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In This Issue...

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CRC President Dr. Veena Rawat retires and reflects

Dr. Veena Rawat, President of the Communications Research Centre (CRC), has retired after a distinguished 36-year public service career.

In 1974, Rawat joined the Department of Communications, a predecessor of Industry Canada. Thirty years later, she took the helm of its research arm, the CRC.

Her career spanned a period of rapid technological expansion. She was often at the centre of major policy and regulatory decisions that brought communications services to Canada and other parts of the world. Rawat helped Canada garner international recognition

CRC President Dr. Veena Rawat at her retirement party with:
1) CRC Executive Vice-President Robert Kuley;
2) The team from the President's office (from left) Gisèle Lewis, Diane Tanguay and Myrrya Murphy;
3) Helen McDonald, ADM, SITT;
4) CRC's VPs (from left) Alex Vukovic, Bernard Caron, Claude Bélisle and Jean Luc Bérubé

as a leader in communication technologies by securing spectrum for Canadian interests, promoting Canadian capabilities on the world stage, and advancing telecommunications R&D at the CRC.

At CRC, Rawat pursued every prospect to provide insight to clients, to aid in their decision making and direction setting. She worked hard to ensure the direction of CRC R&D remained aligned with clients' strategic priorities. Leading the organization through a period of federal fiscal restraint reinforced the importance of her efforts.

The trends influencing her clients included the continued convergence of telecommunications, broadcasting and the Internet, coupled with consumer demand for ubiquitous broadband access; the communications needs of the public safety and defence communities; a growing digital economy and the evolution to next generation networks; and the threat of cyber attacks.

Rawat was also a strong supporter of technology transfer, sponsoring a new technology commercialization program within the organization. Under her tenure, CRC received several awards in recognition of its tech transfer successes, and its Innovation Centre rebounded from the high tech boom of the late 1990s to reach full capacity once again.

"Veena understood CRC's great potential and demonstrated her confidence in CRC by trying to give the researchers the means to exploit that potential," says Bernard Caron, Vice-President of CRC's Broadcast Technology Research branch. "An excellent example is her support of the technology commercialization program, which aims to increase our transfer of technologies to industry."

Rawat recognizes that CRC's greatest asset is its world class research scientists and engineers, plus the teams that support them. They have given her many reasons to be proud over the years: solving problems related to the introduction of new wireless technologies; improving search and rescue satellite-aided tracking; assessing satellite communications for rural broadband; evaluating sensor networks for improved military capabilities; contributing to international standards development; introducing applications to extend the benefits of ICT to more sectors of society; advising on the impact of new broadcast technologies; equipping the regulator to monitor the airwaves during important international events; addressing emerging needs like Green ICT and cyber security; winning an Emmy award for their contribution to HDTV… Rawat's list is long.

"We are a centre of excellence in SDR [software defined radio], cognitive radio, MIMO [multiple-input, multiple-output] technology and broadcast-quality assessment," says Rawat, reflecting on CRC's contribution to ICT. "And just recently, we were involved in an e-health demonstration on CANARIE's new 100-gigabit computer network."

Highlights on the corporate front include strengthened relationships: between CRC and Industry Canada's Spectrum, Information Technologies and Telecommunications (SITT) sector; and among the teams within CRC. In addition, Rawat renewed many aspects of CRC's operations, navigating the team of research and support staff to be a more responsive organization. She also capitalized on recent opportunities for infrastructure renewal at the Shirleys Bay campus, offered through the federal government's Accelerated Infrastructure Program.

Prior to joining CRC, Rawat served Industry Canada in several capacities. She managed programs related to spectrum planning, engineering and regulations development for terrestrial and space services. Rawat made significant contributions to spectrum engineering

and the telecommunications industry both in Canada and on a global scale. It was during this period that she established her reputation for international collaboration by leading Canadian delegations, and chairing technical and working groups, at international fora.

Rawat represented Canada on several bilateral and multi-lateral groups advancing joint science and technology agendas in the ICT sector. She co-chaired the Canada-U.S. Radio Frequencies Negotiations Committee, where she was responsible for the negotiation of spectrum coordination treaties. In the International Telecommunication Union's (ITU) Radiocommunication sector she was chair of several technical committees. She chaired the 2003 World Radiocommunication Conference, for which she was awarded an ITU Gold Medal.

She currently chairs the ITU Study Group for satellite services. This group examines issues related to the efficient use of spectrum and orbit resources for all satellite services and their applications, ranging from emergency telecommunications to the provision of broadband connectivity.

"Veena is respected internationally for her wisdom, expertise and managerial abilities," says Helen McDonald, Assistant Deputy Minister, SITT sector. "She has done an excellent job representing CRC and Industry Canada at events around the world, including countless conferences where she served as a keynote invited speaker. She has ensured that CRC is truly the government's centre of excellence in communications R&D."

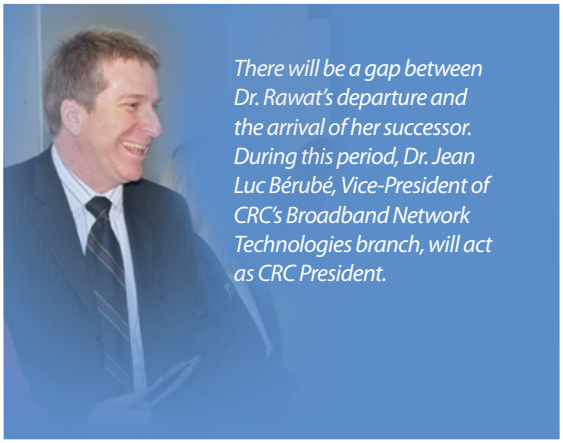
Most recently, Rawat ran for the position of Director, Radiocommunication Bureau of the ITU. She enthusiastically embraced the challenge of the election campaign. While not successful, she feels the campaign significantly increased Canada's visibility in ICT R&D and highlighted the country's leadership role in this area. Plus it was a tremendous learning experience for her.

"Learning about the ITU's election process, and about the challenges and opportunities faced by many countries around the world trying to keep pace with developments in a rapidly changing technology environment – what an opportunity," she says. "I am grateful to the government and to industry for the nomination and their support."

Throughout her career, Rawat fostered the participation of women engineers at home and abroad. She promoted hiring and developing women engineers through a university recruitment program at Industry Canada. She urged other administrations to add more women to their delegations to international meetings, and to accept women in leadership roles. She coached women on her team, enabling them to undertake roles as spokespersons and chairs of international working groups.

Reflecting on her career, Rawat hopes her legacy will be Canada's continued contribution to innovation in communications and better representation of women in areas where they are under represented.

"I sincerely hope that my extensive involvement in the telecommunications community nationally and internationally has both helped Canadian industry and opened doors for women to contribute to this exciting field," she says.



There will be a gap between Dr. Rawat's departure and the arrival of her successor. During this period, Dr. Jean Luc Bérubé, Vice-President of CRC's Broadband Network Technologies branch, will act as CRC President.

CRC's free software advances mobile broadcasting

When the Communications Research Centre's (CRC) François Lefebvre heard the news from the October 2010 WorldDMB general assembly in Belfast, Ireland, he was understandably pleased. Mathias Coinchon, an engineer with the European Broadcasting Union (EBU) and Vice Chairman of the WorldDMB Technical Committee, made a powerful demonstration of EBU's low cost digital radio broadcasting transmitter, made possible thanks to CRC-mmbTools.

Coinchon's demonstration on local radio broadcasting outlined the potential of free software platforms and software defined radio technology to advance digital radio. It took Coinchon less than €3500 to build his 10-watt experimental transmitter based on CRC-mmbTools software components. In essence, Coinchon's endorsement validated the last five years of work for Lefebvre and his modest team of two research engineers.

CRC-mmbTools consists of a number of mobile multimedia broadcasting (mmb) building blocks that have been developed or integrated by CRC: application encoders, a multiplexer and a software defined radio modulator. A unique feature of CRC-mmbTools is that it is made available as free open source software under the General Public License (GPL), the widely used free software license. With this, users can help fix, tweak and enhance the tools, and even build their own products on top of them.

As Coinchon concluded, it's good for experimentation and it enables innovation. After all, the Internet blossomed in a similar fashion. The "icing on the cake" for Lefebvre was Coinchon's closing challenge to his Belfast audience: will you participate in future enhancements? This is precisely what Lefebvre wants: more users experimenting, exchanging and expanding the capabilities of the tools.

The CRC-mmbTools live CD, the FM TwoO Android App on a mobile phone and the FM TwoO logo

"How can we maximize innovation?" asks Lefebvre. "Through collaboration. To me, free and open source software is collaboration on steroids. And since software becomes ubiquitous in telecommunications, the potential for innovation is huge."

Genesis of CRC-mmbTools

Lefebvre reflects on the origins of CRC-mmbTools. Using new broadcasting technology, the team's goal was to explore not only radio, but new applications and services for mobile multimedia broadcasting, and to enable others to do the same.

"Initially, when you have a new technology domain like digital broadcasting, you have just a few players and manufacturers, so you're limited in terms of functionality and cost of the equipment," explains Lefebvre. "Typically, a commercial transmitter would easily sell for close

to $100K. You ask yourself, 'How can I help lower the barrier to entry so that it triggers even more innovation and reaches Canadians as soon as possible?'"

Lefebvre and his team wanted to innovate, quickly, without reinventing the wheel, so they looked around and found existing software components from other people sharing their work.

"Over time, we redid the whole system that's required to do digital radio transmission with the DAB standard. We ended up with a complete end-to-end software platform, including an open source mobile phone to which we added digital radio functionality."

Lefebvre went to the WorldDMB Forum. This international organization works with the various parties involved in digital multimedia broadcasting (DMB), including broadcasters as well as equipment and receiver manufacturers, to ease the introduction of digital audio broadcasting-based services. In 2006, his offer to the technical committee to release CRC's code as free open source software evoked a cool reception. Some members felt it could disrupt their market. Today, it seems that most members recognize the positive effect of making the technology widely available.

"It allows for an organic adoption of the technology along with a more traditional orchestrated deployment: the forces of bottom-up and top-down simultaneously," says Lefebvre.

But as Lefebvre cautions, software is not everything.

"It's one part of the equation and a good basis for collaboration, but what's key is talent – the people around it."

His advice to adopters is to try to become autonomous and develop local talent.

"Build your own ecosystem within your country based on our software. When you make your software better, we ask that you contribute it back into the main code. Come back and share. Build a common core platform."

The CRC-mmbTools users' community now represents over 100 key industry players. Among users, located in countries that have either adopted DAB or are entertaining the possibility, some tell Lefebvre that without this free software, they would not have been able to afford their test or demonstration transmitters. A few keen users even launched a website to share their expertise online (*www.opendigitalradio.org*).

Along with the international recognition this brings CRC, there is a major return on investment through the insight Lefebvre's team gleans from ongoing interactions with users.

"Now, they come to us. They tell us their plans, their strategies and their challenges. We're right in the middle of the action."

With this unique perspective, CRC keeps Canadian industry partners and Industry Canada apprised of developments.

On the national front, Lefebvre's vision was to support Canadian broadcasters by offering them very low cost infrastructure tools instead of commercial products. But digital audio broadcasting is by no means sweeping this country, even though interest in the mmbTools platform remains: website hits and requests for the mmbTools live CD keep coming from all over the world, including Canada.

So Lefebvre's team has leveraged its knowledge of software defined radio and the Android operating system learned during the DAB years. They have released an FM software transmitter and the FM TwoO Android App to show the potential of FM-RDS (Radio Data System) for new, hybrid,

connected radio applications. Discussions are also underway with a Canadian university to adapt mmbTools to the emerging Advanced Television Systems Committee (ATSC) Mobile DTV standard.

"Rich from our DAB expertise," explains Lefebvre, "we are now very flexible and can integrate systems for pretty much any mobile broadcasting standard in just a few months."

"That's how we help Canadian industry – we stay in contact with them, we maintain leading edge hands-on expertise, we give them tools and we grow talent around them," says Lefebvre. "And we can ultimately offer them exclusive software licences, as we have all the rights to the code."

For more information, or to receive a free copy of the CRC-mmbTools Live CD, contact François Lefebvre, Project Leader, Radio Broadcast Systems and Transmission, at 613-991-6901 or *francois.lefebvre@crc.gc.ca.*

New flexibility in software defined radio: "plug and play" waveforms

Emergency radios enable communication. First responders rely on them every day. They come in various voice and data protocols such as AM, FM, P-25 and even some proprietary ones. But emergency radios typically do not communicate across protocols.

This communications conundrum can have devastating effects during major incidents such as earthquakes, floods, forest fires and even crowd control for sports or cultural events. Non-interoperable emergency radios – units that don't communicate – plague the various forces that need to join their efforts in an emergency.

It's a problem that takes both technical expertise and a practical approach to solve.

The challenge was presented to Robin Addison, Project Leader in Software Defined Radio (SDR) at the Communications Research Centre (CRC). In a joint CRC-National Search and Rescue Secretariat (NSS) initiative that wrapped up in 2010, he was tasked with developing a proof-of-concept for a deployable, interoperable communications terminal (DICOMT).

"Fire services, police forces – they can't afford to replace their radios all at once to ensure interoperability. Nor can they constantly purchase new ones to have access to new features brought in by the advancement of commercial applications," says Addison. "Some will replace them with the new standard, others will have old radios. You will end up with the same problem."

The deployable, interoperable communications terminal (DICOMT) developed by CRC

"That's why we are looking at solutions that bridge waveforms," he says.

Addison and his team developed an SDR radio system that not only bridges waveforms – enabling communication among AM, FM and P-25 standards – but it also provides satellite backhaul capability for communicating back to base. Their proof-of-concept terminal, if commercialized, would be very useful in search and rescue operations.

The DICOMT essentially digitizes, or converts communication to bits.

"Everything is done digitally," explains Addison. "With an analogue waveform you are putting in something that's not broken into bits. With a digital waveform you are putting in bits. You can take in voice, digitize it, and send it out as bits. You can also embed messages, and move them around to encrypt them so others can't listen."

While not a voice communication tool, the satellite backhaul is capable of transmitting a vast number of bits. The prototype terminal uses the Digital Video Broadcasting-Satellite (DVB-S) standard to send digital information – crash site video for example – via satellite back to base. And just as the broadcasting industry is moving to an improved version of the DVB-S standard, Addison and his colleagues in CRC's Satellite Multi-Media Applications and Demonstrations section will be employing the next generation of DVB-S in their projects.

"The whole idea of SDR," explains Addison, "is that different waveforms run on it like programs run on a computer. When you decide you want to get Excel on your computer, you don't have to get a new computer, you just load it on. When DVB-S2 is ready, you will just load it on. This shows the flexibility of the solution."

Along with search and rescue applications, the DICOMT project generated considerable knowledge that now becomes part of CRC's repertoire of tools for the next challenge.

DICOMT and the SCARI Software Suite

In developing the DICOMT, Addison and his team used CRC's own SCARI Software Suite and relied heavily on the expertise of the research scientists who created it. For more information on SCARI, visit ***www.crc.gc.ca/scari-software.***

"The architecture we built, the software we developed, all those waveforms are usable in any project, not just this one," says Addison. "It's an important capability that we are developing that is feeding into the next project."

In fact, Addison feels that some of the greatest success of the project has been in the tinkering and tweaking of the architecture.

"We developed a way of putting the SDR modules together to allow more flexibility. If you've got a menu of waveforms, you can pick any two and they can talk to each other with the way we connected the modules together," he says proudly. "That kind of plug and play of waveforms is a flexibility that did not exist before."

For more information, contact Robin Addison, Project Leader, Software Defined Radios, Satellite Multi-Media Applications and Demonstrations, at 613-998-8965 or *robin.addison@crc.gc.ca.*

CRC reaches new "lows" communicating through 30 metres of rock

Advancements in the telecommunications industry have enabled the delivery of several viable wireless technologies in support of a wide range of user requirements. Current applications include e-mail and video streaming on an Internet tablet or cell phone, emergency voice, video and data communication for public safety and disaster relief efforts, and tactical life-saving military missions. Regardless of the application and technology used to communicate wirelessly, they all use radios communicating by means of electromagnetic waves, which often require visible line-of-sight.

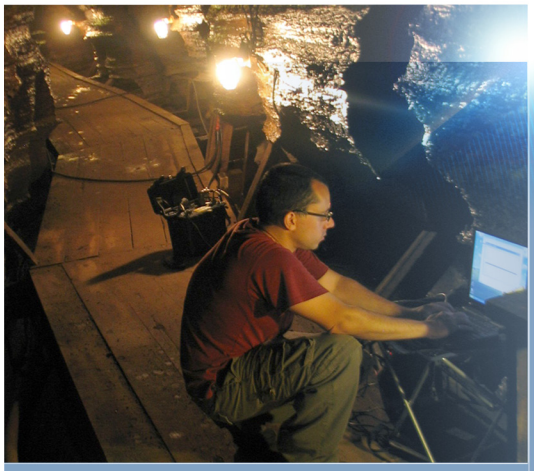
A challenge today, especially for public safety and tactical military missions, is communicating through buildings, heavy foliage, earth and even rock. Propagating waves cannot penetrate very well through these mediums due to absorption, diffraction, reflection and scattering. In trying to address this issue, the Wireless Applications and Systems Research group (WASR) of the Communications Research Centre (CRC) has been working with the Director Land Command Systems Program Management 3 (DLCSPM 3) group of the Department of National Defence (DND) to evaluate the use of magneto inductive (MI) communications. By making use of the magnetic component of a transverse electromagnetic (TEM) wave, as opposed to the electrical component, MI communication does not require a line-of-sight and can penetrate these mediums.

"Recent developments and enhancements in magneto inductive communications have caught the attention of the Canadian Military," explains Leon Anderson, Systems Engineering Consultant of DLCSPM 3. "The technology that enables communications through rock has been around for a while, but only recent implementations allow for applications such as text, voice and data."

In summer 2010, WASR researchers conducted a detailed evaluation of MI technology in various scenarios.

The technology was benchmarked using quasi line-of-sight ground level communications using three different loop antenna sizes laid on the ground for the transmit side, and the integrated built-in antenna (in the case) to receive. Using the large transmit antenna, 5-10 KB files were successfully sent over distances of approximately 700 metres. Voice and text communication was successful up to about 800 metres and roughly 950 metres respectively. The performance of the MI radio system was further evaluated by using different shapes/patterns of the transmit loop antenna, again for a quasi line-of-sight ground level deployment. As expected, the system performs best with the loop antenna deployed in a circular shape.

The ability of the radios to communicate through buildings was also evaluated for the



Researcher in cave communicating with colleague above

Bonnechere Caves

following scenarios: communicating horizontally through different buildings of various sizes, and communicating vertically through multiple floors of a building. Depending on the scenario, some tests were successful while others provided limited performance.

Researcher above ground communicating with colleague in the cave located directly below

Finally, the MI system performance was evaluated against environmental blockage. Attempts to communicate through a hillside (such as the Champlain Lookout in Gatineau Park) were successful after fine tuning both transmit and receive antenna locations. Last but not least, communication through rock inside a cave at the Bonnechere Caves in Eganville, Ontario, was successful. The owner of the caves, Chris Hinsperger, and his staff kindly supported WASR with this work.

"We were intrigued with this technology when first contacted to use the Bonnechere Caves as a test site and we were thrilled to learn that successful communications was achieved beneath 93 feet of solid rock," says Hinsperger.

The preliminary results of this work indicate that MI communications is capable of penetrating through various mediums, unlike conventional radio technologies that fail to do so in a direct point-to-point configuration. MI can deliver voice and text reliably, but is limited in its capability to transmit data due to data rate limitations of approximately 2 Kbps and maximum transmit file size of 5-10 KB before getting errors and/or the radios failing. Improvements could be made by implementing compression and Direct Modem File Transfer Protocols to enhance the radio's data capability.

When compared to today's MANET, Mesh and other relay enabled technologies, which can extend communication coverage by introducing hops while maintaining a respectable throughput, MI communication may not be the best option for public safety and tactical communication. Nevertheless, there is definitely a niche application for MI communications; it can penetrate through practically anything and reach certain areas that other technologies cannot. WASR will continue to work with DLCSPM in this area.

For more information contact Simon Perras (613-993-1779, *simon.perras@crc.gc.ca*) or Eric Lafond (613-990-2982, *eric.lafond@crc.gc.ca*), Senior Research Engineers, Wireless Applications and Systems Research.

Doyletech updates CRC's economic impact analysis

The Communications Research Centre (CRC) maintains a family tree of the companies "germinated" by its technology or its people, or those of its predecessor, the Defence Research Telecommunications Establishment. The CRC also measures the contribution of its "descendants" to the country's economy through jobs, sales and taxes.

The most recent data collection and analysis exercise was completed in 2010 by Doyletech Corporation, updating a similar study first conducted in 1995 and revisited at five-year intervals.

Spin-offs: jobs, sales and taxes

While life events like marriages and births extend the branches of a conventional family tree, CRC's variety is shaped by spin-offs, and their future mergers and acquisitions. CRC spin-offs numbered 54 in 2010, down from 62 in 2005. Employee numbers were higher however: 7,856 in 2010, up from 6,378 in 2005. Annual sales revenue was also up, to $2.6 billion in 2010; five years earlier it stood at $1.6 billion. In 2010 alone, spin-off companies contributed over $525 million in taxes from their sales revenues of $2.6 billion.

Tech transfer: jobs and sales

Doyletech determined that commercialization of technology transferred from CRC to Canadian clients resulted in the creation of employment equivalent to over 3,400 person-years between 1990 and 2009. Company products and services based on technology transfer from CRC through Canadian licensing and contract R&D generated sales revenues of $688M over this 20-year period.

Tech transfer: revenue to CRC

The Doyletech study also tracks cost recovery directed back to CRC through licensing and contracting-in. CRC generated $45M in licensing and contracting-in revenue between 1990 and 2009, $22.5M of which came from Canadian clients through 1,046 Canadian licenses and R&D contracts.

A family tree poster holds pride of place on CRC's boardroom wall. A companion piece shows a cross-section of the organization's licensing and contracting-in clients, emanating from 1990 when CRC embarked on its formal technology transfer program.

The report is available on request from *info@crc.gc.ca.*

Awards and Recognition

Natural Resources Canada's (NRCan) Earth Sciences Sector (ESS) recognized a team of problem solvers in November 2010, including CRC's Christopher Iles. Iles, along with Michael Kristjanson and Robert Roy, both of NRCan, received an "Innovations in Operations" award for their work in providing essential IT services for NRCan's most northern facility located at Resolute, in Nunavut.

The team developed a custom-designed satellite communications network for NRCan's Polar Continental Shelf Program (PCSP), which provides logistical and support services to research

(from left) Christopher Iles, Robert Roy, award presenter and ESS ADM/Acting David Boerner, and Michael Kristjanson

teams working in Canada's North. As explained in the awards ceremony program:

> The nominees worked together and redesigned the network, creating several virtual networks complementary to a single infrastructure. Now, the high-bandwidth applications are handled by a separate virtual network which is linked, via Telesat's Anik-F2 satellite. For the first time ever, the PCSP is connected to Canada's high speed research network, CANet4, providing it with the required bandwidth to function as a true research centre.

For more information on Iles's work, see Eye on Technology, Issue 11 at *www.crc.gc.ca/en/html/crc/home/mediazone/eye_on_tech/2009/issue11/polar_science*

Four PhD students working at CRC were awarded Telecommunications Hall of Fame scholarships at the Telecom Hall of Fame Gala held in Ottawa in November 2010. A $1,000 scholarship was presented to Greg Brzezina, Carleton University; Ben Smith, University of Toronto; Mohamed Haj Taieb, Laval University; and Ksenia Yadav, Carleton University.

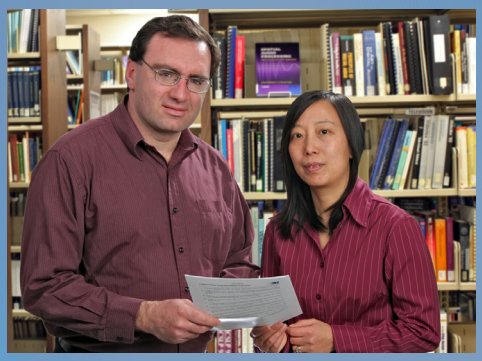
CRC's Software Defined Radio (SDR) Team was recognized with the Wireless Innovation Forum's (WInnF) International Achievement Award for furthering SDR on an international scale. The presentation took place in November 2010, at the WInnF annual technical conference, held in Washington, D.C.

"Properties of Mobile Tactical Radio Networks on VHF Bands," co-authored by CRC's Li Li and Phil Vigneron, won the best paper award at the NATO Research and Technology Organization symposium, Military Communications and Networks. The symposium was held in Wroclaw, Poland, in September 2010.

CRC's Robin Addison received an Achievement Award in recognition of a collaborative effort under The Technical Cooperation Program (TTCP).

(from left) Greg Brzezina, Ksenia Yadav, Mohamed Haj Taieb and Ben Smith

CRC's SDR team with Wireless Innovation Forum representatives (from left) Bruce Oberlies, WInnF Board of Directors Chair; Hugues Latour, CRC Research Engineer; Claude Bélisle, CRC Vice-President, Satellite Communications and Radio Propagation Research; Lee Pucker, WInnF CEO; Steve Bernier, CRC Research Manager, SDR Team; and François Lévesque, CRC Computer Researcher.



Phil Vigneron and Li Li

(from left) Robert Walker, former Assistant Deputy Minister (Science & Technology) and Chief Executive Officer, DRDC; Robin Addison, Project Leader, Software Defined Radios, Satellite Multi-Media Applications and Demonstrations, CRC; and Matthew King, Associate Deputy Minister, National Defence.

Defence Research and Development Canada (DRDC), which represents this country in the international program, hosted the awards ceremony in Ottawa in October 2010.

TTCP member nations – Australia, Canada, New Zealand, the United Kingdom and the United States – collaborate in select areas of defence science, including electronic warfare systems (EWS) and command, control, communications and information systems (C3I). C3I includes a panel of international experts on radio frequency (RF) communications, who focus on communication via satellite and terrestrial radio. Addison is the Canadian national leader for that panel. The EWS group includes a panel of international specialists in wireless communications, with a specific focus on Communications Electronic Warfare. Several experts from DRDC Ottawa are on that panel and also received the Award.

The two panels worked together to study limitations and vulnerabilities of using the Broadband Global Area Network (BGAN) system on the Inmarsat commercial satellite network. As indicated at the awards ceremony, their results "will help military communications planners advance their understanding of how BGAN can be securely deployed to achieve maximum military utility and effectiveness."

coral
Cognitive Radio Learning Platform

Research, design and build WiFi cognitive radio networks with CRC-CORAL

The Communications Research Centre is researching methods for improved spectrum use by exploiting the capabilities of Cognitive Radio. CRC is now advancing this research with CRC-CORAL – the world's first Cognitive Radio Networking Platform based on the ubiquitous IEEE 802.11a/g standards (WiFi®).

As a development platform, CORAL is being used by researchers around the world to experiment and implement radio sensing and control algorithms that intelligently control sensor networks, rural wireless networks, femtocells, and other cognitive radio applications and investigations.

Visit www.crc.gc.ca/coral for more information or 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 also aims to help identify and close the innovation gaps in Canada's communications sector by:

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