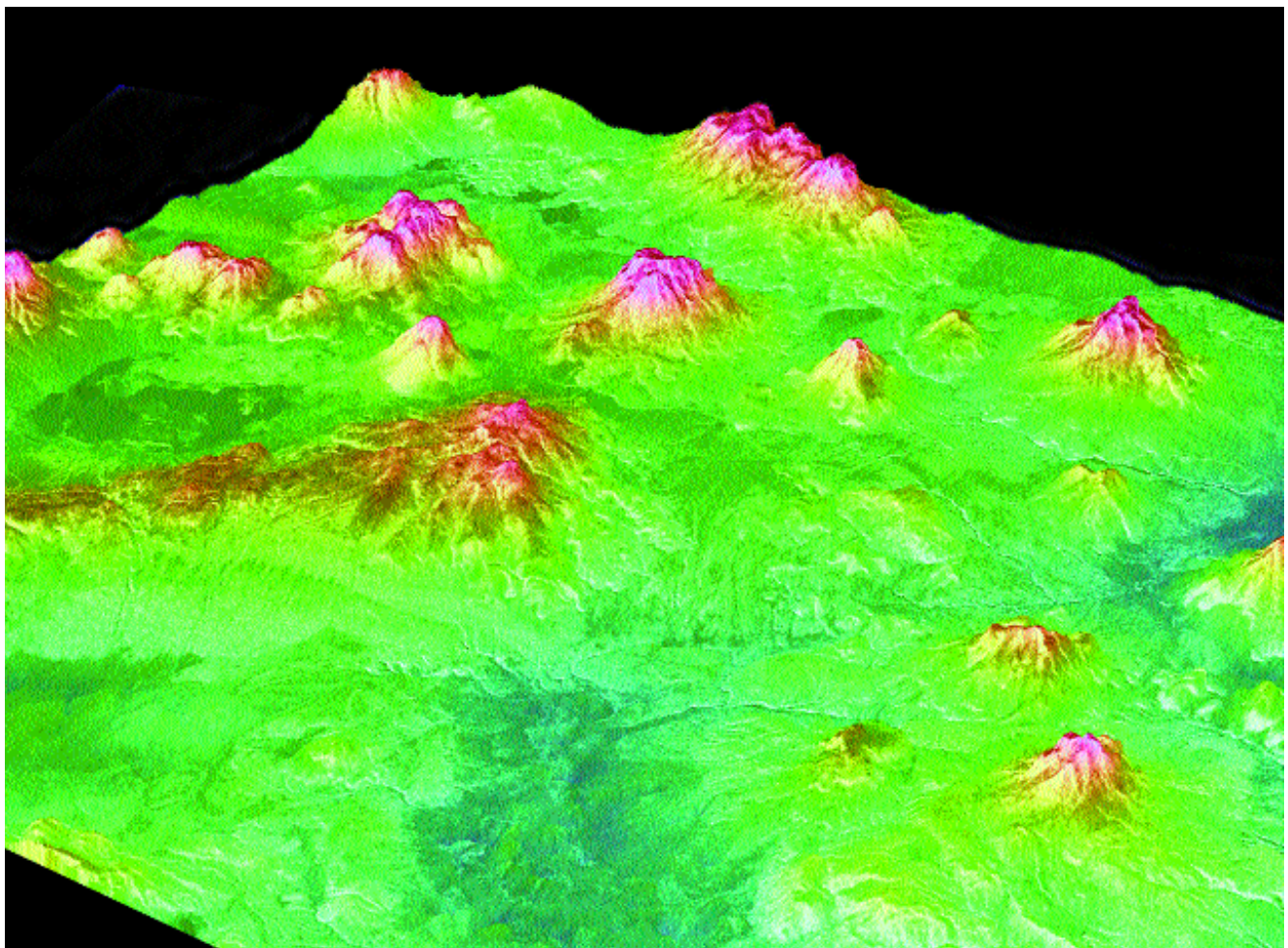
## GlobeSAR-2

GlobeSAR-2 is developing radar expertise in 11 Latin American countries mainly through RADARSAT applications demonstration projects. Now in its second year, GlobeSAR-2 is sponsored by the Canadian International Development Agency (CIDA), the International Development Research Centre (IDRC), RSI, PCI Geomatics Group, and Atlantis Scientific, and managed by CCRS. By the end of 1998, more than 200 RADARSAT images had been acquired to support GlobeSAR projects.

Preliminary results from the more than 60 demonstration projects were presented at the GlobeSAR-2 Mid-Term Symposium held in Cartagena, Colombia, April 20 - 24, 1998. Attended by 120 participants, including 13 Canadian geomatics companies, the conference highlighted the technical progress of the projects and the remarkable advancement in knowledge of radar and RADARSAT techniques. Full project results will be presented at the GlobeSAR-2 Final Symposium in Buenos Aires, Argentina, May 17-20, 1999.

***This chromo-stereoscopic image of a volcano in the Villa Alota-Pasto Grande area of the Bolivian Andes was produced using a DEM generated from stereo RADARSAT imagery and colourized using an IHS transformation. The resulting image was draped over the DEM to create a perspective view. The imagery is being used for geologic interpretation of the region.***

RADARSAT data © Canadian Space Agency 1997, 1998.  
Enhanced and provided by the Canada Centre for Remote Sensing (CCRS).





# RADARSAT-2

As a key step in privatizing Canada's satellite-based SAR systems, MacDonald, Dettwiler and Associates (MDA) has signed an agreement with the Government of Canada to construct and manage RADARSAT-2. MDA is based in Richmond, British Columbia.

"This project will result in the construction of the world's most advanced Earth observation satellite. RADARSAT-2 is concrete proof of Canada's commitment to a vigorous knowledge-based economy through the establishment of public-private sector partnerships," said John Manley, Industry Minister and Minister responsible for CSA.

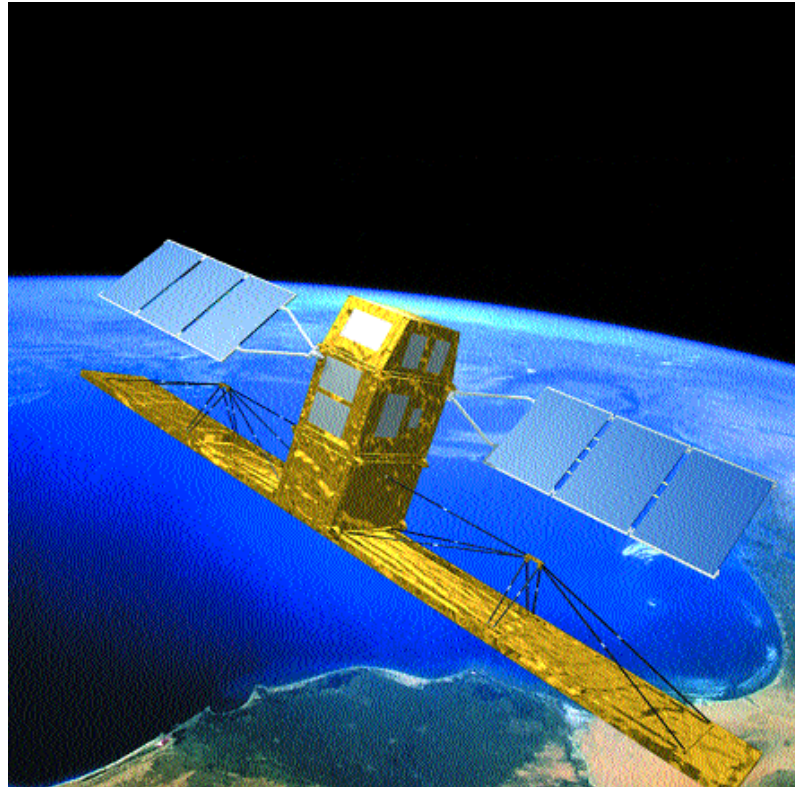
Under this partnership, CSA is investing \$225 million and MDA is investing \$80 million. MDA is also responsible for operations and business development.

Scheduled for launch in 2002, RADARSAT-2 is designed to operate for seven years and will:

- maintain data continuity for RADARSAT-1 users,
- aid in developing the global Earth observation business for the benefit of Canadian industry,
- advance Canada's technological leadership, and
- assist in creating a self-sustaining, commercial/industrial, satellite remote sensing business in Canada.

Utilizing state-of-the-art technology, RADARSAT-2 will provide the most advanced commercially available satellite radar technology in the world. Enhancements include three-metre spatial resolution and multi-polarization imaging, which will be valuable in developing new applications for satellite SAR data, especially in the fields of mapping and surveillance, which are projected to comprise 60 percent of the total remote sensing market.

Industrial benefits in the space/Earth observation sector resulting from RADARSAT-2 are estimated at \$2 billion - 10 times the Canadian government's investment. This follow-on satellite program is expected to generate approximately 3,500 person years of employment, \$1.2 billion in export sales, and small- and medium-sized enterprises will benefit as the value-added industry continues to grow.





The mandate of the CSA is to promote the peaceful use and development of space, to advance the knowledge of space through science and to ensure that space science and technology provide social and economic benefits for Canadians.



**RADARSAT-1** - The Canadian Space Agency's first Earth observation satellite is equipped with a powerful synthetic aperture radar (SAR) instrument that operates day and night, in all weather, regardless of cloud cover, smoke, haze and darkness, to acquire high quality images of the Earth.

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