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Bridging the innovation gap, CRC demonstrates SCA applications running on Android™

The reaction to the Communications Research Centre's (CRC) late 2011 demonstration of JTRS SCA[1] public safety waveforms running on Android smartphones is still reverberating around the radio manufacturer and user communities. Trade publications are covering the news, and manufacturers are probing CRC's Advanced Radio Systems research team to better understand the potential impact.

The demonstration, held during SDR'11-WInnComm – the Wireless Innovation Forum conference on Communications Technologies and Software Defined Radio in Washington, DC, proved that smartphones are powerful enough to run even the most demanding public safety waveform.

As CRC's Steve Bernier explains, his team bridged the gap between users who want the flexibility of software defined radio (SDR) on small handsets, and manufacturers who had maintained that small handsets held limited signal processing and battery power – so not a good fit for SDR.

"We thought, how do we break this cycle – how do we stop this resistance to SDR in small devices," says Bernier, Research Manager with the team. "Users say the manufacturers won't provide it. Manufacturers tell us the users don't want it because it wouldn't last long enough or be good enough. So we figured, let's take a regular phone and put our SCARI-GT core framework on it. We'll use an external radio frequency [RF] box to control our costs for a demonstration, and if this works, all a manufacturer will need to do is add the RF part."

Objective Interface Systems, Inc. (OIS) supplied an important piece of the puzzle for this demonstration by providing CRC with ORBexpress, the communications middleware. For full technical details of the demonstration, visit **Running SCA waveforms on Android**.

Demonstration of Android smartphone running public safety waveform.

[1]The Software Communications Architecture (SCA) is a set of specifications describing the interaction between the different software and hardware components of a radio, and providing software commands for their control. The SCA was developed by the U.S. Department of Defense Joint Tactical Radio System (JTRS) project. An early adopter of the SCA, CRC has been involved in the evolution and adaptation of the specification.

Because smartphones cannot transmit in the same frequency range as commercial hand-held radios for public safety, Bernier and his team found an RF box to cover all the frequencies they needed. They connected the RF box to a Wi-Fi access point. Once the phone had completed all of its signal processing, voice was sent via the Wi-Fi link to the RF box that served as the antenna to radiate the signal.

The demonstration was a success, leaving some at SDR'11-WInnComm in shock.

"Some manufacturers came to our booth and said, 'it works with your demo phone, but will it work with mine?' We asked them which frequency they're on, we entered that frequency on our phone and it worked with theirs," says Bernier. Following two impromptu demonstrations like this, the requests stopped, as radio manufacturers connected the dots of their new reality.

"I had to assure them that CRC is not in the business of selling this; it's just a scientific demonstration of what can be done with today's technology," he says.

Others connecting the dots during the demonstration included members of the military community, who envisioned potential use of the technology **with** the separate RF box.

"We thought this was impractical, but the military crowd said, 'this is the first time we see a dismounted soldier as a software defined radio,' the advantage being that SDR can be reconfigured on the spot to adapt to multiple situations," Bernier points out.

Dismounted soldiers must maintain communication and situational awareness, including position, relative position of comrades and command, and enemy location. With an RF box packing plenty of energy back in a vehicle, this set-up could provide efficient and light-weight communication and navigation solutions, as well as other utilities.

Similarly, first responders could use their "smart-phone-turned-smart-radio" to switch from commercial networks to their own private networks, while continuing to have access to the plethora of other Android applications.

After proving the proficiency of SDR in small devices, Bernier and his team are exploring ideas generated in the lead-up to the demonstration, during the event and since returning home.

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Forging the future of broadcast television — CRC, a founding member of FOBTV

Just as television programming can provide viewers with a window on the world, a conversation with Bernard Caron, Vice-President of the Communications Research Centre's (CRC) Broadcast Technology Research branch, and Dr. Yiyan Wu, Research Scientist in the Television Networks and Transmission group as well as Editor-in-Chief of the *IEEE Transactions on Broadcasting*, provides a window on the future of terrestrial broadcast television.

CRC participated, as a founding member, in the Future of Broadcast Television (FOBTV) Summit, held in Shanghai in November 2011. Fellow organizers included leading broadcast television associations, research laboratories and standards development organizations from around the world.

The international gathering featured the Europeans, where broadcasters use the Digital Video Broadcasting (DVB) standard; the Americans, who follow the Advanced Television Systems Committee (ATSC) standard; the Japanese, who use the Integrated Services Digital Broadcasting (ISDB) standard; the Chinese who follow the Digital Terrestrial Multimedia Broadcast (DTMB) standard; among other players.

"They were all in the same room talking a similar language," says Caron. "They all want that."

What they are aiming for is some commonality to support today's realities, which include intercontinental travelers with mobile devices operating in a limited spectrum environment. (See the **FOBTV Shanghai Declaration**.)

"Right now, if you bring a radio to any country, it works; if you bring a TV, don't even think about it," says Wu. "In the future, hopefully you can bring your hand-held TV and get a signal. That's good for the consumer."

While the parameters of a common platform have yet to be determined, the role of the FOBTV group is cast.

"FOBTV is not going to be a standards body; it's for a broader purpose – for people all over the world to discuss and the results will be fed to the standards groups," says Wu. "It will bring tools, ideas, recommendation and suggestions to the table, and this exchange should shape standards so they're as common as possible."

(Top) CRC's Bernard Caron delivers Broadcast 3.0 at FOBTV Summit 2011 in Shanghai.

(Bottom left) FOBTV Summit host, Pingjian Xia, President of the National Engineering Research Center of Digital Television, displays the joint declaration, carved into a bamboo scroll, with CRC's Yiyan Wu (right).

One broad consideration is the role of terrestrial (i.e., over-the-air) broadcasting, or any point-to-multipoint multimedia service for that matter, in the Internet age.

"Spectrum is the key issue and at the end of the day, that's why we're there," says Caron. "When you have information that's needed by a large number of people, the most efficient way to deliver it is broadcasting – you send the signal to everyone."

Today, TV over the Internet is a one-to-one connection, while Internet Protocol Television (IPTV) is similar to a cable or satellite service. Terrestrial broadcasting is one-to-many, instantaneous and local.

"This has some advantages," explains Caron, on a day of a snow storm. "When a lot of people want to use it at the same time in a given location, for local weather and news for example, it's particularly useful because one-to-many is an efficient use of spectrum."

What's more, as Caron points out, Internet and cellular carriers charge for data delivered over one-to-one connections, while terrestrial television has traditionally been delivered for free. Another advantage of terrestrial broadcasting is that it's wireless – there is no cord attached.

"In an emergency situation, terrestrial broadcasting is often the only infrastructure that can reach people because their cable is dead, their telephone is dead," adds Wu. Emergencies aside, he points to the Super Bowl to substantiate the enduring popularity of broadcasting.

"A 30-second advertising spot on the Super Bowl costs $3.5 million and they're sold out, so people are still watching. Try reaching this number of people, live, over the Internet; it would be a problem."

While a big game or a big disaster draws a big audience, audiences are increasingly fragmented given more choice. To accommodate highs and lows in viewership, Caron envisions a platform capable of seamlessly adapting how information is delivered, depending on the need.

"What we are trying to do with FOBTV is develop an over-the-air broadcast mode of one-to-many that will transmit information to a large area and a lot of people when the need arises," he explains, "and seamlessly return to a one-to-one Internet mode when consumer demand shifts back to niche programming choices."

So when will seamless shifting and intercontinental device portability be possible? In five to ten years, predict Wu and Caron, who both addressed the Summit.

CRC Presentations

Advances in cloud transmission, the subject of Wu's presentation, could make this happen. Cloud transmission is a new terrestrial digital broadcasting transmission system that enables spectrum reuse. The system overcomes technical problems including co-channel interference and multipath distortion. It also eliminates TV white-space – the channels left unused by TV broadcast allocation plans in various areas to ensure an interference-free environment, but space that has branded broadcast spectrum as "inefficient."

Under the cloud transmission broadcasting system, all radio frequency (RF) channels in one city are available for broadcast service, thus increasing spectrum efficiency by three to four times. And its simple receiver is energy efficient. The system provides mobile and fixed / indoor reception. What's more, it is scalable and can be implemented progressively, thereby easing a transition.

The system cannot compete with cable, satellite and IPTV systems on data capacity, however. But these systems will be integrated with terrestrial broadcasting, so that people can always access various types of information using the most convenient link available.

"In many countries around the world, over-the-air is still the main way of receiving TV, which is different from Canada," Caron points out. "Similarly, your home phone always works here. But in many places around the world, cellular phones are much more convenient and reliable."

The lack of infrastructure has fuelled cell phone penetration rates in developing countries. As the future of broadcast television unfolds, what effect will this have in developing countries?

"The idea is that over-the-air will be more than TV, that this will be the Internet for everyone," says Caron, pointing to a bamboo scroll of the Shanghai Declaration, specifically to the passage that recognizes the 21st century as an era of integration of broadcasting, Internet, and communications for all.

Caron's position as VP in charge of broadcast technology research provides him with a perspective that spans not only the range of CRC's capabilities – satellite communications, terrestrial wireless, multimedia broadcasting and broadband networks – but also how technologies can work together to form an efficient seamless communications network. He brought this perspective to his FOBTV Summit presentation, *Broadcast 3.0*. Caron described new television distribution models and the role now played by wireless communications networks. He highlighted the response of the broadcasting industry to these challenges, as well as specifications for the broadcasting systems of the future. He also outlined roles of the FOBTV and the contributions from broadcasting to the future of television distribution.

Next Steps

Wu ended his FOBTV presentation with a call to action: "There is a lot of work to be done! We are open to collaboration with research labs and industries!" To this end, he recently met with his counterparts at the Electronics and Telecommunications Research Institute (ETRI) in Korea.

"ETRI has set 2018 as a target for demonstrating cloud transmission – the year Korea hosts the Winter Olympics," Wu points out.

In the short-term, Caron will be reporting back to the Canadian Digital Television Technology Group (DTV-TG), which provides decision-makers in government (e.g., Industry Canada, Canadian Radio-television and Telecommunications Commission) and industry (e.g., broadcasters and manufacturers) with the technical information they need to advance. The next meeting of the FOBTV will take place during the National Association of Broadcasters show in Las Vegas in April.

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CRC researchers dig in the technology "sandbox"

A group of researchers from the Communications Research Centre (CRC) working in the area of Software Defined Networking (SDN) recently got to "play in the sandbox." But instead of using shovels and pails, they had the chance to try out some slightly more sophisticated SDN tools.

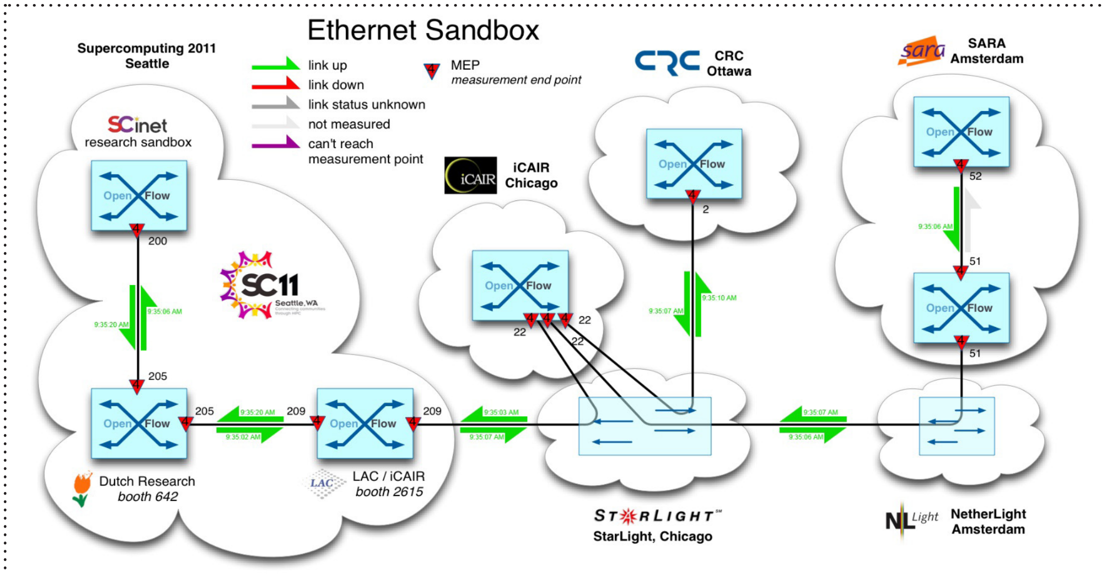
CRC took part in a special program called the SCinet Research Sandbox (SRS) at the SC11 International Conference for High Performance Computing, Networking, Storage and Analysis (www.sc11.supercomputing.org), held in Seattle in November 2011. SCinet is the primary network infrastructure built each year supporting the over 10,000 SC conference attendees and exhibitors who show off their cutting-edge computing applications and collaborations. At SC11, the sandbox provided researchers with access to 100 Gigabits per second (Gbps) dedicated links, as well as a 10 Gbps multi-vendor OpenFlow network test bed.

"OpenFlow is the 'open' protocol to control the traffic flows of multiple switches from a centralized controller, and is an example of Software Defined Networking," says Michel Savoie, Research Manager for Broadband Applications and Optical Networks at CRC. "It was first developed at Stanford University to allow researchers to run experimental protocols using the campus network without requiring frequent, ongoing changes and authorization from the university's IT department."

Savoie says that as researchers look ahead to the future of networking, they anticipate a strong demand for increased flexibility and for network resources to be shared among many users.

"SDN is an evolving area of technology research that seeks to meet the increasing demand for 'network virtualization,' which is one of the key attributes of next-generation networks," says Savoie. "Networks will soon need to be capable of transforming themselves 'on the fly' to dynamically accommodate the needs of their users."

To help CRC clients usher in such advancements, Savoie's group set up a Virtual Infrastructure-based Services, Technology and Applications (VISTA) laboratory at CRC, which enables his research team to experiment with emerging SDN technologies and develop a stronger



Dynamic web page representing live link status information for the Layer 2 network used for the second demonstration showcasing the Ethernet OAM features.

Canadian presence in the global research focus on SDN. CRC's VISTA Lab includes wired networks as well as a diverse set of wireless access technologies that will interconnect a rich and diverse array of communication devices.

At SC11, the Ottawa-based VISTA lab was linked to the OpenFlow test bed in order to carry out two live demonstrations in Seattle. First, CRC joined research partners including the National Center for High-Performance Computing (NCHC in Taiwan), iCAIR at Northwestern University (Chicago) and SARA High Performance Computing and e-Science Center (Amsterdam) for a demonstration of an automatic network topology discovery mechanism, based on the Link Layer Discovery Protocol. OpenFlow was expanded to include additional capabilities to enable federated domains, and allow individualized and hybrid networks.

"This demo illustrated how nodes can come up and down for ad hoc networking purposes," says Savoie. "It also showed viewers how a user can utilize OpenFlow to dynamically identify the possible routes to get to a particular destination on the network."

The second demonstration, which involved CRC and research partners SARA and iCAIR, showcased how OpenFlow can be utilized by end users to easily add new network protocols to OpenFlow switches. Protocols – in this case IEEE 802.1ag protocol for Ethernet OAM[1] – implemented in an OpenFlow controller once could then be used with any switch that supports the OpenFlow API[2] to enable the protocol on that switch.

"With this demo test bed spanning Europe, Canada and the U.S., Layer 2 OAM capabilities, like those offered at Layer 3 for IP measurements such as ping, traceroute and pathchar, have been successfully demonstrated," says Savoie. "These OAM features will be extremely beneficial in terms of diagnosing the network, monitoring services and verifying their end-to-end performance."

During the demo, an Ethernet "ping" was sent out over the Layer 2 network to show if the node, or link, was up or down. The signal or ping enables the user to receive packets with information about the status of the node and link between the source and destination MAC[3] addresses. Ottawa-based CRC disconnected its link so that viewers at the conference in Seattle could see the visual interface depicting that the link was no longer available through a dynamic web page using network metrics collected by the perfSONAR application. A web services-based infrastructure for end-to-end monitoring and trouble-shooting of multi-domain network performance, perfSONAR stands for PERFormance Service Oriented Network monitoring ARchitecture. It can be used to test and measure network performance, as well as archive data in order to pinpoint and solve service problems that may span multiple networks and international boundaries.

[1] operation, administration and maintenance
[2] application programming interface
[3] medium access control

For more information, contact Michel Savoie at 613-998-2489 or michel.savoie@crc.gc.ca.

CRC showcases technology solutions for public safety at CITIG

CITIG – the **Canadian Interoperability Technology Interest Group** – brings together representatives from public safety, industry, academia, government and non-governmental organization to collectively shape the future of Canadian public safety communications interoperability. In December 2011, the Communications Research Centre (CRC) participated in CITIG's Annual Public Safety Interoperability Workshop.

This included a number of technology demonstrations delivered during the exhibit portion of the program.

"With CRC's solid track record in communications technologies, it was rewarding to showcase a number of R&D initiatives CRC is working on to advance public safety communications systems," said Claude Bélisle, Vice President of CRC's Satellite Communications and Radio Propagation Research branch, reflecting on the workshop.

CRC's demonstration of P25 running on an Android™ smartphone "opens up a world of possibilities and flexibilities, particularly for first responders," says Claude Bélisle.

"A consumer-grade Android phone connecting directly with a public safety P25 radio is a prime example," added Bélisle, referring to the technical feat described in this issue's cover story. "This innovation opens up a world of possibilities and flexibilities, particularly for first responders."

Martin Phisel, a researcher engineer with CRC's Advanced Radio Systems team, treated CITIG delegates to a demonstration of P25, the most demanding and complex of the public safety waveforms, running on an Android smartphone.

Interoperability overview

Large scale emergencies drawing on resources from across regions, or search and rescue operations involving land, sea and/or air resources, are among the situations that can pose radio interoperability challenges. Similarly, national forces using distinct communications networks face interoperability obstacles when working together on international missions.

But different forces have distinct radio procurement policies and priorities. Short of interjurisdictional forces launching a joint procurement process for common equipment, technology must be developed to "bridge" the communications chasms that can exist within the same country. When countries co-operate on a military mission, communicating across their respective networks also presents hurdles. At the network level, common standards and protocols are the most practical solutions.

At the device level, a solution is software defined radio (SDR) technology. For two radios to communicate, both must send and receive information using the same waveform and frequency. Traditionally, these have been fixed in the radio's hardware, so forces using different hardware-centric radios could not communicate. When signal processing is carried out by software, such as in SDR, a single radio handset can transmit and receive new waveforms by simply downloading the software needed to process that particular waveform. SDR is, in essence, a mini-computer that transmits and receives over multiple frequency bands.

CRC's Semra Gulder, project leader in Network Systems, was joined by a researcher from the Royal Canadian Mounted Police (RCMP) in a demonstration of interoperability over federated networks over IP, which allows organizations to be technologically independent, yet interoperable. The solution provides voice, video and data, and allows phased elimination of legacy systems. CRC was instrumental in the design and validation of the NATO Tactical Communications (TACOMS) interoperability standards. It also helped the Canadian Army become interoperable with coalition partners, and provided an interoperability solution between Canadian Army and RCMP radios. Similar architecture is currently being deployed between the RCMP and United States Border Patrol along the Canada-U.S. border.

Martin Phisel also demonstrated the Satcom Gateway, developed by CRC's Satellite Multimedia Applications and Demonstration team for enabling search and rescue communications. The SDR-based system bridges some of the various waveform standards that first responders may bring to a search and rescue operation, namely AM, FM or P25. The system offers high-speed satellite backhaul for communicating back to base. The team is also working to interface with a smartphone network, offer Wi-Fi access, and integrate the system's geo-location functions with that of COSPAS-SARSAT.

CRC's CITIG demonstrations showed that not all public safety communications challenges relate to interoperability. Richard Boudreau and Dr. Hossein Najaf-Zadeh, both project leaders in CRC's Advanced Audio Systems group, demonstrated a number of voice enhancement processing techniques that can improve the quality of communications links for first responders who have to operate within a noisy environment, and make quick decisions based on what they hear. Video enhancement processing is also available from CRC. While not demonstrated at CITIG, CRC is working with the RCMP to optimize its outdoor video surveillance systems and enhance video quality.

For more information on innovation to advance public safety, visit www.crc.gc.ca or contact Claude Bélisle at 613-998-2605 or claude.belisle@crc.gc.ca.

1) 700 MHz system assembled on a 7-metre mast with 2.4 GHz Wi-Fi hot-spot that gives access to image sensors (cameras). 2) CRC personnel Li Pan (left) and Larry Stone (right) installing the 700 MHz radio box 22 km from CRC. 3) 700 MHz radio box.

CRC demonstrates reach of wireless 700 MHz long-range system for public safety regional coverage

Excitement over the upcoming release of 700 MHz spectrum is not confined to the commercial sector; the public safety community is also eager to expand its capabilities with some of the sought-after spectrum, known for its superior propagation properties.

In anticipation, the public safety community has commissioned a feasibility study on the technical possibilities at 700 MHz, so they can be better positioned to capitalize on its capabilities when they receive a slice of the spectrum. Defence Research and Development Canada's (DRDC) Centre for Security Science is one government partner enlisting the expertise of the Communications Research Centre (CRC).

In December 2011, CRC showcased a packet radio system operating over long distances using existing Wi-Fi technology. Researchers' innovative use of Wi-Fi – constrained to 5 MHz bandwidth over 700 MHz licensed spectral allocation, and employed in a multi-hop mode as opposed to point-to-point or point-to-multipoint fashion – allows for a possible expansion towards a true mesh network for long-distance packet radio.

The packet radio system demonstrated by Andre Brandao, Research Engineer and Project Leader in CRC's Broadband Wireless team, connects CRC, via cameras, with two other sites: one 22 km to the east, and the other 7 km to the west. The system is energy efficient and transmits around 1.5 Mbps with powers below 400 mW while consuming less than 7 W to operate each node. In remote locations it could operate with a solar panel.

"CRC's work is useful because it helps answer the question: what is the lowest price and simplest system one can possibly assemble for a certain minimum broadband performance," says Brandao. "This benchmark data helps public safety personnel with test systems in advance of LTE procurement, by educating them of the capabilities they can expect from suppliers when procuring high-end communications in the very near future."

Long-Term Evolution or LTE, the fourth generation (4G) of cellular networking technology, promises uploading speeds of 50 Mbps and downloading speeds of 100 Mbps. It is expected, but not yet confirmed, that public safety communications networking in 700 MHz spectrum will evolve to LTE.

Squeezing more capacity out of LTE

Officials attending the demonstration were also advised that in future, they can expect LTE with cognitive radio capabilities. John Sydor, Broadband Wireless Research Manager, is spearheading research into Wi-Fi based cognitive radio for, among other uses, long-range applications.

As Sydor reported, collaborators around the world are using CRC-CORAL – the world's first cognitive radio networking platform based on the ubiquitous IEEE 802.11a/g standards – 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.

By modifying off-the-shelf Wi-Fi equipment, Brandao and his colleagues assembled the system for roughly $600. While this low-cost surveillance solution is not a production model, but a research model, it serves to demonstrate what video surveillance delivered at 1.5 Mbps looks like, and what it costs – important yardsticks for officials going forward.

Police, public safety and defence officials attended the demonstration, which served as milestone nine as defined in the project: "Asymmetric Threat Mitigation in the Great Lakes, St. Lawrence Seaway and Maritime Ports and Inshore Waters."

This work was supported by the Public Security Technical Program (PSTP 02-341), which is managed by Defence Research and Development Canada – Centre for Security Science.

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Jack Belrose appointed to Canadian Amateur Radio Hall of Fame

CRC emeritus researcher Dr. John (Jack) Belrose has been appointed to the Canadian Amateur Radio Hall of Fame, in recognition of his long and distinguished career as a radio pioneer in Canada, both as a professional and as a radio amateur. His extensive research in antennas and propagation at CRC led to many applications in amateur radio. Belrose has written over 150 papers for professional publications and books, as well as numerous magazine articles.

Radio Amateurs of Canada (www.rac.ca) recognizes deserving Canadian radio amateurs through the Canadian Amateur Radio Hall of Fame.

Richard Ferch (left) welcomes Dr. Jack Belrose (right) into the Canadian Amateur Radio Hall of Fame.

CRC at the 63rd annual Technology & Engineering Emmy Awards

The collective effort involved in the standardization of loudness metering for use in broadcast audio was recognized with an Emmy award, presented at the 63rd annual Technology & Engineering Emmy Awards in January 2012.

(Top, encircled) CRC alumnus researcher Dr. Gilbert Soulodre (left) of Camden Labs and CRC's Advanced Audio Systems research manager Louis Thibault (right) were among those accepting awards in Las Vegas. Others were (l-r) François Rancy and Christoph Dosch of the International Telecommunication Union (ITU), along with Craig Todd and Steve Lyman of Dolby Laboratories.

(Bottom) Back in Ottawa, Thibault shared CRC's Emmy with Advanced Audio Systems colleagues Dr. Scott Norcross (left) and Michel Lavoie (centre). Norcross has served as Chair of the ITU-R Rapporteur Group on Loudness Metering since 2009.