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Eye on Technology

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In This Issue...

Alouette 1: Engineering Feat, Scientific Success and now, National Historic Event of Canada

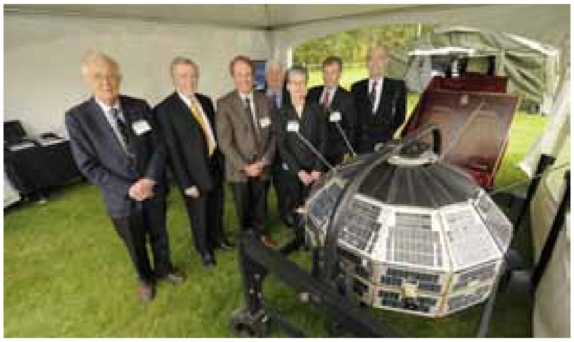
Dr. John Chapman and Dr. LeRoy Nelms toast the success of the Alouette 1 satellite in 1970 at the eighth anniversary of its launch (photo on left). Dr. Nelms and Dr. Colin Franklin recreate the 1970 photo with a toast at the 2010 event (photo on right). ***Photo: Janice Lang, DRDC Ottawa***

Satellite television, accurate weather forecasts, search and rescue... these are among the satellite-aided services we take for granted in 2010. But they were unimagined more than 50 years ago when a group of visionary research scientists and engineers proposed producing an instrument to "sound" the ionosphere from above. They ended up engineering and operating Canada's first satellite, Alouette 1, which is now recognized as a National Historic Event of Canada.

Mr. Ross Fines, President of the Friends of CRC (left) and the Honourable John Baird, Minister of Transport, Infrastructure and Communities and Member of Parliament for Ottawa West-Nepean (right) unveil the plaque commemorating the historic significance of the Alouette 1 Satellite Programme. ***photo: Janice Lang, DRDC Ottawa***

On May 12, 2010, the Historic Sites and Monuments Board of Canada unveiled a plaque commemorating the historic significance of the Alouette 1 Satellite Programme in a ceremony held at the Communications Research Centre Canada (CRC) in Ottawa. The satellite was largely designed, built and tested at the CRC's Shirleys Bay campus when it was home to the Defence Research Telecommunications Establishment. In fact, Alouette's success contributed to the creation of the CRC in 1969. Many of the pioneers gathered at the event became part of CRC and established its tradition of scientific excellence that continues today.

The event featured dignitaries, Alouette pioneers, their families, former colleagues, present day staff of Shirleys Bay campus, and Grade 7 students from Longfields-Davidson Heights Secondary School in Ottawa who bestowed celebrity status on the pioneers by asking for autographs.



Pictured with the commemorative plaque and the Alouette satellite prototype are, left to right: Dr. Colin Franklin, former Chief Electrical Engineer, Alouette 1 Satellite Programme; Dr. Robert Walker, Assistant Deputy Minister (S&T) and CEO, Defence R&D Canada; Dr. Steve MacLean, President, Canadian Space Agency; Mr. Ross Fines, President, Friends of CRC; Ms. Helen McDonald, Assistant Deputy Minister, Spectrum, Information Technologies and Telecommunications Sector, Industry Canada; Dr. John Jennings, Ontario Representative, Historic Sites and Monuments Board of Canada; and Dr. LeRoy Nelms, former Director, Defence Electronics Division, Defence Research Telecommunications Establishment.
photo: Janice Lang, DRDC Ottawa

Prior to the plaque unveiling ceremony, pioneers manned several exhibit tents where artifacts, photos and papers illustrated the story of Alouette 1. The centerpiece of the exhibit was the prototype of the satellite, generously loaned for the day by the

Alouette pioneer Don Muldrew (background) and CRC research engineer Hossein Najaf-Zadeh (foreground) examine an ionogram, or scan of the ionosphere.
photo: Janice Lang, DRDC Ottawa

Canada Science and Technology Museum (CSTM). Dr. David Pantalony, a CSTM curator, added to the explanation and interaction with school children, staff and other visitors.

Alouette pioneer Dr. John Barry (left) and Canada Science and Technology Museum (CSTM) curator Dr. David Pantalony (right) speak to school children and others about Alouette 1, aided by the prototype of the satellite.
photo: Janice Lang, DRDC Ottawa

Especially poignant was the presence of family members whose pioneer had passed away, including Mrs. Irene Mar, wife of the late John Mar, chief mechanical engineer for Alouette 1; the family of the late David Florida, after which the Canadian Space

Mrs. Irene Mar (centre), who travelled from Victoria, B.C., for the event, reminisces with Frank Vigneron (left) and Alouette pioneer Jim Moffat (right).
photo: Janice Lang, DRDC Ottawa

Agency laboratory is named; and John Chapman Jr., son of Dr. John H. Chapman, considered the father of Canada's space programme. Other adult children came, asking to meet a particular pioneer with whom their deceased dad worked closely.

For the pioneers, the event was a family reunion of sorts, given the long hours they shared in ensuring the satellite's success. Their sense of pride was palpable as they posed with the plaque.

Thirty-four of the Alouette pioneers celebrate the success of their achievement. ***photo: Janice Lang, DRDC Ottawa***

For more information on Alouette 1 visit *www.crc.gc.ca/alouette*.

Cyber crime fighters to converge on Ottawa

The Communications Research Centre (CRC) and Defence Research and Development Canada-Ottawa (DRDC-Ottawa) will co-host the 7th International Symposium on Visualization for Cyber Security (VizSec) on September 14, followed by the 13th International Symposium on Recent Advances in Intrusion Detection (RAID) from September 15 to 17, 2010.

On January 26, 2006, at approximately 8:00 a.m. EST, several U.S. security specialists sighted a new computer worm attached to e-mails coming from Russia. In what would turn out to be a prescient act, they dubbed the worm "MyDoom." By noon, the propagating MyDoom worm accounted for one-tenth of the e-mail traffic on the global Internet, eating up bandwidth and causing significant delays in data exchange. Two days later, 1 in 5 circulating e-mails were progeny of MyDoom. It wasn't until February 1, with an estimated 1 million computers infected, that MyDoom unleashed the second phase of its assault – an orchestrated denial-of-service attack against a specific high-tech firm.

Since MyDoom, there have been successive waves of highly contagious, pernicious malware designed to wrest control of residential and corporate computers and recruit them into botnets. The botnets – extensive, distributed networks of as many as 3,500,000 "zombie" computers – are then used by criminals to capture personal information, send e-mail spam, and steal digital records and passwords, among other illegal activity.

The cost of cyber crime to businesses is enormous. A 2009 survey of 800 chief information officers carried out by the computer security firm McAfee estimated a 4.6-billion dollar price tag attributable to data lost through malware infections, with an additional $600 million required to clean up after the security breaches. It is for precisely this reason, says Dr. Mathieu Couture, a network security researcher with CRC's Broadband Network Technologies group, that landing two prestigious cyber security conferences here in Canada is a major coup for the Canadian business and IT security communities.

This autumn, the Communications Research Centre (CRC) and Defence Research and Development Canada-Ottawa (DRDC-Ottawa) will co-host the 7th International Symposium on Visualization for Cyber Security (VizSec) on September 14, followed by the 13th International Symposium on Recent Advances in Intrusion Detection (RAID) from September 15 to 17, 2010. The conferences will be held in downtown Ottawa, and will bring together leading researchers along with security personnel in charge of computer and network security, and technical staff looking for the latest in security solutions. A planned technology-showcase will also give Canadian and international companies an unprecedented opportunity to display the newest developments in cyber security.

"RAID alone usually draws over 150 academic, industrial and governmental participants from around the world," says Frédéric Massicotte, CRC network security researcher and general chair of RAID 2010. This size, combined with the academic/industry mix, gives all participants the opportunity to make connections and seek out collaborations and partnerships with leaders in the cyber security field.

Traditionally, the location of RAID alternates between Europe and the U.S. This year's RAID 2010 will be the first time that the conference has been held in Canada.

"We were truly honoured," says Massicotte, "to have been chosen to host the conference." Research laboratories, he says, compete to play host, and past hosts include MIT, Carnegie Mellon University, and IBM. Putting CRC and DRDC in such illustrious company, however, doesn't come as a complete surprise.

CRC, explains Massicotte, became widely known for intrusion detection research when the lab developed a tool called the Automatic Experimentation System (AES). CRC researchers used the tool to generate a data set of computer-attack "traffic traces." These traffic traces record the network activity that occurs when an "exploit" is in the process of assaulting a computer. Exploits are essentially hacker tools, small pieces of open-source computer code designed to take advantage of some vulnerability in the computer or network software. Like a hammer used by a burglar to break a basement window, exploits are tools used to gain access though a vulnerable route. They then allow the virus or malicious code to enter the system and carry out its intended goal.

CRC's traffic traces, says Massicotte, have been used worldwide by research teams studying intrusion detection, providing them with invaluable information on how software products react when under attack, and therefore what can be done to detect these attacks. And the traces developed in the initial AES work are still in use today.

The laboratory's current work, says Couture, builds upon the initial traffic-trace work, but now focuses on the more complex and rampant problem of malicious software, also known as malware.

"The difference between working with exploits and malware is that with exploits, you know what you're downloading. You know what they're designed to do. With malware, you have no idea. You just know that it's probably going to be really nasty."

One of the challenges in working with malware, he says, is to provide it with a network environment rich enough to let it "show its stuff" while at the same time, ensuring the infected machines and network are fully isolated from any external computers or external network access that could allow the malware to spread.

"To carry out its attack a piece of malware may need, for example, an IRC [Internet Relay Chat] server, or it may need access to Twitter or Facebook. It's hard to mimic that on an enclosed, isolated system, but because of the destruction malware can cause, we have to protect other computers and the network from being infected by this code."

To get around the problem, the laboratory is using the AES tool to simulate a real network made up of virtual computers and virtual connections. With over one-million malware programs to study, the virtual network will provide researchers with invaluable information on malware attacks. It will also, says Massicotte, help industry security specialists deal with malware infections.

"If we can use AES to rapidly analyze malware samples, this will help network security companies reduce their reaction time when a new piece of malware makes its appearance," says Massicotte.

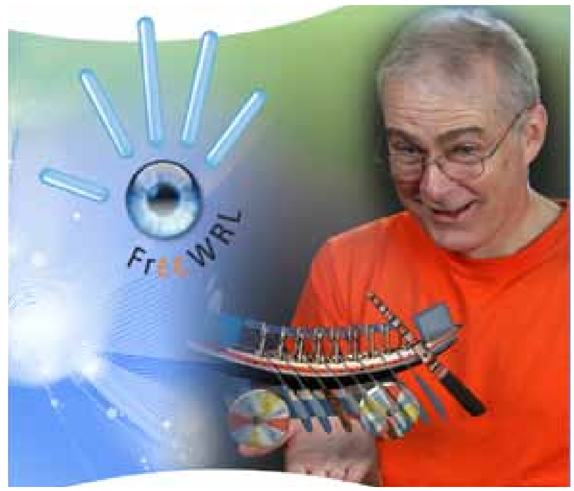
More information on RAID can be found at *www.raid2010.org.* For VizSec see *www.vizsec2010.org*. Frédéric Massicotte can be contacted at *frederic.massicotte@crc.gc.ca* or (613) 998-2843.

Coming soon to a computer near you: interfacing with the Web in 3D

With Avatar a box-office hit and the Consumer Electronics Show displaying 3D televisions, a 3D interface with the Web cannot be far off, correct? Communications Research Centre (CRC) computer network researcher John Stewart sheds some light on the future of the Internet and the role that open standards will likely play in that future.

Stewart is CRC's representative on the Web3D Consortium (www.web3d.org), which has contributed to the evolution of the Internet over the years by writing the computer language and defining the standards to render 3D graphic content. The original virtual reality mark-up language (VRML 1), developed in the mid-1990s, was followed by VRML 97 and later by extensible 3D (X3D) graphics. All have been adopted by the International Standards Organization (ISO).

Today, Stewart is chair of the Web3D Consortium's X3D-HTML5 working group, which is working to integrate X3D – ISO standardized 3D graphics, and HTML – the hyper text mark-up language that "tells" the Web browser certain text is a heading, other text is body text, and a myriad of other features that define the "look" of a page.



Users of FreeWRL "reconstructed" this 3D likeness of a sunken vessel, shown here with CRC computer network researcher John Stewart.

Multi-cast conferencing enhanced with virtual reality

When Stewart joined the CRC in 1996, he was involved in projects funded by the European Commission involving multi-cast conferencing over the Internet. From their respective offices participants contributed via video, audio and a shared whiteboard. As it turns out, the "meat" of the meetings was in the whiteboard record; the video added little and the audio lacked the flexibility to allow sub-groups of participants to confer, as they could in a real meeting. Stewart proposed dropping the video component and replacing the audio capability with virtual world technology he was advancing at the time. FreeWRL 3D Graphics and MVIP-II networking produced proximity-based audio, so that a participant could approach fellow participants and have a conversation apart from the whole-group proceedings that were unfolding on the whiteboard.

Integral to virtual reality is 3D graphics and Stewart's multi-cast conferencing experience told him where the trend was heading. The momentum toward more powerful and cheaper computer graphics will see consumers using 3D graphics to interface seamlessly with computer networks, he predicted.

The standardization process and evolution toward 3D in HTML

The Web3D standardization process requires at least two implementations of any element in a working X3D viewer before it becomes standardized. One of those viewers has to be open source. FreeWRL, the open source software Stewart shepherded, provided the perfect fit. Distributed by Apple, FreeWRL is downloaded, on average, 3,000 times a month. From viewing models of DNA to models of the International Space Station, FreeWRL has been used to render data for countless applications.

But viewing a Web page through an HTML browser like Firefox or Internet Explorer requires a plug-in to read a postscript file.

"Currently, Web browsing is all done in 2D graphics – click a button or image and text gets 'redrawn' on it. You cannot walk up and look around [an object] with fixed pictures," explains Stewart. "With X3D as part of your Web page viewer, it's no longer a plug-in, so the whole interface for your Web browser can be written in X3D."

"If we are able to successfully include open standard 3D graphics with every Web browser – and we are – the ideas that CRC helped standardize will be in every networked device worldwide," says Stewart.

The HTML 5 standard should be finalized in early 2010, but Stewart expects it will some time for all browser writers to include X3D.

For more information contact John Stewart, Computer Network Researcher at *alex.stewart@crc.gc.ca* or at 613-998-2079.

MEOSAR – removing the search from search and rescue

Every year, search and rescue crews from St. John's to Victoria to Nunavut are called into action at the news of a distress signal received from an emergency beacon. Over the past 27 years, the COSPAS-SARSAT (C-S) system has helped save over 27,000 people worldwide. But what few Canadians know is that our country is a world leader in the design and development of search and rescue satellite-aided tracking (SARSAT) technology.

While Canada's contribution to the international COSPAS-SARSAT system is coordinated by the National Search and Rescue Secretariat, much of the R&D is carried out by the Communications Research Centre (CRC). Work now in progress at the CRC is paving the way for a next-generation C-S system with capabilities far beyond what currently exist.

"In the C-S system," explains CRC's Richard Paiement, engineer and project leader in the Satellite Systems Research division, "satellites pick up signals from radio beacons that are triggered by an emergency." The satellites then relay the signals to a ground station. From there, the information is sent to a mission control centre, then on to the local rescue coordination centre.

There are two types of satellites in the current system. Four low Earth orbit (LEO) satellites form the backbone of the search and rescue system. Orbiting at an altitude of approximately 850 km, they receive and relay the emergency beacon's signal. Because these satellites move relative to the position of the beacon, ground station operators are able to use the shift in the received frequency (Doppler shift) that occurs as the satellite moves across the sky to calculate the location of the emergency beacon. But, says Paiement, because LEO satellites orbit so close to the Earth, they have a small footprint.

Poster commemorating the 30th anniversary of the signing of the COSPAS-SARSAT Memorandum of Understanding.

"They 'see' only a small patch of the planet at any given moment, an area with a radius of about 3000 km."

While this may sound vast at first glance, if you're adrift on a disabled vessel somewhere between Vancouver and Hong Kong, this is a small window indeed. The problem is compounded, says Paiement, by the fact that LEO satellites move at approximately 26,750 km per hour, giving them about a 15-minute view of any particular area. So, if your beacon was triggered just after the 15 minutes when you were within the satellite's range, it could be hours until another satellite passes over your location. Several hours stranded in Arctic conditions or injured on the side of a mountain can be the difference between life and death.

To overcome constraints posed by LEO satellites, geostationary Earth orbit (GEO) satellites were added to the C-S arsenal in the 1990s. These high-altitude satellites orbit directly above the equator,

COSPAS-SARSAT Celebrates 30 Years

The 30th anniversary of the signing of the COSPAS-SARSAT Memorandum of Understanding (MOU) was marked in October 2009 in Montreal. In the mid-1970s, the Department of National Defence (DND) asked the CRC to explore the use of satellites to aid in search and rescue. Nations conducting similar research joined forces: France and the United States signed the SARSAT MOU with Canada in 1979, and the former Soviet Union with its COSPAS initiative, came on board later that year, resulting in the COSPAS-SARSAT program. COSPAS-SARSAT now involves 40 countries.

"What started out as an innovative concept on the part of CRC engineers and scientists turned, within a few short years, to a very successful operating system that has resulted in saving numerous lives," said Dr. Bert Blevis, then CRC Director General of Space Technology and Applications, and head of the Canadian delegation at negotiations that resulted in the COSPAS-SARSAT agreement.

In 1995, Dr. Blevis as well as other scientists and engineers from CRC received an Alouette Award from the Canadian Aeronautics and Space Institute for their contributions to the success of the COSPAS-SARSAT Program.

The program is also a technology transfer success story. DND delegated responsibility for all technical aspects of the Canadian portion of the international program to the CRC. Hardware development and equipment procurement were contracted out, positioning Canadian industry to capitalize on this new market. To date, the program has generated over $100 million in sales revenues for Canadian companies, an achievement that garnered the Canadian SARSAT team a Federal Partners in Technology Transfer Award in 2008.

"It is rewarding to see that research and development done at CRC over 30 years ago is still being used today, and we are carrying it forward as we build the next generation satellite system with our international partners," said Jim King, who now works part-time on the COSPAS-SARSAT program at CRC, after retiring as Director of CRC's Major Satellite Communications Program.

moving in synchrony with the Earth. A GEO satellite positioned over Brazil, for example, will remain over Brazil as the Earth rotates through its day/night cycle. Because they orbit at about 36,000 km above the Earth, GEO satellites have a huge footprint. They can, says Paiement, instantaneously detect and relay a distress signal from an area covering slightly more than one-third the surface of the Earth, and because they move in synchrony with the planet, they are always “watching” a specific area.

They have, however, several downsides. GEOs are unable to “see” the poles, leaving much of the Arctic and Antarctic without service. Also, mountains or other obstacles may block the satellite’s view of the beacon. Finally, because GEO satellites maintain a steady position over a portion of the Earth, they don’t move relative to a signalling beacon. With no Doppler shift to provide additional information, GEOs can readily detect a distress signal but are unable to help in determining the beacon’s location.

To overcome the combined limitations of LEO and GEO satellites, search and rescue organizations are now working to recruit MEO satellites into the search and rescue effort. MEO – medium Earth orbit – satellites orbit between the LEO and GEO satellites. If you use a GPS receiver in your car, you’re already making use of MEO satellites in your everyday life. Unlike the LEO satellites, MEO satellites have a substantial footprint – a radius of over 14,000 km– and their 20,000 km altitude gives them a view time of a few hours from a given ground location, rather than the brief 15 minutes of a LEO satellite. And, says Paiement, a constellation of several MEO satellites brings a huge added bonus.

“When a distress beacon is triggered it repeats its signal every 50 seconds. With a constellation of MEO satellites, there is usually enough information in two to three bursts [repeats] to determine the beacon’s coordinates. Often it can be done in a single burst. That means that within a few minutes we can locate the beacon’s position.”

Currently, says Paiement, Europe, Russia and the U.S. all have plans to launch constellations of navigation satellites in MEO with search and rescue transponders aboard to form the MEOSAR system, and by 2018 one or more of these constellations should be fully operational. But, says Paiement, while the use of MEO for search and rescue holds tremendous potential, there are significant issues to resolve before depending on them to save lives. For example, his division is working on the satellite tracking problem.

“Given current launch plans, there may be 12 or more MEO satellites ‘in view’ of a single ground station, but that station may, for example, only have four antennas, so it can only track four of those satellites. And that constellation of satellites is changing all the time as these satellites speed across the sky. Ground station operators need to know which four satellites to track. In other words, which four satellites will give them the most precise location information if a distress beacon starts transmitting in their area of responsibility? We’re developing an algorithm to make these kinds of decisions.”

In addition to the work being done by Paiement and his colleagues, CRC has also set up an experimental tracking station able to collect distress and test signals from experimental MEOSAR and operational GEOSAR satellites. CRC engineers and scientists are using the test facility to devise, among other things, advanced signal processing techniques for improving both the detection and location of beacons, as well as develop tools to monitor satellite traffic and to locate and identify sources of interference.

With the help of work being carried out at CRC, by 2013, when the first operational MEOSAR satellites are launched, Canada will be ready to harness their lifesaving potential.

For more information contact Richard Paiement, engineer and project leader in the Satellite Systems Research division, at 613-998-2861 or *richard.paiement@crc.gc.ca*.

CRC Innovation Centre filled to capacity

Not since the high technology boom in the late 1990s has the Communications Research Centre's (CRC) Innovation Centre been bursting at the seams. The start of 2010 sees the Centre once again filled to capacity as technology start-ups in the communications field capitalize on what the facility has to offer: access to cutting-edge technologies, R&D expertise and world-class facilities.

To qualify as an Innovation Centre client a company must first receive a letter of endorsement from a CRC research group to underwrite their residency in the program. As a prerequisite, CRC must establish that there is R&D interest in following the company's work, if the company requires access to CRC's unique laboratory facilities and expertise of a research team.

The Millennium Building, which opened in 2000, is home to CRC Innovation Centre clients.

Kevin Shackell of CRC's Technology Transfer Office has managed the Innovation Centre since 2008. He notices that most companies are starting smaller and not growing as quickly. Lack of venture capital has created a trend toward "micro" companies which are largely bootstrapped by private funding and customer cash flow. This new reality of the marketplace has prompted CRC to reconfigure the total space (just under 750 m^2 or 8000 $ft.^2$) to accommodate smaller companies that only want to lease smaller office and lab spaces of 100 to 300 $ft.^2$ to start out. A cross-section of the companies is profiled below.

Innovation Centre clients

Protecode's expertise is in tracking code – whether it be third party, internal or open source – to assist clients in determining if and where others are using their code or vise-versa, thus providing clients with an efficient way to manage compliance. CRC's Advanced Radio Systems group, research sponsor of Protecode, worked with the beta version of the company's software to test it.

"The Software Defined Radio project of CRC's Advanced Radio group has a technology leadership position, witnessed by the wide distribution of its software code to government, commercial and academic organizations worldwide," says Mahshad Koohgoli, CEO of Protecode. "Protecode's Intellectual Property Management solutions ensure clarity of IP ownership, and awareness of licensing and copyright obligations, in the sophisticated applications created by CRC's Advanced Radio Group."

A recent addition, Indusface Consulting specializes in information security services, from assessing client needs, to identifying vulnerabilities and providing tools to manage threats. Indusface Consulting is sponsored by CRC's Network Systems group, which researches network security threats.

"Their 'security from the cloud' approach to Web security assessment is of interest to us," says CRC's Mathieu Couture, network security researcher. "Having a group of experts on the subject in close proximity can bring an interesting complement to certain aspects of our research."

Vital Alert is the only company licensed to use patented "through-the-earth" communications technology, which employs very low frequency (2-4 kHZ) electromagnetic waves to enable wireless communication in tunnels, underground sewage pipes, mines and similar difficult environments. Vital Alert is working with CRC researchers who developed communications techniques for mine rescue communications.

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"Very low frequency communication presents some very difficult engineering problems," says Vital Alert's Heather Simmons. "We look forward to working with the top notch scientists at the CRC to solve these inherent distance, bandwidth and weight issues."

Gain Microwave specializes in the design of high performance gallium nitride (GaN) electronic components. Gallium nitride is a wide bandgap, compound semiconductor, with a number of inherent material properties that make it very attractive for designing and manufacturing high performance, robust, electronic components. Gain Microwave's GaN devices and monolithic microwave integrated circuits (MMICs) are ideally suited for application in the wireless infrastructure, space, aerospace and military sectors.

According to Gain Microwave, the value of CRC is threefold: knowledge, capability and infrastructure. On the knowledge and capability front, CRC's expertise spans the spectrum from advanced components to leading-edge system and network applications. On the practical level, Gain has benefited from access to CRC's expertise in RF components and systems, RF test and measurement capability, and comprehensive prototyping capabilities. CRC's Integrated Electronics Research group, led by Valek Szwarc, sponsors Gain's residency in the Innovation Centre.

The newest resident, GSTS is licensing elements of Spectrum Explorer®, CRC's suite of radio frequency spectrum monitoring and surveillance technologies that help ensure reliable communications. GSTS will be integrating some Spectrum Explorer® technology into a commercial product offering that the company is in the very early stages of developing.

Since its inception in 1994, the CRC Innovation Centre has hosted over 50 companies, commercialized many CRC technologies and helped fuel SME innovation in Canada's information and communications technology sector.

For more information contact Kevin Shackell at 613-998-0138 or at *kevin.shackell@crc.gc.ca*.

CRC on Parliament Hill

The Communications Research Centre (CRC) participated in S&T Day on Parliament Hill, along with many other federal science departments, on October 19, 2009. The CRC demonstrated some of its world-renowned research initiatives, including the Search and Rescue Satellite Aided Tracking (SARSAT) program, 2D-to-3D video conversion technology, the Health Services Virtual Organization (HSVO) platform and the Spectrum Explorer® spectrum monitoring system.

Minister of State (Science and Technology), the Honourable Gary Goodyear (right), speaks with Claude Bélisle, Vice-President of CRC's Satellite Communications and Radio Propagation Research branch (centre) and Charles Benoît, Research Engineer, Communications Signal Processing (left) about CRC Spectrum Explorer®.

***Photo**: Janice Lang, DRDC-Ottawa*

CRC's mission is to be the federal government's centre of excellence for communications R&D, ensuring an independent source of advice for public policy purposes. CRC also aims to help identify and close the innovation gaps in Canada's communications sector by:

- *engaging in industry partnerships;*
- *building technical intelligence;*
- *supporting the information and communications technologies industry.*