Communications Research Centre Canada
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Centre de recherches sur les communications Canada
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Eye on Technology

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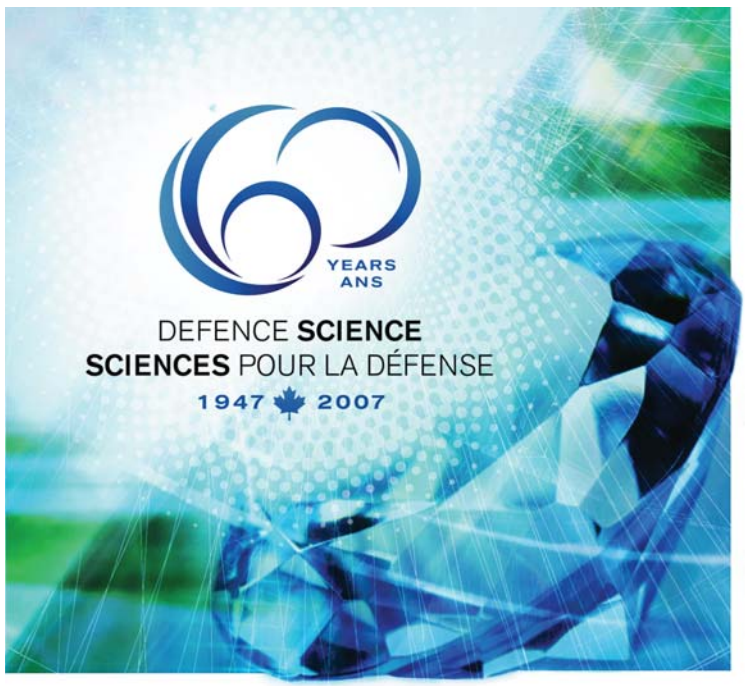
In This Issue...

Celebrating 60 Years of Defence Science in Canada



The traditional book of etiquette dictates that diamonds are the symbol of 60 years of marriage. The jewel also seems a fitting icon to represent the 60th anniversary of defence science in Canada, dating back to the establishment of the Defence Research Board (DRB) in 1947.

Like a diamond in the rough, the Communications Research Centre Canada (CRC) evolved from the original DRB to become a sparkling gem in the field of Canadian telecommunications. This year, Defence Research and Development Canada (DRDC) is recognizing both CRC and the National Research Council (NRC) as key partners as we collectively pay tribute to the advancement of Canadian defence science through nine months of special events and activities.

DRDC applauds CRC not only as a part of the original DRB, but also for its significant contributions to the design and fabrication of satellites and the advancement of wireless technologies. Just like a multi-sided diamond, there are a variety of major milestones achieved through CRC's research and development efforts that have put Canada on the map for its expertise in the field of advanced communications technology. These milestones or technologies generally fall into two main categories – civilian applications and military applications.

Civilian Applications

In the late fifties and early sixties, the then-Defence Research Telecommunications Establishment (DRTE) spearheaded the **Alouette** satellite program, making Canada the third country in the world to have a satellite in space. In the wake of Alouette's success, the government expanded communications for civilian purposes, and the CRC was formed.

Later, CRC and the then-Defence Research Establishment Ottawa (DREO) worked together on **Search And Rescue Satellite-Aided Tracking (SARSAT)**. The project involved not only several federal departments, but multiple international players – the United States, France, the Soviet Union as well as Canada. With common specifications and agreement to share each other's satellites, the SARSAT system has helped save many thousands of lives since its launch in 1982.

To read more about the CRC's latest work with SARSAT, see "*CRC Scores a Satellite 'Hat Trick'*" in Issue 6 of Eye on Technology.

Spectrum Explorer (SE) is another renowned CRC technology with civilian applications. A combination of open software and hardware architectures, SE is used to assess the use and quality of radio spectrum. With development continuing since 1993, SE is now deployed across the country by the regional offices of Industry Canada. In addition to using SE to manage Canada's radio spectrum, Industry Canada's radio inspectors have supported the police by using SE to provide radio surveillance for events such as the Summit of the Americas in Quebec City in 2001, the G20 Summit in Ottawa in 2001, the G8 Summit in Kananaskis, Alberta, in 2002, and more recently the North American Leaders' Summit in Montebello, Quebec, in August 2007.

For more information on the newest version of Spectrum Explorer, see "*Spectrum Explorer: Monitoring the Pulse of Canada's Communication System*" in Issue 4 of Eye on Technology.

The CRC and DRDC share another technology milestone that is often overlooked – Canada's first connection to what would eventually be known as the Internet. In the spring of 1985, CRC and the Department of National Defence participated in a ceremony to open the **Canada/ARPANET gateway**, becoming the first network terrestrial connection to the existing ARPANET from outside the United States. This Canada/ARPANET connection and research activities evolved into Canada's first and longest standing national TCP/IP network (the DRENet). The gateway, installed over 20 years ago and used under the supervision of CRC's Dr. J.L. Robinson, was one of the key research building blocks for the future of IP networking in Canada. The network research conducted in 1985 and afterward formed the basis for many subsequent technology areas, such as audio/video applications, CRC's BADLAB and VirtualClassroom, wireless and satellite network communication technologies.

For more information about the ARPANET, visit the CRC Web site.

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Military Applications

CRC's research responsibilities have not been strictly civilian; some programs of the then-DRTE were adopted by CRC. While the military's communications research needs have evolved over the years, DRDC remains one of CRC's major clients today.

The **Military Digital Analysis System (MiDAS)*** is the military version of Spectrum Explorer (SE). It uses the SE technology as the core and augments it with additional capability for signals of military interest. Like SE, MiDAS has also attracted favorable attention and is a key part of the TDP (Technology Development Program) ICEWARS project for the Canadian Army. DRDC Ottawa, with assistance from CRC, has developed a specialized prototype MiDAS system and provided it to the U.S. Marine Corps Systems Command for $1.5 million USD.

Current requirements for military communications R&D include interoperability of communications networks, quality of service, network security and high-capacity wireless systems. The High Capacity Tactical Communications Network (HCTCN) is an example of a partner project between CRC and DRDC. The goal of the HCTCN is to develop an improved tactical radio communications system to meet current and future military requirements. An experimental system, the HCTCN aims to provide several key improvements while optimizing the flow of data and voice information within bandwidth-constrained wireless networks.

For more information on the HCTCN, see "*CRC Radio Project to Improve Military Communications*" in Issue 5 of Eye on Technology.

The **Directorate Land Command Systems Program Management (DLCSPM)** is another joint initiative between CRC and the Department of National Defence (DND). The project evolved when Canada's Land Forces needed to evaluate new wireless communications technologies to fill specific secure broadband wireless needs. CRC's Wireless Applications and Systems Research group (WASR) are involved in the investigation of a potential application called the Joint Tactical Radio Systems (JTRS) Soldier Radio Waveform (SRW), 802.16 WiMAX Broadband Wireless Communications Systems, as well as wireless communications within vehicles. One of the goals of these evaluations is to put advanced communications capabilities into the hands of soldiers, rather than into vehicles, thereby moving towards a network-centric future.

For more information on the evolution of CRC, as well as DRDC's campaign "*Celebrating 60 Years of Defence Science in Canada*", please visit DRDC's Web site.

* This system is now called *radio*Spectrum Warrior.

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Radio Propagation: Powering Communications Then & Now

If you're a regular user of a wireless phone, chances are you've experienced the frustration of a "lost" call or a conversation with poor reception. What you might not realize is the connection between your phone's signal and an important area of advanced communications research known as "radio propagation".

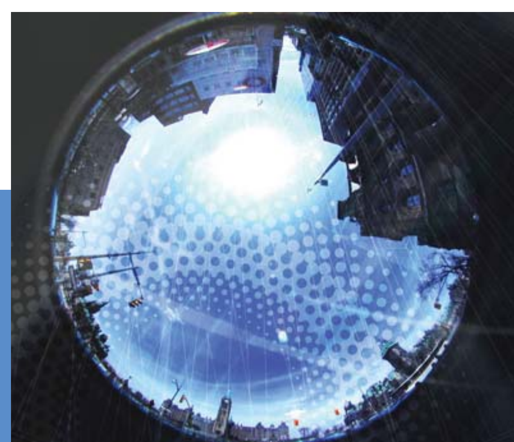
Radio propagation research focuses on the interaction between radio waves and the physical media in which they travel (see below for further details). This is the scientific concept behind the functionality of wireless phones, as well as countless other wireless communications technologies. Over the past two decades, the demand for and dependency on such wireless products, services and networks have grown astronomically. According to the Canadian Wireless Telecommunications Association (CWTA), Canadian wireless phone subscribers numbered 19.5 million at September 30, 2007, representing a national wireless penetration rate of more than 60 per cent.

As traffic load in wireless networks increases, there is a need to improve how the radio spectrum is used by these technologies. The Communications Research Centre Canada (CRC) is exploring ways to improve system reliability and techniques to overcome adverse propagation effects.

CRC is a long-time leader in radio propagation research. As it joins Defence Research and Development Canada (DRDC) in celebrating "60 Years of Defence Science in Canada", it is noteworthy to recognize that CRC's beginnings in radio propagation date back to grassroots R&D efforts.

A Snapshot of History

Canada had a modest start in propagation research, made by the National Research Council (NRC) during the 1930s. Wartime requirements for communications resulted in a substantial expansion and acceleration of that work. Commissioned by the Royal Canadian Navy in support of its anti-submarine campaign, an ionospheric sounder was installed in Chelsea, Quebec, in 1941, to study the conditions affecting the transmission of radio waves.



Statistics generated from this "fisheye" photograph of downtown Ottawa are used to identify whether or not a signal path is obstructed by foliage, terrain or buildings. Compiling statistics on such images assists in designing an optimal mobile satellite system.

What is radio propagation research?

Radio propagation research focuses on the interaction between radio waves and the physical media in which they travel. The troposphere and ionosphere affect radio waves in a variety of ways – they can absorb, scatter, bend, reflect, depolarize, delay or offer several paths to radio waves. These possibilities must be considered in the design of communications systems, as well as in the development of spectrum policy and spectrum management. In the case of developing a large-scale application, service providers can benefit from using the CRC-PREDICT software used to estimate the strength of radio signals that cross terrestrial paths.

When the war concluded in 1945, the importance of propagation research for peacetime communications was recognized, but its close ties to operational needs made a long-term future within NRC unlikely. A small unit known as the Radio Propagation Laboratory (RPL) continued the work, and was moved to a building on the Prescott Highway just outside of Ottawa in 1947. Following the formation of the Defence Research Board (DRB), the RPL became an integral part of that organization.

The CRC would later evolve from the Defence Research Telecommunications Establishment (DRTE), which existed from 1951-1969 as part of the DRB. In 1969, the federal government established a Department of Communications. The DRTE in its entirety was transferred to the new department's research branch, and renamed the Communications Research Centre Canada.

What is CRC doing today?

With nearly 40 years of experience, CRC has inspired a number of applications for communication systems design and spectrum management and is recognized today as one of the world's leading radio propagation research organizations. CRC's R&D program has been translated into many successful commercial applications, such as the design of cell phone systems and broadcasting networks. Through its technology transfer program, CRC has licensed various elements of its Intellectual Property (IP) to major companies such as CTS International (France), LS Telcom (Germany), and Fox Broadcasting, and to many Canadian SMEs. Among other major users are Industry Canada (for spectrum management and licensing), DND, and the Swiss Federal Office of Telecommunications.

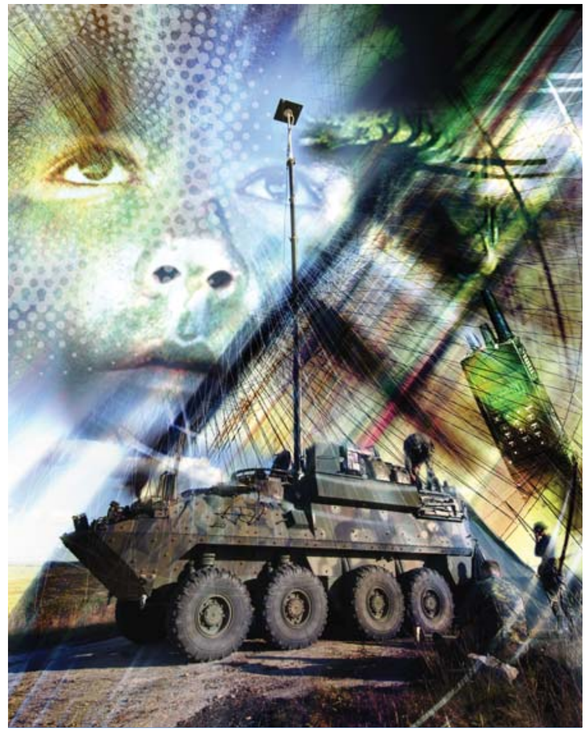
One of the most successful CRC-developed applications is CRC-PREDICT, a unique software package for estimating radio signal strengths on terrestrial paths at VHF and UHF (30 MHz to 3 GHz). CRC-PREDICT accounts for terrain and obstructions (foliage, buildings, etc.) on transmission paths, and is considered to be one of the most accurate prediction models available for these applications. It has been successfully licensed in Canada and worldwide for a number of applications, including land mobile planning, broadcasting and broadcast licensing, point-to-point relays and interference studies.

CRC-PREDICT is an excellent tool for service providers implementing a large-scale application, such as a cell phone company that needs to determine the best location for its base stations. CRC's Broadcast Technology branch has also incorporated the algorithm into several software suites developed mainly for broadcasting applications. Another recent example of CRC-PREDICT in action is an interference assessment conducted by a Montréal-based company. By using CRC-PREDICT as the engine in its in-house models, the company was able to generate detailed estimates of the likelihood of interference to television broadcast services from windmill-energy farms, an issue of concern to Radio-Canada and other service providers.

CRC also has an extensive record of research in Earth-space (satellite) propagation, dating from pioneering work on the fading experienced on paths at very low elevation angles (an early DND concern for Arctic communications with geostationary satellites). One recent project involved evaluation of the severe propagation impairments that occur in tropical climates, due to large storms and heavy rainfall. This study was performed in collaboration with research partners in France, Italy and Brazil, and was funded by the European Space Agency. Perhaps surprisingly, CRC has performed a variety of tropical propagation studies on behalf of several clients, including DND, Industry Canada and CIDA, and has a good reputation in such endeavours. Just as for terrestrial services, mobility is a requirement for many satellite applications. Fisheye photographs (see figure) are used to quantify the probability that a path to the satellite will be available for mobile system users in different environments (urban, rural, etc.).

CRC also plays a government-mandated role in the provision of information required for spectrum management. Some of the R&D results have influenced spectrum policy actions and have been adopted in standards venues on the world stage, such as the International Telecommunication Union (ITU).

As wireless products, services and networks become increasingly interwoven in the social and economic fabric of Canada and around the globe, it is clear that the demand for R&D efforts that advance these developments will only increase with time. With its rich history of radio propagation research, CRC is a uniquely-placed organization that will continue to contribute its capabilities to the Canadian industry, government and research partners the world over.



The military's need for faster, more efficient and easier-to use communications is rapidly exceeding the capabilities of the currently deployed low-bandwidth wireless networks, which use relatively low bit rate waveforms for transmission. CRC is developing a family of VHF/UHF waveforms that are helping radio developers overcome these challenges.

CRC Technology Aims to Bring Better Communications to the Battlefield

The Communications Research Centre Canada (CRC) is developing a family of radio signal processing products capable of supporting more robust applications and higher performance communications for soldiers on the battlefield. The technology is ideally suited for next-generation radios operating in rugged environments, including urban areas.

The military, just like your average cell phone user, isn't content with just voice anymore. They need high-performance tactical radio communications systems that provide real-time data and internet-like applications. The United States, Canada and NATO are all working towards what's called the 'networked battlefield'; that requires more capable communications waveforms.

The research is part of CRC's work to develop technologies for improved tactical radio communications systems, in collaboration with Defence R&D Canada (DRDC). Such systems aim to meet the military's increasing demand for data transmission in the field – demands that are rapidly exceeding the capabilities of existing low-bandwidth wireless networks, which use relatively low bit rate waveforms for transmission.

A key element of the work is the development of a family of Very High Frequency (VHF) waveforms, using advanced signal processing techniques. The new waveform provides several key improvements, including higher data rates than currently available within power-limited and bandwidth-constrained systems, and the opportunity for integration of voice and data within wireless networks.

For soldiers on the battlefield, these new waveforms will provide extended-range capability through network relaying and more robustness against interference. It will significantly improve their ability to operate in these environments over the existing technology.

Waveforms can be added to commercially available wireless modem platforms, reducing the time it takes to move new products onto the market. As part of a strategy to make these available, Burnaby BC-based Spectrum Signal Processing by Vecima announced plans in October to offer one of CRC's current waveform implementations to clients who need this capability on Spectrum's flexCommTM SDR-4000 wireless modem.

The CRC implementation, which is compatible with the U.S. Department of Defense's MIL-STD-188-181B military standard, operates using narrowband 5 KHz and 25 KHz channels, which enables efficient use of power and maximizes the range of communications.

This isn't the first time Spectrum has collaborated with CRC. The company's SDR-4000 radio transceiver also incorporates CRC's SCARI Software Suite 2007, which together provide a development platform that enables radio manufacturers to accelerate the rollout of Software Defined Radio (SDR). SDR is ideally suited for military use because it can receive and transmit a new form of radio protocol simply by running new software.

Having both technologies available on this platform means that users can request a modem with this particular waveform that could, in the future, be readily ported to be compliant with the SDR Software Communication Architecture (SCA) standard, which is a requirement in the U.S. under its Joint Tactical Radio System (JTRS) program.

Thinking for Themselves: CRC Develops "Smart" Networks

Picture the do-it-yourself investor at the home computer, managing his stocks online. Everything looks status quo; our aspiring millionaire takes a sip of lukewarm coffee while sleepily continuing to browse the financials. Suddenly, something makes him sit up straighter, fully opening his eyes. Could it really be…? Yes, the day has arrived…it seems the underdog upstart on the TSE has finally made it. Stocks are soaring and it's time to sell! Fingers poised on the keyboard, our hero goes to make his move. Time is of the essence. The transaction is nearly completed and…WHAM! Connection failed. How could this be?

As it turns out, a neighborhood construction project has taken a wrong turn and mistakenly cut a critical fibre to the network. The result is a termination of Internet access to all subscribed homes and businesses within a 10km radius. For our investor, not only is the Internet connection down, so too is his net worth. While this sequence of events arguably doesn't present severe consequences, there are many situations in which network reliability is extremely critical. A sudden lack of service to a hospital's online network, for example, could potentially put human lives at stake. As we increasingly rely upon networks in our day-to-day lives, there is a corresponding demand for improved reliability.

At the Communications Research Centre Canada (CRC), a small group of specialized researchers are dedicated to the study of Broadband Applications and Optical Networks. Currently, this research team is working to develop the Autonomous Intelligent Reconfigurable Optical Network (AIRON), a unique network that responds automatically to changes, correcting deficiencies that have, till now, relied on human intervention. For example, a weakening signal within a network would be intuitively detected and amplified before it disappears. In addition, the network would offer a tracking system for deteriorating components, so the system could be upgraded before a network breakdown.

The economic benefit of a network such as AIRON would be a significant reduction in operating costs, due to the autonomous nature of the network. The number of staff employed to respond to network changes and implement upgrades could be greatly decreased.

To date, researchers at CRC have partnered with industrial collaborator Inocybe Technologies and researchers at Carleton University and the University of Ottawa to develop a fully functional AIRON testbed. This will enable research and development activities in automatic network reconfiguration, dynamic wavelength routing, lightpath provisioning and wavelength dropping/adding. The AIRON testbed offers a unique opportunity for collaborative work, and industrial participation is expected to grow nationally and internationally over time. CRC's facility is attractive for verifying and validating technology offerings in a real test environment, prior to actual network trials. Users can also get valuable, independent feedback on their technology, along with recommendations for potential further developments.

In September 2007, the concept of AIRON was presented and well-received at ECOC 2007, the largest optical communication conference and exhibition in Europe.

For more information about the AIRON project, please contact Alex Vukovic, AIRON Program Leader at *alex.vukovic@crc.ca*.

The Future of TV: Illusions of Reality in 3D

In the world of science, researchers are always looking to the future. While consumers are still scratching their heads and trying to decide which high-definition television (HDTV) to buy for their home theatres, researchers in laboratories around the world are already working to develop technologies that would surpass HDTV.

What will be the next step in the evolution of television? While there are labs in Japan that are working on super high-definition displays, the next true milestone is expected to be much more significant than simply improving image sharpness and color. At the Communications Research Centre Canada (CRC), researchers believe the next coup in the advancement of

television will involve the addition of a third dimension. This monumental step can be likened to the addition of color to black-and-white television displays. In the future, stereoscopic or three-dimensional (3D-TV) displays will allow viewers to immerse themselves inside a world of objects that are separated in depth, far beyond the screen's surface. Best of all, you won't need those restrictive red and blue glasses that our parents or grandparents wore to enjoy 3D in the movie theatre.

At the CRC, research into 3D-TV has been underway since the mid 90s. Initial research projects addressed the important issue of determining the perceptual benefits that 3D would bring. More recently, the focus has shifted to human visual characteristics that could be exploited for applications in video coding, transmission, storage and display of 3D program material. In addition, CRC is also active in the standardization of stereoscopic technology.

How does 3D-TV work?

Since our two eyes are located at different positions in the head, the images perceived with the left eye are slightly different from those observed with the right eye. Differences in the horizontal positioning of objects in the left and right eye images are known as disparities, and our brains are smart enough to convert this into depth information—much like a surveyor solving a triangulation problem. 3D-TV mimics this real-world situation by presenting the viewer with two sets of slightly different images, one for the left eye and one for the right eye. Thus, compared to standard TV, 3D-TV conveys extra information in the form of disparity information contained in the dissimilar images, thereby greatly enhancing the sensation of depth and presence.

The major difference between a standard TV and a 3D-TV is the enhanced technologies that are needed to separately display images to the left and right eyes of a viewer. In the past, successful implementations of 3D display systems have involved some form of special glasses, such as red-blue or red-green colored glasses with anaglyphs, polarized glasses with the polarization method, and liquid crystal shutter glasses with time-sequential technology. The need to wear glasses, however, is possibly the most restrictive barrier preventing broadcasters from considering 3D-TV as a serious option. Today, with the advent of autostereoscopic displays, this gloomy scenario may change, as with these displays the viewer is not required to wear any special glasses to experience the 3D effect.

Autostereoscopic displays are conventional displays – with a twist. The most common are equipped with a plastic lenticular sheet made of many tiny lenses placed in front of the LCD screen. The tiny lenses redirect the light coming from each pixel in a controlled fashion, so that each eye sees different views. Most autostereoscopic displays typically employ nine to 16 different views of a scene, whereas a regular

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TV displays only one. These different views are presented simultaneously on the TV screen but they are spatially interleaved in alternate columns of pixels. The lenticular sheet redirects the light coming from each view in a specific direction in a fan-like fashion. As a result, one eye sees one view whereas the other eye sees another view, recreating the stereoscopic effect.

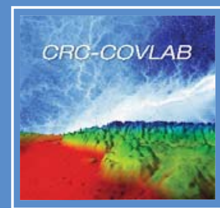
Issues with 3D-TV

Despite the major advancements afforded by autostereoscopic displays, a number of issues need to be addressed before 3D-TV is ready for the general public. High-quality stereoscopic content production will require multiple views captured with multiple cameras. Coding and transmission requirements for broadcasting such a high volume of video information will be considerable.

At the CRC, researchers are currently investigating advanced compression techniques for coding multiple views of the same scene and novel methods for transmitting the depth information contained in a scene. Other research issues include converting 2D images to 3D and viewing interpolation from a stereoscopic pair of views. Visual comfort and image quality assessment involving the use of human viewers for testing are other hot topics of research, and CRC is among the leading research institutions in these areas of research.

How long will it take for 3D-TV to become a reality in our living rooms? At the CRC, we cannot predict when it will happen, but we can easily predict that it will happen. Why? You just have to see it to believe it.

Free Online Service for Coverage Prediction



CRC now offers a complimentary online service (lrcov.crc.ca) for calculating radio frequency coverage. Coverage prediction using this type of software allows you to plan and design broadcast systems to reach optimal coverage while reducing implementation costs. This tool provides a glimpse into the advanced workings of CRC-COVLAB – CRC's licensed software package used for coverage prediction and interference analysis.

CRC-COVLAB enables you to:

- design communication systems with confidence
- evaluate interference and diagnose difficult coverage situations
- optimize service coverage to reach more people and reduce costs

Almost 20 years of research expertise has culminated in CRC-COVLAB, now licensed to numerous companies worldwide.

For more information please contact:
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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, an agency of Industry Canada, also aims to help identify and close the innovation gaps in Canada's communications sector by:

- *engaging in industry partnerships;*
- *building technical intelligence;*
- *supporting small and medium-sized high technology enterprises.*