by Ernest Granson

Industry looks to eye in the sky

Remote sensing for the energy and mining sectors

When Albert became the first monkey in space more than 60 years ago, few could have predicted that his 143-kilometre-high flight would eventually lead to the development of technology now being used to provide invaluable information for industries such as mining and oil and gas.

Remote-sensing technology is becoming increasingly relied upon to supply data ranging from monitoring the slope stability of a pit mine to gauging pressure movement at a steam-assisted gravity drainage (SAGD) site.

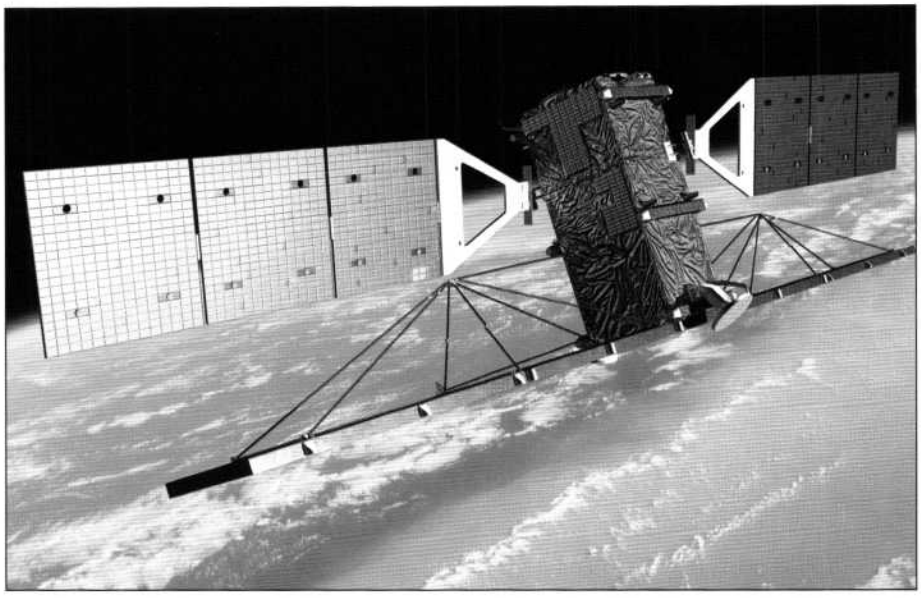
Satellites are a primary carrier of the instruments used for remote sensing, along with vehicles such as helicopters, airships, drones and autonomous subsea vehicles.

Canadian businesses are playing pivotal roles in not just in the consumption of the data for use in our country's abundant natural resources sector, but also in the development of the technology gathering that data. Richmond, B.C.-based MacDonald, Dettwiler and Associates Ltd., for example, has been instrumental in the global advancement of remote-sensing technology.

That technology owes much of its existence to Canada's history of developing and operating satellites, in which MDA has played a major role. The company designed and built RADARSAT-1, Canada's first commercial Earth-observation satellite.

MDA also partnered with the Canadian Space Agency to build RADARSAT-2, a next-generation Earth-observation satellite. MDA operates RADARSAT-2 and maintains exclusive worldwide distribution rights to RADARSAT-2 products.

RADARSAT-1, which was launched in 1995, is equipped with state-of-the-art synthetic aperture radar (SAR) instrumentation to collect images with a swath as wide as 500 kilometres. The on-board technology provides timely information about the planet's natural resources and environmental changes.



MacDonald, Dettwiler and Associates Ltd.'s RADARSAT-2 Earth observation satellite in orbit. *Photo courtesy MDA.*

RADARSAT-2 was put into orbit in 2007 with additional capabilities such as high-resolution imaging, flexibility in selection of polarization, left- and right-looking imaging options, shortened programming, processing and delivery timelines, superior data storage and more precise measurements of spacecraft position and attitude.

RADARSAT echnologies allow MDA to offer a broad range of services to a variety of sectors, including mining and oil and gas, says Michael Nemirow, MDA vice-president and business unit director of energy and mining.

"We can divide the activities we carry out in the oil and gas sector into four main areas," says Nemirow.

The first is offshore operations, where MDA can monitor production and exploration areas so that oil companies are made aware of any oil present in their operating areas, including illegal bilge dumping or from natural seeps, and to help with incident situations.

"The RADARSAT imagery can be used to determine the extent of the oil and wind direction and speed — information vital for tracking oil on water," says Nemirow.

Related to offshore operations is the satellites' ability to monitor potential hazardous situations, such as ice movement, in extreme northern and southern regions. These situations could apply to the condition of sea ice or location and movement of icebergs.

In addition, MDA can carry out, through its satellites, general remote-sensing services such as mapping programs, which support exploration and production.

"We can also monitor pipelines and other infrastructure to spot potential encroachment or issues related to subsidence of the facilities," says Nemirow, noting because oil companies have massive facilities with large amounts of activity, they tend to be one of the largest users.

The fourth area in which MDA is delving into is monitoring surface movement using a technique called InSAR or interferometric synthetic aperture radar.

"In simple terms, the satellite sends down a beam, which bounces off the Earth's surface, creating an image of

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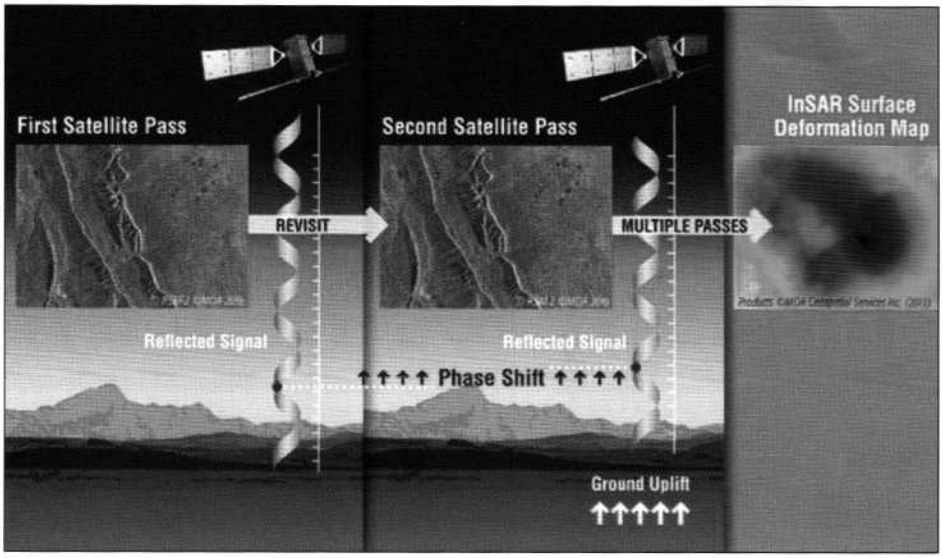

Schematic diagram illustrating the InSAR process. InSAR monitoring is currently accepted by the Alberta Energy Resources Conservation Board's Directive 54. *Illustration courtesy MDA.*

a specific area, such as an oil and gas operator's field," explains Nemirow.

"The satellite orbits over the site often, returning to the same orbital position every 24 days in that process to produce another image of the same surface location."

By measuring changes to how the image reflects back to the satellite, MDA can detect small amounts of uplift or subsidence to within a millimetre's level of accuracy.

And, as the satellite continues to pass overhead, it can also produce images of that location from various angles to give reports more frequently, depending on the client's needs

"The satellite travels in a polar orbit, — circling the Earth every 100 minutes — and is able to image a specific point from different locations," explains Bruce MacDonald, MDA's technical solutions manager for energy and mining.

"Our team can use different satellite passes with different imaging geometry. We then integrate that information to provide high-frequency temporal coverage. The information is delivered to customers as a geospatial product such as a surface motion map with detailed analysis of key features."

Remote sensing is particularly useful for SAGD-related issues, adds MacDonald.

In a SAGD well, a steam chamber is created when high-pressure steam is injected. This opens up the porosity of the well and reduces the viscosity of the crude so it flows downward into the lower well bore to be pumped out.

"When a well site is at low depth, pressure is continually expanding, and eventually expands enough to create movement on the surface as the cap rock is lifted ever so slightly," says MacDonald.

"If it's lifted too much, the well loses its dynamics. At the most extreme, the pressure can cause a surface breach which can affect the whole pressure regime. By monitoring the surface through remote sensing, we are able to see and advise that this movement is occurring. This information allows operators to adjust steam pressures to prevent surface breaches. "

The technology also applies to the mining sector — monitoring slope stability of pit mining and movements involving other infrastructure such as tailing ponds, dams around the ponds and even buildings.

The sensing technology collects high-density measurements of subtle movement of the structures to identify potential problems, allowing for proactive stabilization or remediation strategies to mitigate environmental risks.

For both mining and oil and gas applications, remote sensing replaces the hazardous practice of physical surveys on unstable stock and waste piles.

Monitoring the Earth's surfaces for industry use is more common today than ever, says Nemirow. In fact, InSAR monitoring is accepted by the Alberta Energy Resources Conservation Board's (ERCB) Directive 54 — Performance Presentations, Auditing, Surveillance of In Situ Oil Sands Schemes.

The component that has propelled remote-sensing technology toward greater acceptance is the algorithmic methodology, which MacDonald says, has greatly advanced in the past several years.

"The major components of remote sensing consist of instrumentation, such as sensors and, just as importantly, the algorithms used to process the information collected by the instruments," he says.

"The algorithms have certainly improved, as has the computing power. "

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For example, MDA has created new processing techniques specifically tailored to generate the maximum number of measurements over a field. The company has also enhanced the way RADAR imagery is processed to further improve the usefulness of the information.

"That track record of innovation and experience has now become something that companies can rely on," says MacDonald.

Remote sensing a key to unlocking the North

Still, the real potential for remote sensing has yet to be realized, according to Mark Fawcett, Calgary-based business development manager with LOOKNorth, a national Centre of Excellence for Commercialization and Research (CECR) developed by C-CORE, a research and development corporation headquartered in St. John's, N.L.

Leveraging its international reputation for remote-sensing innovation in harsh cold environments — having pioneered RS-based iceberg detection for Canada's East Coast oil and gas developments, as well as managing the European Space Agency's Polar View project — C-CORE has formed the LOOKNorth centre (Leading Observations & Operational Knowledge for the North) under the federal government's Network of Centres of Excellence.

"Our mandate is to prove and promote Canadian remote-sensing technologies that support safe, sustainable development of Canada's northern natural resources," says Fawcett.

Fawcett is assessing the needs of the oil and gas industry for remote sensing that aren't currently being applied.

"We are doing sector assessments and interviews — talking to companies active in areas such as the Beaufort Sea, MacKenzie Valley and Fort McMurray," he says.

"Our objective is to bring together the people who have potential technology solutions with the industries that need solutions."

For LOOKNorth's purposes, remote sensing refers to sensors that operate from a distance on various platforms, such as satellites, aircraft, unmanned aerial vehicles and even sub-sea autonomous underwater vehicles.

The types of projects resonating with producers are those that address information needs in establishing environmental baselines for parameters such as vegetation, wetlands, water quality, air quality and mammal populations; engineering challenges such as terrain stability; or operational challenges such as SAGD.

The challenges have interesting overlaps with those being uncovered in the mining and hydroelectric industry through LOOKNorth's efforts in that sector.

Another major federal initiative that's helping unlock the mineral and energy potential of Canada's North is Natural Resources Canada's Geo-Mapping for Energy and Minerals (GEM) program.

The $100-million five-year program funded by the federal government is part of an ambitious plan to significantly advance and modernize geological knowledge in the North.

The program, being carried out by the Geological Survey of Canada, of Natural Resources Canada's Earth Sciences sector, is providing public geoscience to support increased exploration for new resources and enable northern communities to make informed decisions about their future economy and society, says acting GEM co-ordinator. Alain D. Leclair.

The program's focus is to understand the geology of Canada's North, he adds, noting two-thirds of the North has not been assessed to modern geological standards.

Supporting GEM is an advisory group that includes representatives from governments, the private sector and aboriginal socio-economic development organizations.

GEM activities also involve participation by academia, in particular students ranging from junior undergraduates to post-doctoral fellows conducting field work, laboratory analysis, and data integration.

GEM is divided into three components:

The first is an energy component, designed to provide the detailed geological framework needed to evaluate energy resource potential supported by maps that indicate the major geological factors controlling the distribution of potential resources.

New framework geoscience is being undertaken by multidisciplinary teams, and includes airborne geophysical studies, fieldwork, seismic interpretation, studies of subsurface materials such as old industry core and cuttings, as well as petroleum systems analysis.

The program's minerals component, meanwhile, is intended to improve knowledge of Canada's North through the acquisition and rapid release of new geoscience information for targeted areas with high potential for base

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metals (copper, nickel, iron, zinc and lead), precious metals (gold, silver, platinum), diamonds and multiple commodities including rare metals.

In addition, the assembly and dissemination in digital form of existing field and remotely-sensed data, and accompanying analysis of mineral potential, is intended to provide an accurate portrayal of the land.

Lastly, GEM's knowledge-management component is intended to ensure new data, information and knowledge being collected, processed and interpreted by GEM projects are well managed and accessible to all Canadians.

In addition, GEM is working with its partners to establish, over the longer term, a more co-ordinated management and delivery of key geoscience information from multiple jurisdictions in a coherent and easily accessible process.

"Depending upon the question we need to answer, we select the appropriate suite of modern field tools and analytical methods to collect, distribute and deliver comprehensive reports, maps, and geodatabases freely, via the Internet," says Leclair.

Modern geo-maps integrate information from all scales; from satellite and ground-based observations, to microscopic details.

Data layers include bedrock geology, surficial geology, geophysics, geochemistry, geochronology, mineral showings, satellite imagery and topography.

Data is acquired remotely via satellite imagery or geophysical airborne surveys, as well as in the field using hand-held devices such as a Ganfeld.

Data is also collected as a result of modern laboratory work conducted in the GSC's research labs using instruments such as the Sensitive High-Resolution Ion Micro-Probe (SHRIMP).

Ganfeld is an application developed at the Geological Survey of Canada that leverages the power of ArcPad (a Geographic Information System. It runs on a Windows based personal digital assistant PDA.

Ganfeld enables field researchers to set automatic GPS location points on an electronic base map that can be immediately verified through observation. Field data can be downloaded in the field so the interpretation of the area's geology can almost instantaneously.

Currently in the fourth year of its five-year mandate (2008–2013), GEM to date has undertaken 20 new field projects in the three northern territories and the northern parts of six provinces: Ontario, Quebec, British Columbia, Saskatchewan, Manitoba and Newfoundland and Labrador

"Thirty regional geophysical surveys have been completed, and 563 GSC open-file releases have been published and publicly released and can be accessed online through Natural Resources Canada's website," says Leclair.

More than 630 technical information sessions have also been delivered at venues frequented by industry, government and non-governmental organizations.

A recent GSC open-file report providing a foundation for all surficial geology mapping and science language has already generated interest from key stakeholders.

The new public geoscience created by GEM has identified areas of high potential for gold, nickel, platinum-group elements, rare metals, base metals and diamonds.

The exploration industry is beginning to follow up on these leads.

Ernest Granson is a Calgary-based writer and editor, and a contributor to PROCESSWest.