



Communications
Research Centre
Canada

An Agency of
Industry Canada

Centre de recherches
sur les communications
Canada

Un organisme
d'Industrie Canada

HIGHLIGHTS

OF THE COMMUNICATIONS RESEARCH
CENTRE CANADA FOR FISCAL YEAR
2010-2011

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Shirleys Bay Campus

The Communications Research Centre is the custodian of the Shirleys Bay campus, a secure facility located in Ottawa's west end that comprises multiple laboratories of the Government of Canada.

Enabling emergency communication across the facilities of CRC and its campus partners involves reaching roughly 1,600 personnel over dispersed buildings via unique computer networks, each with distinct security requirements. Supported by the Canadian Innovation Commercialization Program of Public Works and Government Services Canada, CRC implemented a highly customizable public alerting system developed by a Canadian company. Along with advancing alerting capabilities on campus, the initiative serves to demonstrate the company's expertise to other government departments.

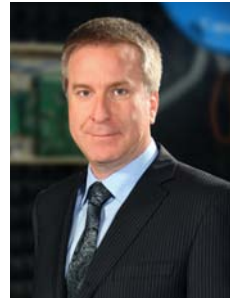


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MESSAGE FROM THE PRESIDENT

As President of the Communications Research Centre Canada (CRC), I am proud to present CRC Highlights 2010-2011.

This past fiscal year, we marked the retirement of Dr. Veena Rawat from the federal public service. I am pleased to have this opportunity to thank her for her service and dedication to CRC, and for broadly promoting the organization.

This is an exciting time in the information and communications technologies (ICT) sector, creating a range of opportunities and challenges across Canada's unique telecommunications landscape. In urban centres, the introduction and adoption of mobile multimedia devices could outpace advancements to liberate spectrum, while in rural regions, the recently completed IEEE 802.22 Wireless Regional Area Network (WRAN) Standard can extend broadband access to these sparsely populated areas.

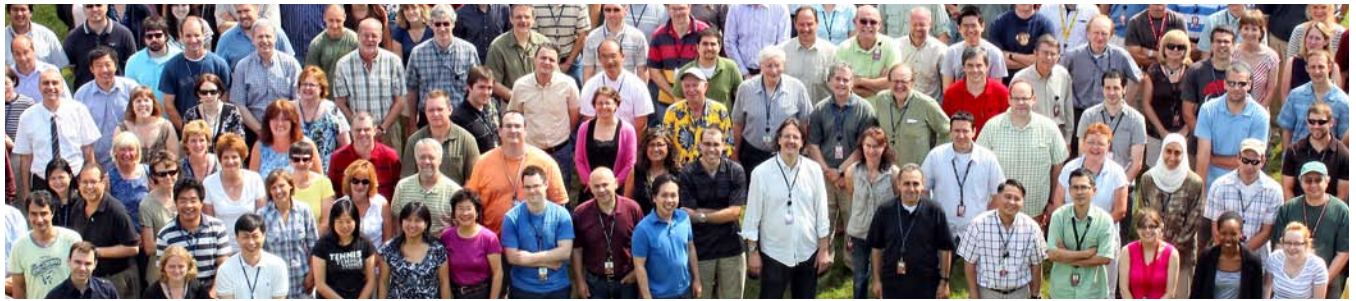
CRC has the capacity to create communication technology innovation starting from basic science, all the way through to prototype development and field deployment / testing – effectively covering all aspects of the technology innovation chain. We then close the loop with the initial science in order to deepen our understanding and refine our models.

CRC will continue to exercise this capacity in meeting the needs of its clients. Over the next three years, we will be guided by our new CRC Strategic Plan: Strengthening Canada's Excellence in ICT Research and Innovation. There will be some realignment as we better target CRC's R&D and consolidate critical mass in its key strategic priority areas: spectrum research; defence, public safety and security; emerging network infrastructure; and ICT applications and adoption.

The consultations we carried out in developing the strategic plan were characterized by quality comments from numerous clients. On behalf of the management and staff of CRC, we look forward to continued client interaction and collaboration.

A handwritten signature in gold ink, appearing to read "Jean Luc Bérubé". The signature is fluid and cursive.

Jean Luc Bérubé Ph.D., P.Eng.

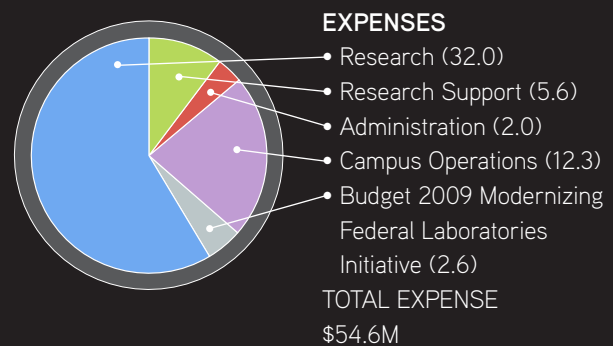
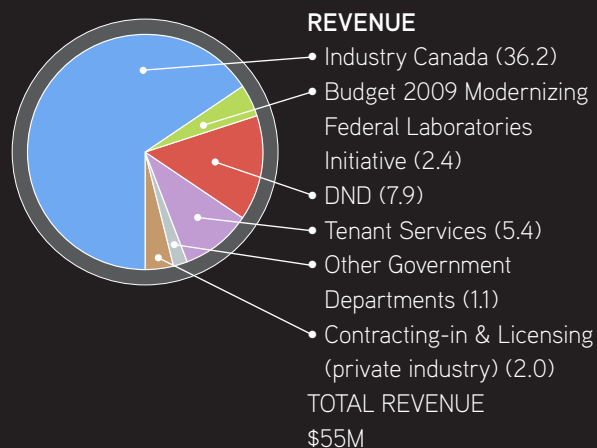


CRC RESEARCH AT A GLANCE

The Communications Research Centre (CRC) is the federal government's primary laboratory for research and development in advanced telecommunications, and a centre of excellence in information and communications technologies (ICT). Its capabilities cover satellite communications, terrestrial wireless communications systems, multimedia, broadcasting and broadband networks.

- Research Staff: 241
- IP licensing and contracting-in revenue: \$3.09 million
- Active IP licenses: 556 (30 new licences in 2010-2011)
- Collaborative and contracting-in agreements: 116 (32 new agreements in 2010-2011)
- Patents: 18 new patent applications; 8 new patents issued; 239 active patents and applications protecting 81 inventions
- Scientific publications and conference papers: 287

FINANCE



ENSURING AN INDEPENDENT SOURCE OF ADVICE FOR PUBLIC POLICY PURPOSES





TESTING NEXT GENERATION NETWORKS

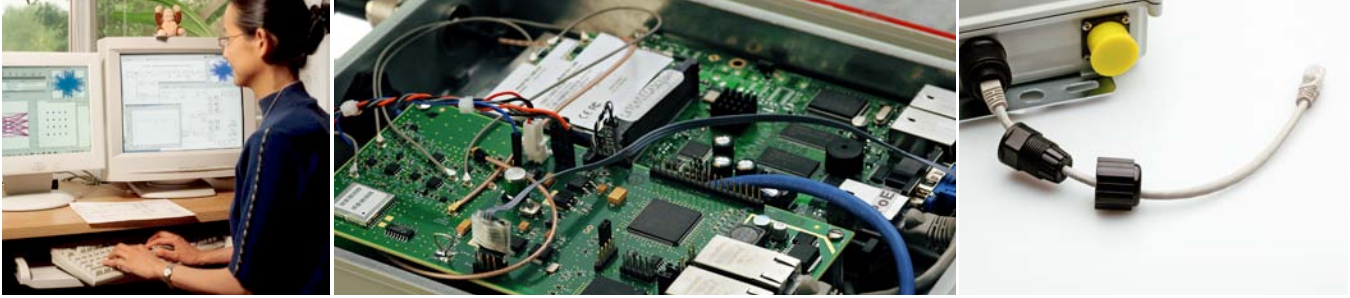
CRC added two mobile WiMAX evaluation networks to its existing broadband test network. The first includes three base stations and a fully integrated core network covering greater than 100 km². The second consists of two base stations tied into a commercial core network in Montreal. What's more, CRC clients will benefit from the establishment of Canada's first non-commercial Long-Term Evolution (LTE) experimental network, which is currently under way.

ASSESSING COMPLIANCE WITH NEXT GENERATION NETWORK STANDARDS

The International Telecommunication Union Radiocommunication sector (ITU-R) set the International Mobile Telecommunications Advanced (IMT-Advanced) requirements for 4G in 2009. In 2010-2011, CRC participated in the Canadian Evaluation Group (CEG) study, a joint government - industry - academia study evaluating IMT-Advanced technologies to verify compliance with minimum ITU-R requirements. CEG provided the results to Industry Canada's Spectrum, Information Technologies and Telecommunications (SITT) sector.

PROVIDING SPECTRUM MONITORING CAPABILITIES FOR G8/G20 SURVEILLANCE

CRC provided 12 Spectrum Explorer® units with direction-finding capabilities to SITT for spectrum surveillance during the 2010 G8 and G20 summits in Ontario. The units helped ensure clear access to radio spectrum for public safety and security agencies.



EVALUATING PROSPECTIVE FREQUENCY SHARING

CRC developed a methodology for predicting attenuation and fading, as part of the ITU-R study of interference from broadcast satellite to fixed terrestrial. CRC's work advances the ITU-R assessment of prospective inter-regional frequency sharing between broadcast satellites and the terrestrial fixed service at frequencies above 17 GHz.

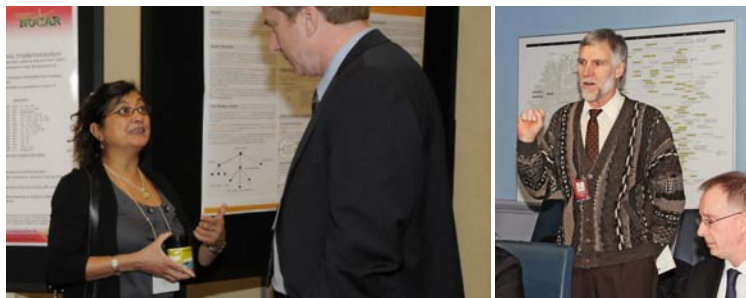
MITIGATING INTERFERENCE IN SHARED FREQUENCY BANDS

Radio frequencies (RF) for industrial, scientific and medical (ISM) purposes are increasingly shared with communications devices. The problem is that ISM devices can produce electromagnetic interference that disrupts radio communication using the same frequency. CRC studied ISM band interference and provided the results to SITT for use as it develops new techniques for controlling ISM band interference.

INVESTIGATING INTERFERENCE WITH CORAL – THE WIFI-BASED COGNITIVE RADIO DEVELOPMENT PLATFORM

Researchers in Canada and around the world are using CORAL to investigate interference. The world's first WiFi-based cognitive radio (CR) development platform, CORAL was developed by CRC. Doctoral students from Simon Fraser University, the University of British Columbia and the University of Ottawa are using the terminals to investigate the interference phenomena to which CR must adjust. SITT is interested in these results. International institutions are also using CORAL to study cognitive control of ISM band interference.





ENABLING EFFICIENT USE OF SPECTRUM

- CRC is investigating radio concepts and techniques to enable adaptive spectrum access. The work involves the study of low-complexity spectrum sensing techniques designed to search for unused spectrum.
- CRC studied new channel coding techniques to boost the Advanced Television Systems Committee (ATSC) bit capacity in North America's next generation broadcast system. One method examined provided a rate gain of approximately 30 percent. Increased data capacity for digital TV channels results in more efficient use of spectrum.
- CRC is working on a new video compression technology for the H.264 video compression standard. It provides 15 percent higher compression efficiency than the existing technology. Video compression is directly related to the efficient use of radio spectrum. The H.264 standard is widely used to stream audio and video over the Internet, deliver satellite and cable TV services, and more.
- CRC research into next generation audio coding is ongoing. Preliminary results point to significant improvements in compression.

The IEEE 802.22 Wireless Regional Area Network (WRAN) Standard was completed in 2011 after six years of shepherding by a CRC subject expert who served as vice-chair of the working group and lead editor of the 802.22 Standard. The resulting WRAN networks will be especially useful for extending broadband access to less densely populated areas such as rural and remote regions in Canada, in other developed countries, as well as in developing countries. The standard capitalizes on the favorable signal propagation characteristics of the VHF and UHF TV bands to provide service over an area typically extending 20 to 40 km from the base station, and up to 100 km under exceptional propagation conditions. Each WRAN will use white spaces between occupied TV channels to deliver up to 22 Mbps per 6 MHz TV channel (proportionally higher capacity in 7 MHz and 8 MHz TV channels) without interfering with reception of existing TV broadcast stations. The standard incorporates advanced cognitive radio capabilities including RF sensing, geolocation via satellite or terrestrial means, and access to incumbent databases. CRC and a Canadian company developed the terrestrial geolocation technique used in this global standard.



FOSTERING INNOVATION IN MOBILE BROADCASTING

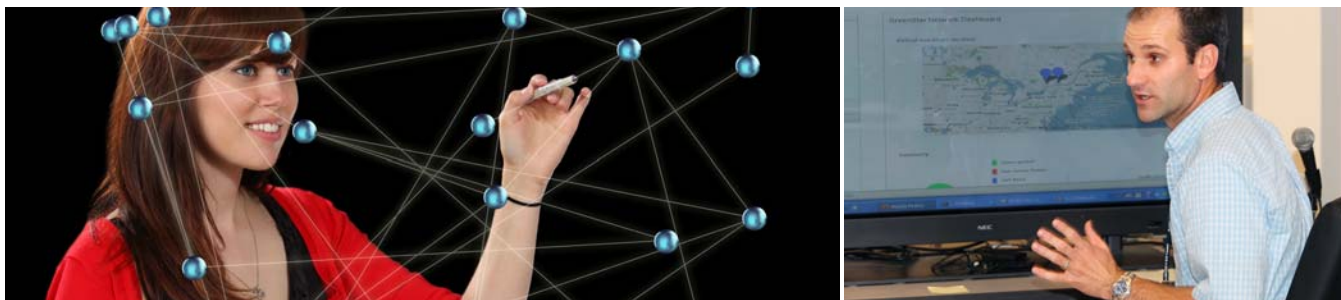
CRC researchers capitalized on their expertise in digital audio broadcasting (DAB), software defined radio (SDR) and the Android™ operating system to foster mobile broadcasting innovation. After seeing steady growth in the number of users of their free open source mmbTools DAB software transmitter, they released the first independent FM-RDS radio decoding App on the Android market. The App, CRC FM TwoO, demonstrates the great potential for delivering new FM-based applications like interactive radio, traffic messaging or public alerting to smart phones.

TESTING THE QUALITY OF MOBILE TV

CRC established a new facility to measure the quality of mobile TV as per the Advanced Television Systems Committee mobile/handheld standard (ATSC M/H) serving North America. The test bed – equipped with an encoder, emulator, receivers and analyzers – accommodates individual mobile TV technologies and devices, as well as entire systems.

ENABLING RDS AND RADIODNS

CRC developed a coverage prediction methodology and engineering guidelines to assist broadcasters in deploying new Radio Data System (RDS) services in addition to their FM offerings. RDS allows FM broadcasters to enhance the radio experience by providing song titles, artist names, traffic updates and other information. An implementation of the recent hybrid radio standard, RadioDNS, demonstrates how even more advanced services can be deployed when they take advantage of the broadcast features of FM-RDS in combination with two-way 3G mobile communications. FM radio then becomes open to innovative enhancements such as CD cover art, radio tagging and more.



EMPOWERING VIRTUAL INFRASTRUCTURES OF ICT RESOURCES

CRC is developing software for virtually forming an infrastructure of ICT resources under the Infrastructure as a Service (IaaS) framework. IaaS provides a collection of tools that enable the range of services involved in sharing infrastructure: from set-up and management, to security and even web-based marketing for brokering slices of virtualized resources. IaaS Core v1 enables the GreenStar Network, a Green IT pilot project running at CRC and partner locations. The upgrade, IaaS Core v2, will be released in 2011.

EXPERIMENTING WITH EMERGING TECHNOLOGIES: OPENFLOW AND SDN

CRC is implementing an OpenFlow test bed in its Virtual Infrastructure-based Services, Technology and Applications (VISTA) laboratory. OpenFlow is a software interface that enables advanced traffic management associated with Software Defined Networking (SDN). SDN is considered by some to be the next generation of the Internet. Researchers will use CRC's OpenFlow nodes to participate in national and international projects such as the GreenStar Network, OpenLab and Ofelia in the European Union, and iGENI in the United States. CRC's collaborators include l'École de technologie supérieure in Quebec and l'Université du Québec à Montréal.

**SUPPORTING GOVERNMENT OPERATIONS LED
BY MAJOR CLIENTS IN SELECTED AREAS OF ICT
APPLICATION**





COLLABORATING WITH DEFENCE RESEARCH AND DEVELOPMENT CANADA (DRDC) AND THE DEPARTMENT OF NATIONAL DEFENCE (DND)

- CRC is investigating network concepts and technologies for advanced high-frequency (HF) communications, concentrating on the particular challenges faced in northern and Arctic regions. The R&D involves assessing strategies to access the spectrum required for the proposed meshed-network architecture. Progress in 2010-2011 included the development of a test bed to evaluate performance.
- The Technical Cooperation Program (TTCP) is a multi-nation collaboration in defence science. CRC sits on two TTCP panels. Work includes the investigation of policies for dynamic use of radio spectrum in coalition operations, and of distributed network management for integration of dissimilar secure networks.
- A self-healing autonomous sensor network, or SASNet, is an intelligent sensor surveillance system for military operation, border control and public safety operations. CRC researchers demonstrated SASNet's performance in different military scenarios at Empire Challenge 2010 in Arizona, and were invited back to EC 2011, where new features will be demonstrated.
- CRC presented an authentication algorithm for wireless sensor networks to the NATO group addressing security for tactical wireless mobile ad hoc and sensor networks.
- Routing protocols are required to organize communications within a network of mobile nodes with different capabilities, including vehicles and soldiers who may be called upon to dismount. To this end, CRC developed the Hierarchical Optimized Link State Routing (HOLSR) protocol and researchers participated in Internet Engineering Task Force efforts to standardize HOLSR.
- CRC developed a test bed at X band for the Canadian Navy and DND's Directorate of Space Development to experiment with and demonstrate modern broadband maritime communication systems in this segment of the spectrum's microwave radio region.



Photo: Department of National Defence



- CRC demonstrated the capabilities of the newly developed CRC-RayPredict, a 3D ray-tracing propagation modeling software that can locate clandestine transmitters.
- Under a five-year Technology Demonstration Program project, CRC is applying software defined radio technology to develop a proof-of-concept for a flexible satellite payload. The flexible qualities will allow agility in user-bandwidth and power allocations.

ANALYZING CANADA-U.S. BORDER COVERAGE

CRC had a lead role in delivering a comprehensive Canada-U.S. border radio coverage study and gap analysis for Public Safety Canada. In work supported by DRDC's Centre for Security Science, CRC carried out, in collaboration with an industry partner, an analysis of the radio frequency coverage along the border, and recommended technical solutions to fill the gaps.

CONTINUING SUPPORT OF INTERNATIONAL SEARCH AND RESCUE CONSORTIUM

CRC is coordinating international trials on the third generation of search and rescue satellite-aided tracking (SARSAT) that will provide service over medium-earth-orbit (MEO) satellites. In 2010-2011 researchers reported to international audiences on MEOSAR technology improvements and field trial results.





DEVELOPING WIRELESS COMMUNICATION SYSTEM FOR CSA'S ROVER

CRC is collaborating with the Canadian Space Agency (CSA) in CSA's development of mobile robots or "rovers" for exploring Mars, the Moon and other near-orbiting bodies. A wireless network developed by CRC will enable mobile broadband communication among rovers and with the control centre. In 2010-2011 CRC demonstrated a fully operational wireless network supporting typical rover-like scenarios and applications.

BUILDING SATCOM GATEWAY FOR REMOTE LOCATIONS

Progress continued on the development of a prototype for a rapidly deployable broadband satellite communications gateway to support deployment in ad hoc operations in northern Canada, or other remote locations in the world where Canada is involved. Design of the software defined radio platform and of the application controllers was completed in 2010-2011, in this CSA-supported project.



ENHANCING QUALITY OF SURVEILLANCE VIDEO

Video surveillance has become a key tool for public safety and security, but limitations in transmission bandwidth and the less-than-ideal conditions under which surveillance video is typically captured result in poor video quality that can hamper investigations. In 2010-2011, CRC signed a research contract with the Royal Canadian Mounted Police (RCMP) to optimize its outdoor video surveillance systems and enhance video quality.

BRIEFING TRADE COMMISSIONERS ON CANADIAN CAPABILITIES IN IPTV

Canadian capabilities in Internet protocol television (IPTV) are well known at CRC and now, trade commissioners who market CRC expertise around the world are familiar with Canada's IPTV expertise. CRC provided the Department of Foreign Affairs and International Trade Canada (DFAIT) with a status report on IPTV for DFAIT trade commissioners.

REPORTING ON THE TECHNICAL COMPLEXITIES OF LOUDNESS

CRC contributed to the knowledge base supporting the Canadian Radio-television and Telecommunications Commission's (CRTC) public consultation on loud TV ads. In a report, CRC shared its insight into loudness control technologies and standardization efforts, including adoption of the ITU-R loudness meter, which was developed at CRC. In 2010-2011, CRC added a gating method to the loudness algorithm to factor out silent and very low-level signals from the loudness calculation.





COLLABORATING ON SMART GRIDS

- Smart grids use information and communication technologies to better manage electrical networks. CanmetENERGY of Natural Resources Canada (NRCan) is the country's leader in clean energy R&D. In 2010-2011 CRC and CanmetENERGY began exploring the use of wireless communication systems to remotely control smart grid devices installed in homes. The suitability of FM-RDS, the radio data system (RDS) communications protocol standard, is one possibility being assessed.
- While the idea of power line communications (PLC) is not new, capitalizing on PLC for smart grid applications is in the early stages. PLC access to transformers, for example, could be a key factor in managing the grid. To this end, CRC studied a 1.8 GHz carrier for PLC and its applicability to smart grids. A CRC representative sits on the working group standardizing communications networks for smart grids in Canada.

In other work:

- *A collaboration has been established with CanmetENERGY to develop a sapphire fibre-based sensor to monitor the temperature of CanmetENERGY's entrained coal gasifier reactor.*
 - *CRC investigated optical sensor architectures based on integrated and fibre gratings for a range of applications including pressure sensors, as well as oxygen and hydrogen sensors for high temperature nuclear reactor monitoring, in partnership with Atomic Energy of Canada Ltd.*
-

STIMULATING CANADA'S COMMUNICATIONS SECTOR THROUGH TECHNOLOGY TRANSFER AND PARTNERSHIPS





DESIGNING AND ENHANCING MULTI-ANTENNA HANDSETS

Given CRC's cognitive radio work, its involvement in IEEE standards and its expertise in wireless circuits and antenna systems, researchers worked with a Canadian company on the design and performance enhancements of multi-antenna handsets. The collaboration also involved the University of Ontario Institute of Technology.

SUPPORTING CANADIAN COMPANIES AS THEY EXPAND THEIR MARKETS

CRC helped a Canadian software defined radio (SDR) platform manufacturer expand its market at the international level by providing its SDR software development suite and technical support. Helping the Canadian industry win business in this new market is crucial for growth.

DEMONSTRATING TECHNOLOGY OF NEXT GENERATION OPTICAL NETWORKS

In a CRC-Carleton University collaboration, researchers have demonstrated optical non-linearities in poled silica multi-layered structures. The ability to implement non-linear optical functionalities in a silicon-based photonic device platform has important implications for low-cost high-speed modulators and other components needed in next generation optical networks. Negotiations are under way with an industrial partner to further develop this potential.



MEASURING SHOCK WAVE PROPAGATION WITHIN EXPLOSIVES

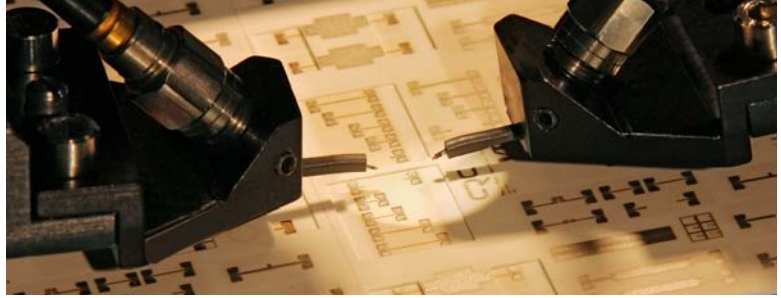
Working with other research organizations, CRC developed an ultraviolet laser-induced fibre Bragg grating (FBG) sensor for measuring the detonation velocity within an explosive. The design of the FBG enables the technology to measure shock wave propagation within explosives over a longer distance. The technology was transferred to a Canadian company.

ENHANCING THE 3D VIEWING EXPERIENCE

Commercialization of CRC's patent-pending "J-Display" is on the horizon. This novel stereoscopic 3D display improves viewers' sense of virtual reality. The J-Display features a curved surface that displays the lower portion of the subject, which a standard display cuts off. This "grounded" view makes the image appear more life-like.

CRC has over 550 active intellectual property licenses worldwide with over 76 percent of active patents either licensed or sold – the highest such ratio for any Canadian government lab. Canadian industry has generated significant revenues from technologies transferred from CRC: estimated at \$408 million in sales and 2040 jobs over the 2001-2010 time period. Since 2001, CRC research has also created 10 spin-off companies. In 2010, total sales for these 10 companies were \$179 million, with 742 employees. CRC also operates an Innovation Centre that provides small and medium-sized Canadian enterprises (SMEs) with access to its facilities, technologies and expertise. In the past five years CRC has incubated 14 SMEs.

CRC Impact Profile 2001-2010, Doyletech Corporation, 2011



COMMERCIALIZING OTHER CRC TECHNOLOGIES IN 2010-2011

- CRC transferred its 2D-to-3D video conversion technology to a Canadian company that is using it in a new generation of mobile phones and hand-held devices.
- CRC supported a licensee incorporating its power amplifier linearization and direct transmitter self-calibration techniques in a new product that will be flown on the International Space Station.
- CRC conducted a detailed performance analysis of a high-power tactical radio in both urban and rural environments.
- CRC studied long-term evolution (LTE) technology for public safety applications under contract with a telecom provider.
- CRC delivered 80 WiFi cognitive radio terminals under collaboration or license agreements.
- CRC licensed its radio wave orthogonal frequency-division multiplexing (OFDM) and medium access control (MAC) protocol for wideband radio to a Canadian company.
- CRC showcased the commercial version of its loudness meter and its 2D-to-3D video conversion technologies, among other new broadcast technologies, at the two largest broadcast conferences in the world.

ADVANCING CANADA'S GLOBAL REPUTATION AS AN ICT RESEARCH LEADER





CONTRIBUTING TO INTERNATIONAL STANDARDS DEVELOPMENT

CRC contributes to seven of the world's most influential standards-setting bodies: the Institute of Electrical and Electronics Engineers (IEEE); North Atlantic Treaty Organization (NATO); International Telecommunication Union: Radiocommunication (ITU-R) and Telecommunication Standardization (ITU-T) sectors; Internet Engineering Task Force (IETF); Wireless Innovation Forum (WInnF); Video Quality Experts Group (VQEG); and Advanced Television Systems Committee (ATSC). What's more, the expertise CRC brings to standard-setting bodies and the insight it gains in these fora are available to Canadian companies. Some Canadian firms aiming for lucrative export markets have gained a significant advantage by working with CRC.

In 2010-2011, CRC representatives served as:

- Vice-chair of the working group and lead editor of the IEEE 802.22 Wireless Regional Area Network Standard;
- Vice-chairs for the Advanced Television Systems Committee (ATSC) planning teams investigating next generation TV broadcasting systems such as 3D terrestrial broadcasting, and technologies including Internet-enabled TV receivers;
- A key member of the ITU and ATSC groups working on the development of recommended practices in loudness metering for both North American and European broadcasters;
- Chair of the ITU-R rapporteur group on loudness metering;
- Chair of the NATO working group developing the new radio interoperability standard for very high frequency (VHF) tactical communications;
- Working group and drafting group chairs (three positions) at block meetings of ITU-R Study Group 3, examining radio wave propagation;
- An associate editor of the IEEE Transactions on Circuits and Systems for Video Technology; and
- Chair of the Radio Advisory Board of Canada License Exempt Committee.
- What's more, CRC was successful in securing cognitive radio-type coexistence in the IEEE 802.16h standard approved in 2010.



SUPPORTING INTERNATIONAL CONFERENCES

Experts from more than 20 countries attended the cyber security conferences RAID, VizSec and Technology Watch, co-hosted by CRC and Defence Research and Development Canada in 2010. This was the first time these prestigious cyber security conferences were held in Canada.

CRC researchers also contributed to numerous conferences, from chairing technical tracks and serving on scientific program committees, to delivering papers, workshops and plenary remarks. The IEEE Vehicular Technology Conference, VTC2010-Fall, was one highlight. Held in Ottawa, the location allowed for CRC involvement in many facets of the program.

SHARING CRC'S EXPERTISE ON THE INTERNATIONAL STAGE

CRC joined the international research consortium High Performance Digital Media (HPDM) addressing issues related to digital media applications and services requiring large-scale, high-resolution, multipoint-to-multipoint digital media streaming.

CRC was invited to become a member in COST-TERRA, the European Union (EU) group investigating cognitive radio. Membership in this EU forum positions CRC to advance CORAL – its WiFi-based cognitive radio development platform – and to share the insight it gains with Industry Canada.

Papers and presentations on CORAL (at DySPAN 2010: the IEEE International Dynamic Spectrum Access Networks symposium; ICT 2010: organized by the European Commission; and IEEE VTC2010-Fall: the Ottawa conference featured a tour of CRC that included a demonstration of CORAL) are returning results. Eighty terminals have been produced and sold to licensees or contributed to collaborators. Research institutions around the world, including India's Centre for Development of Telematics (CDOT), are harnessing the power of CORAL. In 2010-2011 CDOT began a commercialization program employing the CORAL system in rural wireless applications.



CELEBRATING CRC'S EXPERTISE ON THE INTERNATIONAL STAGE

Awards presented in 2010-2011 included the following:

- CRC's Software Defined Radio (SDR) team was recognized with the Wireless Innovation Forum's International Achievement Award for furthering SDR technology on an international scale;
- The National Association of Broadcasters (NAB) presented CRC with the Technology Innovation Award 2011, in recognition of CRC's exhibit at NAB 2011, featuring advanced projects in broadcasting technologies that are not yet commercialized;
- Under the Technical Cooperation Program (TTCP) multi-nation collaboration in defence science, a CRC researcher was recognized for a joint investigation of limitations and vulnerabilities of using the Broadband Global Area Network (BGAN) system on the Inmarsat commercial satellite network;
- Three CRC co-authors shared a best paper award at the 2010 International Symposium on Wireless Communications Systems; and
- Two CRC co-authors shared the best paper award at the NATO Research and Technology Organization symposium, Military Communications and Networks.