Communications Research Centre Canada
An Agency of Industry Canada

Centre de recherches sur les communications Canada
Un organisme d'Industrie Canada

Applications
Wireless RADIO
COMMUNICATION
Networks
Fundamentals
BROADCASTING
& Interactive
TECHNOLOGY
Photonics
MULTIMEDIA
Transfer
International

COMMUNICATIONS RESEARCH CENTRE CANADA

Highlights 2007-2008

Canada

CRC

MESSAGE FROM the President

Veena Rawat

The information and communications technologies (ICT) sector is a dynamic environment in which to operate. This important sector of the economy is being fuelled by consumers' embrace of the Internet and their demand for voice, video and data over a multitude of platforms and devices.

Delivery of feature-rich service, anytime and anywhere, is putting unprecedented demands on bandwidth of core and access networks. Furthermore, broadband access is not yet a reality for many rural and remote regions of Canada, making "last mile" access an issue of particular interest to this vast country.

In addition to bandwidth, other connectivity challenges for CRC include security of ICT networks, and the development of next generation applications and technologies on behalf of our clients, and in response to consumer demand.

CRC is well positioned to address these challenges, with expertise in broadcasting and interactive multimedia, communications networks, photonics, radio fundamentals and wireless, along with test beds to study solutions and applications. With capabilities at the cutting edge of ICT, CRC is strategically poised to ensure its R&D supports the direction of government and the Canadian industry.

It has been another successful year applying CRC's competencies to meet clients' needs, as illustrated in this document. Noteworthy achievements and awards include:

- Our presentation to the House of Commons Standing Committee on Canadian Heritage on the impact of new broadcasting technologies, as part of the Committee's investigation into the role of a public broadcaster in the 21st century. We were also active in the New Media Committee of the Canadian Radio-television and Telecommunications Commission.
- CRC's demonstration, in partnership with DSO National Laboratories of Singapore, of the world's smallest software defined radio (SDR) compliant with the Software Communications Architecture (SCA) specification. This initiative makes SCA applicable to many more products within the vehicular, robotics, and consumer industries.
- The launch of CRC's free online service to calculate radio frequency coverage so users are better equipped to optimize coverage and reduce implementation costs as they plan and design broadcast systems.
- The official opening of CRC's Photonics Laboratory and its Research in Advanced Antenna Technology Laboratory (RAATLab).
- Receipt of awards honouring CRC's technology transfer and commercialization track record, including recognition of the developers of Search and Rescue Satellite-Aided Tracking (SARSAT); receipt of an innovation award as a partner in the Agile All-Photonic Networks (AAPN) Research Network; and a highlight of 2007-2008, CRC's induction into the Telecommunications Hall of Fame.

To learn more about our unique organization, please read on.

ADVISORY Council (07-08)

Michael Binder, ADM, Spectrum, Information Technologies and Telecommunications Sector, Industry Canada

Andrew K. Bjerring, President and CEO, CANARIE Inc.

Guy Bujold, President, Canadian Space Agency

Pierre Coulombe, President, National Research Council Canada

Carol Darling, Executive Director, North American Broadcasters Association

Dino Diperna, Vice-President, Optical Networks R&D, Nortel Networks

Paul Flaherty, President and CEO, Northwestel Inc.

Ibrahim Gedeon, Chief Technology Officer, TELUS Corp.

Tom Hope, Executive Vice-President, Toll Cross Investments Inc.

Roger Pederson, President and CEO, TRLabs

Veena Rawat, President, Communications Research Centre Canada

Gerri Sinclair, Sinclair Consulting

Robert Walker, ADM, Science and Technology, Department of National Defence

CRC
at a GLANCE

MISSION:

To be the federal government's centre of excellence for communications R&D, ensuring an independent source of advice for public policy purposes; to support government operations led by major clients in selected areas of ICT application such as national defence, public safety and space-based communications; and to 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, and working with other research organizations across Canada.

CRC's unique position in Canada's communications research community stems from the fact that it is the only national laboratory with critical mass and expertise in the four major platforms that form the basic transport mechanism for information delivery across Canada: terrestrial wireless, satellite, fibre optics and broadcasting. This allows CRC to pursue research in each platform, and test how technologies can work together to form an efficient seamless communications network.

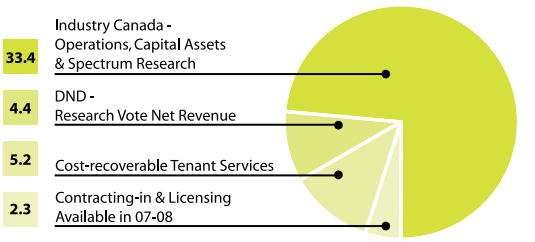
CRC's research is driven by its strategic priorities, identified through consultation with its Advisory Council and principal clients. These include Industry Canada's Spectrum, Information Technologies and Telecommunications (SITT) Sector; the Department of National Defence (DND) and its research arm, Defence Research and Development Canada (DRDC); and the Canadian Space Agency (CSA). To address client issues in the longer term and anticipate future direction in the ICT sector, CRC also conducts core research.

- **Research Staff:** 242, plus some 40 students throughout any given year
- **Number of active IP licenses worldwide:** 489 (23 new licenses in 07-08), including
  - **Number of active IP licenses in Canada:** 207 (11 new licenses in 07-08)
- **Collaborative and contracting-in agreements:** 117 (39 new agreements in 07-08)
- **IP and contracting-in revenue:** $3.37M
- **Patents:** 16 new patent applications, 15 new patents issued, 237 active patents and applications protecting 98 inventions
- **Media Coverage:** 17 print pieces and 2 TV segments
- **Visits:** 30 corporate tours, including international delegations from Austria, France, India, Israel, Japan, Korea, Mexico, Sweden, Taiwan (China) and the United States
- **Scientific publications, conference presentations, technical reports:** 274 external scientific papers and conference presentations, 38 technical reports and memoranda

Finance

Revenue 07-08

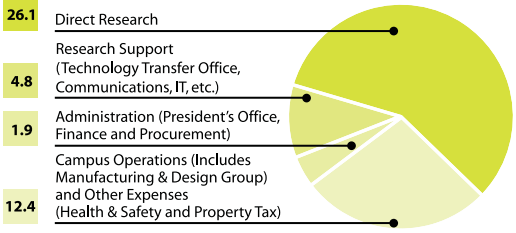
(in Millions)



TOTAL REVENUE $45.3M

Expenses 07-08

(in Millions)



TOTAL EXPENSES $45.2M

Serving as the Federal Centre of ICT Excellence

Building on Canada's strength in information and communications technologies (ICT) requires a continued commitment to scientific excellence, informed public policy, standards, legislation and regulations, as well as national and international collaborations. It also requires access to a federal centre of ICT excellence that has a proven track record in working at all links in the ICT innovation chain – from long-term research, to technology development, standards setting, technology transfer and public policy. In Canada, the federal centre of ICT excellence is the Communications Research Centre.

CRC provides independent advice for policy, regulation and standards development; supports government operations by carrying out R&D to meet respective mandates; builds technological intelligence; and assists industry through technology transfer and partnerships. Consider these examples of CRC's support for federal clients:

- DND, seeking ways to improve tactical communications and ultimately, create a new generation of NATO tactical communications standards, is using CRC's know-how for the TACOMS Post-2000 project.
- CRC is supporting CSA and international partners in the development of new features for next generation broadband communications services, and search and rescue tracking via satellite (SARSAT).
- Industry Canada is interested in CRC's multiple-input, multiple-output (MIMO) research, given MIMO's potential for increasing spectral efficiency.
- CRC continued working with federal partners in integrating ICT solutions – including Spectrum Explorer, cognitive radio and software defined radio – into their respective infrastructures.

From national defence and Arctic sovereignty to public safety and industrial competitiveness, CRC works closely with its federal partners in the laboratory, in the field and in international forums to ensure the technologies and standards that are developed reflect Canada's socioeconomic needs.

Wireless

The wireless wave is whetting the developed world's appetite for data (Internet), video and voice over a single network connection, and generating fresh possibilities in regions of the world lacking wired infrastructure. But hurdles remain in fully capitalizing on the potential of wireless technologies, including coexistence, security and standards. There is also a need for continued long-term research. CRC is active on all fronts. In 07-08:

- CRC was a major player in the development of standard IEEE 802.16h (Institute of Electrical and Electronics Engineers) for the coexistence of WiMAX systems, which currently cannot coexist because systems do not sense each other and produce interference as a result. The standard incorporates cognitive radio capabilities that allow systems to communicate and negotiate. Once adopted, WiMAX systems will be able to coexist. Work on the standard gave guidance to cognitive radio development with India's Centre for Development of Telematics (CDOT).

- CRC's WISELAB began its investigation of mobile wireless convergence: continuous and seamless wireless connectivity – on a single mobile apparatus – over multiple wireless technologies (i.e. Wi-Fi, WiMAX, HSPA, Edge, legacy cellular). With multi-technology capability, a secure communication session should be seamlessly maintained as a user moves from one technology to another. In the current reality, however, there is only limited support for such a desirable feature, and it is usually while operating on a single service provider's network. As a user roams from one carrier or service provider to another, security is not maintained and communications are most often dropped.
- CRC's three-year project with DRDC, to expand existing capacity related to silicon radio frequency integrated circuits (RFIC), came to a successful conclusion with the design, fabrication (at a commercial lab), simulation and verification of both linear and non-linear RFICs. When combined with traditional monolithic microwave integrated circuit (MMIC) design, silicon RFICs provide the widest possible range of circuit options to maximize performance.

Radio FUNDAMENTALS

Radio spectrum is a finite resource which forms the foundation of telecommunications and the ICT sector of the economy. The demands on this global resource have never been greater, with efforts to enhance existing services, explore higher frequency applications, and exploit "white space" left unused in radio frequency (RF) bands. All pose technical and regulatory issues to which CRC responds, by providing Industry Canada with the research required in support of its spectrum management mandate.

- The RCMP regularly calls on radio inspectors from Industry Canada for radio spectrum monitoring during high-profile events including, in 2007, the Security and Prosperity Partnership Summit in Montebello, Quebec. Radio inspectors trust CRC's Spectrum Explorer to provide reliable radio surveillance. Communication among emergency response units, for example, cannot be compromised.
- Further development of Spectrum Explorer software increased its frequency coverage from 20 MHz to 3 GHz and improved its accuracy for direction-finding. These enhancements have enabled CRC to work with Industry Canada on the evaluation of spectrum monitoring technologies, including direction finding capabilities, for the Vancouver 2010 Olympics.
- CRC has made significant contributions to the International Telecommunication Union, Radiocommunication Sector (ITU-R) on the propagation basis for the development of interference criteria between satellite and terrestrial services, especially at higher frequencies.
- CRC was also tasked by Industry Canada's Spectrum Engineering Branch (DGSE) to study sharing between terrestrial-fixed systems and satellite systems in the 2.5 to 2.7 GHz band. Results not only met DGSE's needs, they were shared with the wider community at the 2007 World Radiocommunication Conference.

Broadcasting & INTERACTIVE Multimedia

With broadcasting's evolution from analogue to digital and beyond, combined with video's expansion to cell phones and the Internet, CRC's expertise in broadcasting and interactive multimedia is in demand. That expertise is supporting regulators as they respond to change, and broadcasters and manufactures as they innovate. Through it all, CRC know-how is ensuring consumers get quality of service. In 07-08:

- The broadcast industry began implementing ITU-R Recommendation 1770 – the loudness meter developed by a CRC audio researcher. The industry is adopting the loudness meter to ensure programming is broadcast at a uniform sound level.
- CRC hosted a Video Quality Experts Group (VQEG) meeting where international researchers continued their efforts to establish objective video quality tests. CRC also continued its contribution to the Advanced Television Systems Committee (ATSC) which sets North American TV standards.
- Considerable improvements were made to the algorithms to convert two dimensional television programming to three dimensional. While a 3-D home experience is currently possible with glasses, 3-D video materials and programs are limited. The conversion of existing 2-D video to 3-D is essential to develop a 3-D video market.
- Clients contracted with CRC to resolve technical dilemmas arising with the evolution from analogue to digital, to HDTV and 3-DTV, and with the availability of video over new applications such as cell phones, WiMAX and IPTV.
- CRC evaluated mobile/handheld (M/H) systems that will define the North American standard set by the ATSC. In countries offering digital TV via M/H, the service is delivered over a portion of the terrestrial TV band, the robustness of which has been enhanced. M/H, which can deliver local content, could be a service similar to traditional terrestrial television.
- Researchers studied video compression technologies and their impact on quality at different bandwidths. To avoid distortion of moving subjects, CRC researchers estimate the motion of every pixel between two known images, and develop algorithms to compensate for the differences. This work will help advance ITU and ISO standards, and is of interest to industry as well.
- CRC conducted rigorous laboratory testing of FM-IBOC, the hybrid radio technology being adopted in the U.S. The results of this work are relevant to the regulator, SITT, in bilateral discussions with its U.S. counterpart regarding the rollout of hybrid radio in regions close to the Canada-U.S. border. Similarly, CRC's report will provide Canada's radio industry with necessary technical information for its consideration of hybrid radio.

Photonics

CRC's optoelectronics and photonics research program develops components which increase the capacity, versatility and performance of fibre optic broadband networks – an enabling technology for many sectors, including telecommunications. In 07-08, CRC officially opened its new Photonics Laboratory and equipment essential to CRC's research program continues to be installed. The resulting research:

- Aimed to further exploit the photosensitivity of optical fibres, by using a Femtosecond laser to apply ultra-short, ultra-powerful pulses to fibre material, thereby producing localized changes.
- Focused on fibres other than glass, such as sapphire, which can withstand temperatures of up to 2000° C. This makes it ideal for sensor applications. Ongoing collaborations continue to test the capabilities, but already, scientific publications are capturing the interest of the avionics and space industries, among others.
- Capitalized on the characteristics of semiconductor compounds to develop and test semiconductor optical switches that increase both speed and reliability, thereby allowing rapid reconfiguration of networks.
- Studied selective area growth using crystals, hence eliminating some of the photolithography and etching processes, and producing precise growth patterns measuring merely several microns.
- Probed the potential of planar light wave circuits, which could conceivably compete with fibre optics, given they can be grown and etched en masse.
- Investigated integrated micro structures, which consist of a series of channels. Liquids can be routed through these hollow tubes, enabling switching applications in communications, and lab-on-a-chip applications for medical and environmental purposes.

ADDITIONAL INFORMATION

www.crc.ca

COMMUNICATION Networks

From its early involvement in ARPANET, the precursor of the Internet, to the recent development of User Controlled Lightpaths (UCLP) software, CRC continues to extend the possibilities of communications networks to the benefit of all sectors. Highlights of 07-08 include CRC collaboration with DND to investigate capabilities and challenges related to their communications network needs.

- Capabilities include the investigation of next-generation mobile wireless communication technology to provide increased throughput and enhanced tactical IP networking between battle group units. Efforts have resulted in a new multi-user channel access protocol known as MATRIQS: Multiple Access for Tactical Radios with Integrated Quality of Service. MATRIQS has been designed to exploit the capabilities of high-data rate modems, and support the concurrent transmission of voice and data. A prototype has been implemented for proof-of-concept and demonstrations have been provided to military clients.

- Challenges include security in mobile ad-hoc networks (MANET). Wireless ad hoc networks are particularly vulnerable due to the nature of wireless links, changing topology, and the lack of centralized monitoring and management. One serious attack, and the subject of CRC research, is called the wormhole. An intruder node records packets from one network location and tunnels them to a colluding node, which retransmits them to a different area of the network, thereby creating the illusion that distant nodes are actually neighbours. Even network communication secured with authentication and confidentiality is vulnerable, since an attack can be executed without knowledge of cryptographic keys.

  CRC researchers have developed different detection techniques to defend against wormhole attacks. Techniques typically use geographical (GPS) and temporal information (timestamp) attached to control packets sent over the network to signal parametric discrepancies between the content of a message and the indicators accompanying it. Researchers have run successful laboratory tests on these solutions in CRC's test bed, which offers distinct advantages over computer simulation testing available from other facilities.

Extending the possibilities of communications networks

In earlier work funded by Canada's advanced network organization, CANARIE Inc., CRC collaborated with international partners to develop UCLP software (versions 1 and 2). UCLP allows users, including Environment Canada and the National Research Council, to manipulate network resources as though they were software objects. Within a given network, users are able to create and configure lightpaths – the direct connections between two network nodes.

This fundamentally changes the management and control of optical networks. Users can increase their level of bandwidth and quality of service by drawing on resources from more than one supplier. The resulting network can transfer large amounts of data, and enable globally distributed broadband computing. Institutions can now extend the boundaries of their computing and networking capabilities. With this, UCLP technology has the power to accelerate the pace of scientific advancement by facilitating e-science and virtual super computing applications.

UCLPv2 led to the development of Argia, the commercial version of the software. In 07-08, CRC and its partners improved Argia, making it more robust and adding new features for CANARIE and other R&D initiatives.

- The European Union (EU) Phosphorus project added the "Harmony System" to support dynamic provisioning of end-to-end connections across multi-domains, and advance research networking, e-science and grid computing.

- Work began on a new version of Argia based on the Infrastructure as a Service (IaaS) Framework. IaaS combines the optical network abilities of Argia with the capacity of other products, to allow customers to select and integrate their own media service attributes. EU PanLab II projects are adopting IaaS.

- The network can also support real time multimedia exchanges – key to the convergence of broadcasting and Internet technologies.

INTERNATIONAL

CRC's international involvement ranges from S&T agreements and arrangements coordinated through the Department of Foreign Affairs and International Trade Canada, to memoranda of understanding with foreign counterparts in pursuit of common purposes. In 07-08, CRC collaborated with a number of international partners, including:

- India's Centre for Development of Telematics (CDOT), in the construction of a WiMAX-based cognitive radio network system in India. Under CRC guidance, a basic WiMAX radio system, including test hubs, was installed. There is worldwide interest in this technology, which will operate as the world's first license exempt cognitive radio system (based on the IEEE 802.16h standard) working in the 2.4 GHz band.

- Researchers from National Taiwan University, in the development of a custom 60 GHz RF integrated circuit for sensor network communications. Together, researchers addressed the challenges posed by packaging a minute antenna into ceramic containing the front end circuitry. The 60 GHz band, for industrial, medical and scientific applications (the IMS band), will accommodate considerable throughputs, and CRC's research will facilitate future applications in this band.

- Cámara Nacional de la Industria de Radio y Télevision (CIRT) of Mexico, in the evaluation of new radio broadcasting systems. Insight gained through the collaboration will shape CRC's input to both Industry Canada and the broadcast engineering community, and enhance CRC-COVLAB software and technical documentation.

- The Telecommunications Research Institute (ETRI) of Korea, in the area of 3-D video.

CRC also participates in international standards bodies to promote harmonization, ensure international standards reflect Canada's socioeconomic needs, and see that Canadian standards are compatible with those of other countries. CRC efforts in 07-08 advanced:

- IEEE standard 802.16h for the coexistence of WiMAX systems.

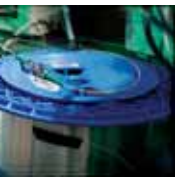
- IEEE standard 802.22 for Wireless Regional Area Network (WRAN). A CRC researcher serves as vice-chair of the 802.22 working group.

- ITU-R Study Group 4, the mandate of which was broadened in 07-08 to include all satellite services, not only fixed services. The study group is chaired by a CRC representative.

Also on the international front:

- CRC participated in the SDR Forum in an effort to standardize the software communications architecture specification and application interfaces, to create a world market around the concept of software defined radio. The team provided training courses on SDR technology and expanded its cooperation with international government organizations such as Defence Science Organization (Singapore), Forschungsgesellschaft für Angewandte Naturwissenschaften (Germany), Centre for Development of Advanced Computing (India) and Massachusetts Institute of Technology Research Establishment (U.S.).

- As Canada's National Contact Point for ICT, CRC and several partners hosted a series of information days to build understanding of FP7 within Canada's ICT research community. FP7 is the EU's latest framework for research and technological development, and its main instrument for funding research in Europe between 2007 and 2013. ICT is one of the key research domains under FP7.



Contact Us

- Tel.: (613) 991-3313
- Fax: (613) 998-5355
- E-mail: info@crc.ca

Communications Research Centre Canada
3701 Carling Avenue
P.O. Box 11490, Stn. H
Ottawa, ON K2H 8S2

Applications

CRC is renowned for not only generating knowledge, but for translating it into valuable applications. Consider SARSAT, an international collaboration spearheaded in Canada by CRC, CSA, DND, the National Search and Rescue Secretariat (NSS), and industry partners. SARSAT is credited with the rescue of more than 24,000 people worldwide since its 1982 launch. In 07-08 nations continued to develop the new constellation of search and rescue satellites soon to operate from medium Earth orbit: MEOSAR.

- CRC contributed to the technical analysis and planning at the international level and at home. Research into the geometric effect of a MEOSAR constellation on distress beacon location estimation accuracy has commenced, in a project funded by the NSS. The required theoretical basis and a software tool have been developed to investigate performance over a full territory – Canada. A report documenting the algorithms and software was released.

- Numerous sets of live 2-channel data were collected during whole passes of GPS/SAR satellites. The resulting time-frequency "dot plots" allow for examination of signal traffic (both beacon and non-beacon) in the 406 MHz SAR band.

- Additional efforts included development of a real-time traffic-monitoring package using CRC's Spectrum Explorer, characterization of both "chirp" radar signals and interference from wind-profiler radar signals, and investigation into a new SARSAT beacon format.

Facilitating communication among emergency response teams is another constructive application of CRC know-how. In 07-08:

- CRC released a new version of the SCARI Software Suite. Performance enhancing features include the fact that software defined radio (SDR) units can now be started much faster and require less memory, a huge advantage for small radio sets such as those used for public safety; modeling tools have been improved to support the full spectrum of the software communications architecture standard features; and the tools contain new and unique features targeted at accelerating the development cycle and minimizing the memory required to run the generated applications.

- CRC initiated development of an SDR-based prototype capable of bridging terrestrial and satellite protocols for emergency management and public safety applications. The work is part of a three-year contract with the NSS.

As Canada exercises its sovereignty in the North, CRC technology holds promise to provide part of the solution to this national priority. In 07-08:

- CRC continued to work with CSA and industry on an extension of the short message service (SMS) concept to provide an automatic identification system (AIS) by satellite for monitoring positions of ships at sea. DND is very interested in the potential of this application, particularly in the waters of Northern Canada.

- CRC also continued to work with CSA, DND and industry to increase Canada's presence in the North by providing satellite communications access to remote communities and monitoring stations.

Achievements

Contributing to the Convergence of Internet and Broadcast

Broadcast's conversion from analogue to digital; consumer demand for voice, data (Internet) and video (TV) over a single device; and technological advancements that support the streaming of high capacity digital media to multiple locations are just some of the factors feeding the convergence of the Internet and traditional broadcasting.

Consider the four platform networks and their original applications: the telephone network transmitted voice; the cable network, television; the computer network, data; and the cellular network, mobile voice. Today, networks are carrying a mix of voice, video, data and mobile voice, and new ingredients are about to rewrite the recipe. For example:

- Multicasting capabilities were added to the High Performance Digital Media Network (HPDMnet) as part of the UCLP project. This enables efficient streaming of high capacity digital media from a source to multiple destinations, a key ingredient for broadcasting over the Internet.

- CRC has done extensive tests of the various digital broadcasting systems to determine how well they can deliver video to portable or mobile wireless devices such as cellular phones.

- Demonstrating a concept called "CRC Tube," CRC has shown how digital multimedia broadcasting and digital audio broadcasting (DMB/DAB) technologies can be used for mobile broadcasting to a cell phone. Using free video content captured from the Internet and packaged for the demonstration, researchers broadcast it over CRC's experimental DAB transmitter at L-band to a cell phone equipped with a DAB/DMB broadcast receiver.

- CRC is also working on Software Defined Radio which enables a computer to be configured as needed to different radio technologies by simply downloading the appropriate software.

For additional copies of this publication, please contact one of the following:

Communications Research Centre Canada (CRC)
Tel.: 613-991-3313
E-mail: info@crc.ca

Public Works and Government Services Canada
Tel.: 1-800-635-7943 (Canada and U.S.)
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E-mail: publications@pwgsc.gc.ca

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TECHNOLOGY Transfer

In 07-08, CRC engaged in a variety of technology transfer arrangements including licensing of its intellectual property (IP), contracting-in and collaborative agreements. These are win-win situations, both for CRC and for the companies that capitalize on its expertise and IP.

- Along with being the only software capable of predicting coverage for all commercial radio formats – AM, FM, Digital Audio Broadcast (DAB), Digital Radio Mondial (DRM), and FM-IBOC (hybrid radio) – CRC-COVLAB is also used by border officials, police departments and defence forces requiring accurate coverage prediction. The software comes complete with training and ongoing technical support. In 07-08, for example, CRC provided training to the Toronto police, fire fighting and ambulance service. Similarly, Environment Canada officials were trained on CRC-COVLITE with their software purchase.

- Improvements were made to CRC-SEAQ (System for the Evaluation of Audio Quality). Since the software's initial release 10 years ago, solid sales to an impressive list of international clients confirm that CRC-SEAQ is *the* sound quality measurement tool in the world, being used for both subjective and automated objective evaluation of audio quality. The software is available from CRC and the commercial supplier licensed to sell it.

- With the rapid growth in digital video formats, there is an increased demand for high quality video format conversion. To more fully exploit the potential of CRC's original video frame rate conversion algorithm, CRC-FRC, the patent was sold. CRC researchers are pursuing another approach in CRC-FRC version 2.

- CRC has established a collaborative agreement with the University of Waterloo and other partners to study technology for future portable and mobile wireless applications.

- A Canadian company contracted with CRC to develop the proof-of-concept and prototype of a more compact and portable antenna for their mobile satellite communications applications. The antenna, which will communicate with Ku-band satellites, is intended to replace the company's traditional parabolic antenna given that the "dish" is difficult to transport. The resulting reflectarray antenna will unfold to its full dimensions, allowing users to automatically find and establish a link.

- A Canadian manufacturer has integrated CRC's SCARI Suite into its military radios, which are being used in Afghanistan and Iraq.