FOCUS – Canada and the Nordic countries

The North and the Canadian Space Program

By Marc Garneau,

President, Canadian Space Agency

Canada is the second largest country in the world, and about 40 per cent of its landmass is above the 60th parallel. Canada’s geography—its vastness and its northern orientation—has always influenced its space program priorities. Canadian space-based science and technologies are providing an unprecedented perspective on today’s key northern issues: Earth observation for sustainable development, ozone layer monitoring over the Arctic, the impact of global warming, and studies of the aurora borealis and the magnetosphere. Arctic sea ice, once considered permanent, has melted at a rate of three per cent a decade since the 1970s. The impact of ozone depletion is greatest at the poles. In the high northern latitudes, the ozone layer has thinned by six per cent since the mid-1980s, and by as much as 40 per cent during the spring. These massive environmental changes come at a time when Canada’s North is experiencing a new wave of oil, gas, and mineral exploration, including plans for oil projects in the Beaufort Sea, and a new era of self-government for Canada’s First Nations, with the creation of the territory of Nunavut in the eastern Arctic in 2000.

Now more than ever, space-based science and technologies are critical to understanding the North and working there in a sustainable way. This article looks at how the Canadian Space Program is responding to three key northern environmental concerns and also at how the North is helping scientists plan for a mission to the Moon or Mars.

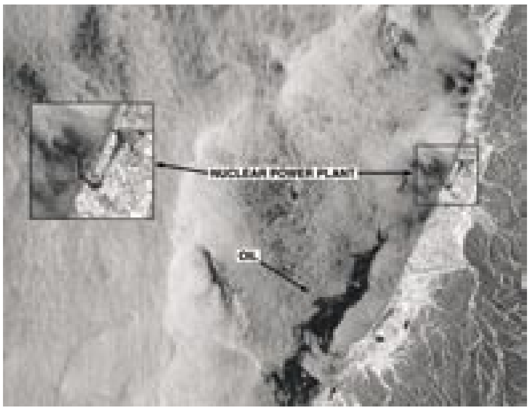
Earth observation

Canada's Earth observation industry is among the foremost remote sensing sectors, and it grew out of the need to monitor our vast Arctic territories and waters. RADARSAT-1, launched in 1995, revolutionized the nature of remote sensing and mapping in the North, and around the world. The satellite is equipped with powerful synthetic aperture radar (SAR) that can capture detailed land and sea information, day or night, regardless of weather conditions. Despite the darkness of an Arctic winter or the thick cloud cover of summer, RADARSAT-1 provides continuous remote sensing information.

RADARSAT-1 in orbit.
Photo: CSA

This 24-hours-a-day, seven-days-a-week Eye in the Sky is the cornerstone of the Canadian and Scandinavian ice monitoring services. Since 1996, the Canadian Ice Service has relied on RADARSAT-1 to provide timely and highly accurate sea-ice images to facilitate safe northern shipping and other marine activities, including offshore drilling, in Canadian waters. Denmark, Norway, and Finland, also rely extensively on RADARSAT-1 images for coast guard support, and ice and pollution monitoring.

The satellite is not restricted to the North. Since its launch a decade ago, its Canadian commercial operator, MDA Geospatial Services, formerly Radarsat International, has sold or offered radar imagery to some 600 clients in 60 countries.



Oil spill detected from RADARSAT.
Photo: CSA

With the launch of RADARSAT-2 in the summer of 2006, Canada will have a significantly improved, SAR-based Earth-observation system that maintains data continuity with RADARSAT-1. The new commercial satellite will be the first to offer multipolarization—the ability to observe a target in a variety of ways to better identify it, whether, for example, it's a ship, an oil slick, or an iceberg. RADARSAT-2's C-band remote sensing radar will also provide greater ground resolution, down to three metres, with available swath width ranging from 20 to 500 kilometres.

The RADARSAT system is the centre of Canada's contribution to the Northern View team. An initiative of the European Space Agency and the European Commission, with participation by the Canadian Space Agency and Newfoundland's C-CORE, the Northern View makes Earth-observation services more accessible and affordable to anyone interested in northern regions. The Northern View provides users with a "one-stop-shop" for northern information, incorporating Earth-observation and other information as needed.

In May 2005, the CSA and Finland's National Technology Agency (Tekes) signed an agreement to jointly support the private sector development of four remote sensing projects. They will use Earth-observation data to produce cost-efficient map products in support of sustainable development activities in northern boreal regions in Canada and Finland.

Large, sophisticated satellites like RADARSAT take many years to develop, so the Government of Canada is now planning for the next generation. A new constellation of three small radar satellites is being developed and will provide more frequent coverage over Canada—flying over any part of the country at least once a day, and more frequently over the North—greatly reducing the risk of an interruption in service. The satellite constellation will benefit Canada and other nations with more timely and comprehensive data, including:

- Support for disaster management by detecting oil spills, monitoring floods, and providing information on the evolution of disaster areas
- Ice monitoring for navigation in the St. Lawrence, the Great Lakes, and our coastal waters
- Support of Canadian sovereignty and security through coastal surveillance by satellite in all weather conditions, including detecting ships in the far North

Ozone depletion in the Arctic

In August 2003, Canada successfully launched SCISAT, marking a milestone in Canadian space science. SCISAT is a unique addition to international research on Earth's stratospheric ozone layer. It also represents the first in a new generation of lower-cost, scientific, Canadian small satellites.

SCISAT's primary scientific mission is to study the chemical and dynamic processes that control the distribution of ozone in the upper atmosphere, particularly over the Arctic. The data gathered will help determine the effectiveness of the Montreal Protocol for the elimination of chlorofluorocarbons (CFCs).

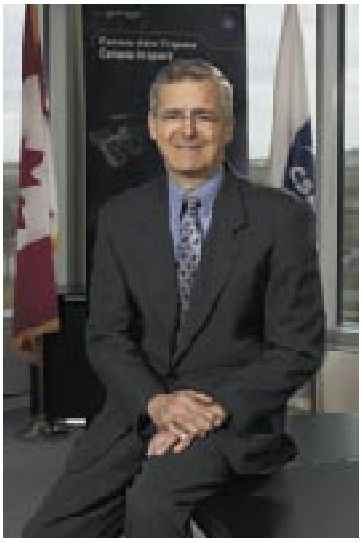
Marc Garneau, President of the Canadian Space Agency

Born in February 1949 in Quebec City, Canada, March Gameau received his early education in Saint-Jean-sur-Richelieu in Quebec and in London, England. He received a Bachelor of Science degree in Engineering Physics from the Royal Military College of Kingston in 1970, and a Doctorate in Electrical Engineering from the Imperial College of Science and Technology, London, England, in 1973. He attended the Canadian Forces Command and Staff College of Toronto in 1982, and that was the beginning of a carree in the Canadian Navy, a post he retired from in 1989.

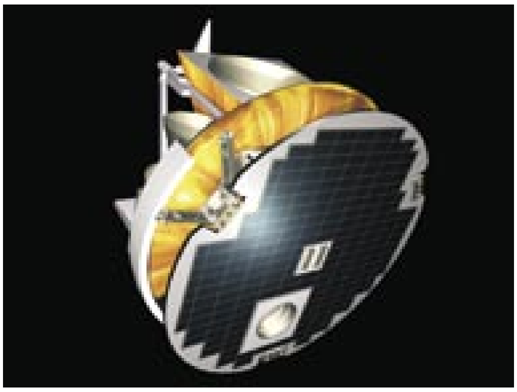
He is one of six Canadian astronauts selected in December 1983, and he began his astronaut training in 1984. He became the first Canadian astronaut to fly in space as a Payload Specialist on Shuttle Mission 41-G in October 1984. He was named Deputy Director of the Canadian Astronaut Programme in 1989, providing technical and programme support in the preparation of experiments to fly during future Canadian missions and was selected for Mission Specialist training in July 1992.

Marc Garneau reported to the Johnson Space Center in August 1992. He completed a one-year training and evaluation programme to be qualified for flight assignment as a Mission Specialist. He initially worked on technical issues for the Astronaut Office Robotics Integration Team and subsequently served as Capsule Communicator (CAPCOM) in Mission Control during Shuttle flights. A veteran of three space flights (STS-41G in 1984, STS-77 in 1996 and STS-97 in 2000), Marc Garneau has logged over 677 hours in space.

In February 2001, Marc Garneau was appointed Executive Vice President in the Canadian Space Agency. He was subsequently appointed President of the Canadian Space Agency, effective November 22, 2001



As a result of his long-standing engagement within space related activities he has received several distinctions and he is named as Honorary Doctorates at a number of universities.



SCISAT. Photo: CSA

Under the scientific lead of Principal Investigator Dr. Peter Bernath of the University of Waterloo in Ontario, SCISAT is providing the highest spectral resolution information on ozone-related atmospheric chemistry, and is setting a new international standard for this data. It is also the only current mission that can detect and document all atmospheric chemicals involved in the ozone-depletion process.

SCISAT might bring a significant change to our understanding of the state of ozone depletion and the time frame for recovery. Initial results indicate that stratospheric levels of hydrogen chloride (HCl), an ozone-depleting molecule, are 15 per cent higher than earlier satellite missions had identified. And with calibration improvements over earlier missions, SCISAT has identified that previous satellite-based ozone measurements may be inaccurate by as much as 10 per cent.

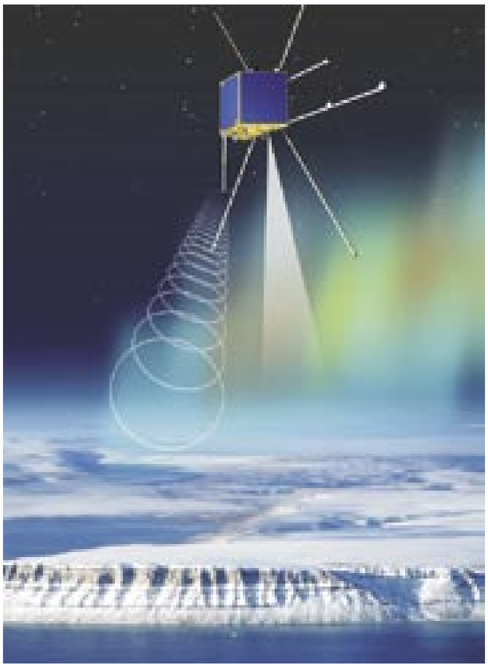
The mission is also providing new information about general atmospheric chemistry in the North. SCISAT recently recorded the first spectrum of noctilucent, or polar mesospheric, clouds. The results indicate that, as suspected, these unique Arctic clouds, with their opalescent glow in the low summer sun, are full of tiny ice pellets.

Canada also has an ozone-monitoring instrument called OSIRIS onboard Sweden's Odin satellite. It has proved to be extraordinarily reliable. It provides global height profile maps of ozone on a daily basis, and it can do the same for aerosols and nitrogen dioxide, an important gas in ozone depletion and in atmospheric pollution.

The aurora borealis and the magnetosphere

Scheduled for launch in 2007, the CASSIOPE mission will study the impact of solar particles on the upper atmosphere. The first made-in-Canada, multi-purpose, small satellite is to carry an innovative scientific payload.

The enhanced polar outflow probe, or ePOP, will provide scientists with an unprecedented top-down view as charged solar particles bombard the upper atmosphere producing the northern lights. This will augment the ongoing, long-term work of the Canadian GeoSpace Monitoring program (formerly CANOPUS), a network of various ground-based sensors that provide a unique overview perspective on the chronological sequence of events that produce aurora.



CASSIOPE (preliminary design). Image: Canadian Space Agency

Orbiting at 325 kilometres above the Earth's surface, ePOP will have eight scientific instruments. The two charged-particle detectors are ten times faster than any currently in use, and they will collect new high-resolution data on the impact of solar storms on the region between the atmosphere and the magnetosphere. This essential information will help us better understand and prevent the potentially devastating impact of these solar storms on radio communications, GPS navigation, and other space-based technologies.

This scientific mission will derive enormous benefit from being bundled aboard CASSIOPE with Cascade, a commercial, high-speed satellite communication prototype being developed by MDA. Cascade will provide ePOP scientists, led by Dr. Andrew Yau at the University of Calgary's Institute for Space Research, with previously unimaginable satellite data transmission rates of gigabytes per second. Previous ionosphere missions settled for a megabyte of data in 10 minutes!

CASSIOPE will provide critical information on this quintessential northern atmospheric phenomenon, and will also help validate a communications technology that could greatly assist commercial and scientific research in remote regions, including the North.

Trying Planetary Suits at Devon Island. Image CSA

Mars North

While some Canadian Space Agency missions seek to better understand the atmospheric environment over Earth's northern pole, these projects also present a wonderful synergy with international efforts to explore Mars.

For example, the core of ePOP's ion-detection instrument is based on a similar Canadian thermal plasma analyzer that was aboard Nozomi, the failed 1998 Japanese Martian orbiter. Here on Earth, Canada's high Arctic is, for the moment, the closest we will get to experiencing the Red Planet. NASA's Haughton-Mars Project, based in the polar desert of the Haughton meteorite crater on Devon Island, the world's largest uninhabited island, is considered the Earth's leading analogue for the Martian environment.

This international, interdisciplinary, field-research project is conducting basic science, gaining insights into the history of water and past climates on Mars, while also developing and testing innovative Martian exploration technologies, strategies and human factors issues. Over the next few years, the Canadian Space Agency is investing in basic infrastructure development at the site to ensure that it is an efficient, long-term research centre.

In applied research on Devon Island, the Canadian Space Agency and a number of Canadian universities are involved in the Arthur Clarke Mars Greenhouse project. It is the world's most northerly, remote-controlled greenhouse, and it's providing critical information on the challenges and possibilities of growing crops in extreme environments. An identical greenhouse has just been built at Canadian Space Agency headquarters near Montreal to provide researchers with a more accessible facility.

The Arthur Clarke Mars Greenhouse on Devon Island is expected to provide its first remotely grown crop in the fall of 2005. This will mark another northern first for the Canadian Space Program, and one small step towards the exploration of other worlds.

