# IEEE Milestone celebrates **first digital processing of satellite-based radar data**

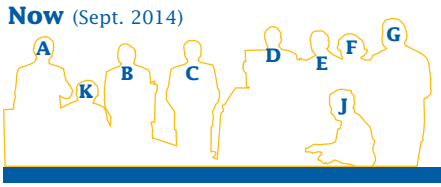
By **David G. Michelson**

The dawn of digitally processed satellite radar imagery was celebrated as an IEEE Milestone in Electrical Engineering and Computing in September 2014 in Vancouver at the headquarters of MacDonald, Dettwiler and Associates (MDA) Ltd. In November 1978, the Canadian company became the first to use a digital computer to reconstruct scenes from synthetic aperture radar (SAR) data (see B&W image on page 9). The SAR data was supplied from NASA's Seasat-A satellite.

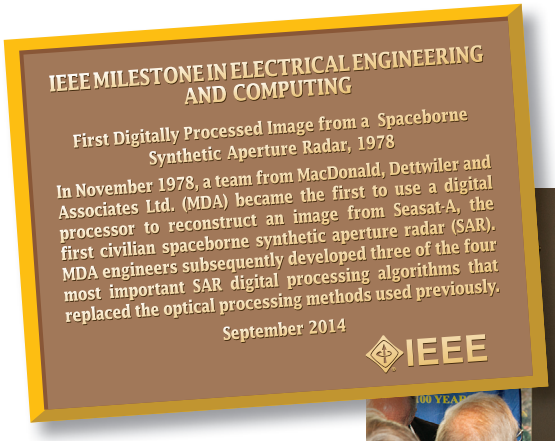
Milestones in Electrical Engineering and Computing are the highest form of historical recognition offered by IEEE. They are approved by the IEEE Board of Directors based upon recommendation of the IEEE History Committee. The vetting process is rigorous and can take more than a year to complete.

The Milestone dedication ceremony was attended by several members of the original MDA team, including John Bennett, Ian Cumming, Ron Fielden, Wayne Fung, Pete McConnell, Robert Orth and Pietro Widmer. MDA co-founder John MacDonald was also present. Among the dignitaries who offered comments and congratulations during the course of the event were Canadian Space Agency Vice-President Luc Brûlé, B.C. MLA Linda Reid, and IEEE Canada President Amir Aghdam.


**Fundamental to their success, MDA engineers developed the necessary complex algorithms to manipulate the data, but which were still compatible with the low-processing-power computers of the time.**




**J** **Luc Brûlé, V.P., Canadian Space Agency**
**K** **John S. MacDonald, Co-Founder, MacDonald, Dettwiler and Associates**




Amir Aghdam, IEEE Canada President 2014-2015, outlines the goals of the IEEE Milestone program. Standing to his left is Dave Michelson, who led the Vancouver Section Milestone proposal team.


*Photos: MacDonald, Dettwiler and Associates Ltd. (MDA) unless otherwise noted*

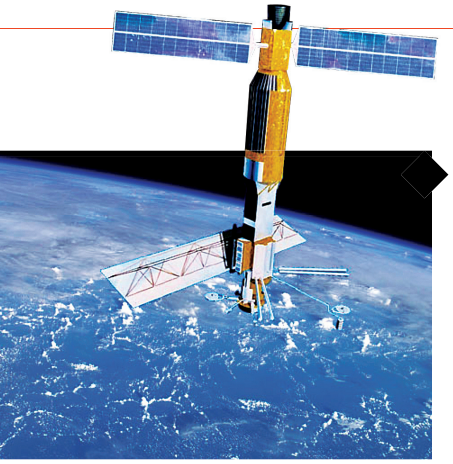


Photo: NASA

Seasat was the first satellite designed for remote sensing of the Earth's oceans with synthetic aperture radar (SAR). The mission was designed to demonstrate the feasibility of global satellite monitoring of oceanographic phenomena and to help determine the requirements for an operational ocean remote sensing satellite system. Specific objectives were to collect data on sea-surface winds, sea-surface temperatures, wave heights, internal waves, atmospheric water, sea ice features, and ocean topography. The mission ended on October 10, 1978 due to a failure of the vehicle's electric power system. Although only approximately 42 hours of real time data were received, the mission demonstrated the feasibility of using microwave sensors to monitor ocean conditions and laid the groundwork for future SAR missions.

First digitally processed Image from Seasat-A's synthetic aperture radar shows a portion of the St Lawrence River near the city of Trois Rivières, Québec. The satellite passed overhead at an altitude of 800 km and the L-band radar antenna had a boresight angle of 20 deg from the nadir. The data was recorded at the Shoe Cove, Newfoundland satellite receiving station and was first processed in November 1978 by MacDonald, Dettwiler & Assoc. , Ltd , of Richmond, British Columbia. The image covers an area 38 km along the river by 41 km.

**Then** (Nov. 1978)


**A** Wayne Fung
**B** Pietro Widmer
**C** John Bennett
**D** Ian Cumming
**E** Robert Orth
**F** Pete McConnell
**G** Ron Fielden
**H** Doug Seymour
**I** Robert Deane

## Historical Significance

From the time that Carl A. Wiley of Goodyear Aircraft Co. introduced the synthetic aperture radar (SAR) concept in 1951, optical correlators based upon various combinations of exotic lenses and optical film had been used to reconstruct synthetic aperture radar imagery. While reconstruction could be accomplished in reasonable time using such techniques, the results suffered from various artifacts associated with slight physical imperfections in the optics and the limited dynamic range of the optical system. While the possibility of using digital technology to process SAR data had been recognized early on, the processing requirements greatly exceeded the capabilities of the general-purpose computers available to researchers in the 1950s and 1960s. The state of the art as of 1970 is summarized in [1].

At the same time, it had been recognized that a synthetic aperture radar carried by an orbiting satellite would offer many important advantages over airborne SARs. First, orbiting Earth observation satellites can achieve worldwide coverage with an ease that airborne platforms cannot match. Second, orbiting SARs are not buffeted by the atmospheric turbulence that shakes airborne SARs; the path they take through airless space is ultra smooth and highly predictable. These advantages are only partially offset by the reduced resolution and lower signal-to-noise ratio achievable with orbital SAR imagery due to their much greater height above the Earth's surface.

Tremendous advances in minicomputer technology during the early 1970s renewed interest in the possibility of placing synthetic aperture radar in low earth orbit and using general-purpose computers to produce high quality imagery from the downlinked data. NASA launched Seasat-A, the world's first orbital SAR, in 1978. Although it failed within 90 days of achieving orbit due to a power system defect, Seasat-A demonstrated the enormous potential of orbital SARs and ushered in three decades of

innovation that saw orbital SARs of ever increasing power and capability launched by NASA, the European Space Agency and the Canadian Space Agency.

Several teams competed to be the first to reconstruct a scene by digitally processing Seasat-A SAR data. However, the general-purpose minicomputers available to engineers in the late 1970s were only barely capable of supplying the enormous processing power required. It was widely expected that a large, well-funded team from NASA's Jet Propulsion Laboratory would prevail. Instead, a small, upstart team from Canada's MacDonald Dettwiler and Associates that had begun their task two years earlier won the race in November 1978 [2].

So significant was the accomplishment that this first image was featured in the 26 February 1979 issue of *Aviation Week and Space Technology* [3]. Details were reported at several conferences early in 1979 [4], [5]. In contrast, as recently as 1980, JPL was still reporting results that had been processed using the less capable optical techniques [6].

## Lessons Learned

MDA's accomplishment underscored a lesson that would be repeated many times as the digital revolution progressed. Other teams had access to the same Seasat data and similar general-purpose digital computers. However, it was the MDA team's careful mastery of algorithm design and software engineering that allowed them to win the race.

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MDA exploited their early success to become one of the most influential and prolific developers of digital SAR processing algorithms and digital SAR processors in the world. Teams at MDA developed three of the four common SAR processing algorithms in use today: Range/Doppler, Chirp Scaling, and SPECAN. MDA also developed the digital SAR processors used by such notable NASA, ESA and CSA programs as SIR-B, SIR-C, ERS-1, J-ERS-1, RADARSAT-1, ENVISAT and, most recently, RADARSAT-2 [7].

## A Turning Point in the History of SAR

The events of November 1978 marked a turning point in the history of synthetic aperture radar. Demonstration that data from spaceborne SARs could be digitally processed using general-purpose digital computers helped to dramatically reduce the cost of SAR imagery and make it much more widely available for civilian applications. Until 1978, military applications of SAR were predominant. Since 1978, civilian applications of SAR have assumed steadily increasing importance. The reputation that MDA earned from this accomplishment fuelled its rapid growth into the world's largest supplier of SAR processors and Canada's largest space technology company. ■

## References


[1] R. O. Harger, Synthetic Aperture Radar Systems: Theory and Design. Academic Press, New York, 1970.

[2] Herbert J. Kramer, Observation of the Earth and Its Environment: Survey of Missions and Sensors, 4th ed., Springer, 2002, p. 32.

[3] "Seasat Imagery Shows St. Lawrence," Aviation Week and Space Technology, 26 Feb. 1979. [Clipping Available Online.] http://rsl.ece.ubc.ca/AWST-Seasat-26Feb1979.png

[4] I. Cumming and J. Bennett, "Digital processing of Seasat SAR data," in Proc. IEEE ICASSP '79, Apr 1979, pp. 710-718. [Available Online.]

[5] John R. Bennett and Ian G. Cumming, "A Digital Processor for the Production of Seasat Synthetic Aperture Radar Imagery," LARS Symposia, Purdue Univ., 1979, Paper 316. [Available Online.] http://docs.lib.purdue.edu/lars_symp/316

[6] R. L. Jordan, "The Seasat-A synthetic aperture radar system," IEEE Journal of Oceanic Engineering, vol. 5, no. 2, pp. 154-164, Apr. 1980. [Available Online.]

[7] I. G. Cumming and F. H. Wong, Digital Processing of Synthetic Aperture Radar Data, Artech House, 2005. [Summary Available Online.]


**N.Ed.** This is IEEE Canada's 15th Milestone; details of previous Milestones can be found at: http://www.ieee.ca/history/milestones/index.html

For the IEEE Milestone program criterion, please see: http://ethw.org/Milestones:IEEE_Milestones_Program

Please contact the IEEE Canada History Committee Chair for further information: d.kemp@ieee.org

### About the Author


**David G. Michelson** is with the University of British Columbia, Department of Electrical and Computer Engineering in Vancouver, where he leads the Radio Science Laboratory. He currently serves as the Canadian Representative for Commission F (Radio Wave Propagation and Remote Sensing) of the International Union of Radio Science (URSI) and is Editor of the Wiley/IEEE Press Series on Vehicular Technology. He is a Member of the Boards of Governors of both the IEEE Communications and Vehicular Technology Societies, Corresponding Member of the IEEE History Committee, Member of the IEEE Canadian Foundation and Corresponding Member of the IEEE History Committee. He has championed more than one-quarter of Canada's IEEE Milestone recognitions. He can be reached at dmichelson@ieee.org