



Communications
Research Centre
Canada

An Agency of
Industry Canada

Centre de recherches
sur les communications
Canada

Un organisme
d'Industrie Canada

Communications Research Centre Canada | Highlights 2003 - 2004

Innovation without Boundaries



Canada



An aerial photograph of a city, likely Ottawa, is shown in a yellow-tinted style. The image is overlaid with several white, flowing, abstract lines that sweep across the scene, suggesting movement and connectivity. The lines are most prominent on the left side of the page, where they curve and loop around the city's buildings and streets.

About The Communications Research Centre Canada

The Communications Research Centre Canada (CRC) is the leading federal laboratory for research and development (R&D) in advanced telecommunications. An agency of Industry Canada, CRC focuses on the technologies that form our nation's basic communications - radio, satellite, broadcasting and fibre optics. Within these key areas, CRC works in collaboration with public, private and academic sectors, both in Canada and abroad.

Through its many partnerships, CRC is bridging the gaps in Canada's telecommunications sector. This means sharing our technical intelligence and providing independent advice to help shape public policies and regulations. It also reflects CRC's emphasis on assisting small- and medium-sized enterprises through technology transfer and commercialization.

Most of all, CRC aims to innovate - to help shape the future of Canadian communications. CRC's talented research force is breaking down technology barriers to bring broadband services to all regions of Canada, especially under-served rural and remote areas. CRC is expanding Canadians' access to education, healthcare and global business opportunities.

Through innovation in communications, CRC is pushing the boundaries to create a better future for Canadians.

Message from The Chair

Dynamic. Fast-paced. Innovative.

These are just a few of the words that spring to mind when reflecting on this past year at the Communications Research Centre Canada (CRC). CRC is a federal laboratory whose excellence in telecommunications R&D not only has a great impact on Canadians, but also plays a key role in shaping applications of future communications technologies across the country and around the world.

CRC provides communications technology expertise and advice to its government clients, primarily Industry Canada, the Canadian Space Agency and National Defence. Working closely with these clients and other organizations, CRC translates research into real solutions and contributes to sound decision-making on policies and standards - two qualities that make CRC an asset to its clients and partners.

CRC had a number of notable technical achievements this year. MILTON, an experimental wireless access network designed to provide broadband services to remote areas, has been further developed by CRC and is now ready for field trials with industry. CRC was recognized for its advancements in Software Defined Radio (SDR), and now offers a complete portfolio of software tools for the development of SDR technology by industry. In the area of Digital Television, CRC has developed a datacasting system for data and multimedia transmission over digital television channels, for use in broadcasting as well as rural and remote broadband access.

None of these accomplishments would have been possible without the commitment of CRC's clients, employees and Board members. This team effort ensures CRC's position as Canada's national centre of excellence for communications R&D.

Congratulations to CRC for a successful year - it is an honour to work with such a committed and experienced team.

Dr. Alan E. Winter



Alan Winter

Message from The President

The past year has brought a flurry of technical achievements, recognition of the innovative talent of our staff and many positive changes for the Communications Research Centre Canada (CRC).

Collaborative R&D remains at the heart of CRC. We have continued to work closely with our federal, industrial and academic partners towards the collective goal of advancing communications technologies in Canada. The recent launch of a new, national wireless partnership is just one example of the results this cooperative approach has yielded over the past year. As the following pages illustrate, CRC has produced many technological accomplishments that span the core areas of our expertise. CRC is proud to uphold its reputation as the Government of Canada's number one laboratory for technology transfer to industry.

Scientific achievements and discoveries are a team sport, and CRC's roster of dedicated men and women and their collective hard work create a winning combination. Last October, we celebrated the achievements of those researchers whose inventions have gained distinction through the granting of Canadian, U.S. and worldwide patents.

The year 2004 began with a new federal innovation agenda based on the theme, "Building a 21st Century Economy". The message was clear – Canada is striving to position itself among the world leaders in developing and applying path-breaking technologies of the 21st century, including information and communications technologies. The government also reinforced that we must do more to ensure that our scientific knowledge is converted to commercial success.

CRC has embraced these ideas and is ready for the challenge. The importance of communications will inevitably grow and we must respond to the constant changes in our economic and technology environment. We look forward to playing a major role, along with our partners, knowing that our work is ultimately improving the quality of life for Canadians.

J.G. (Gerry) Turcotte



J.G. Turcotte

Technology Achievements



Technologies for Rural and Remote Broadband Access

In 2002, CRC launched the Rural and Remote Broadband Access (RRBA) Program to research and develop cost-effective technologies for bringing broadband services to Canada's rural and remote areas.

In 2003-2004, the RRBA Steering Committee awarded \$830,000 in seed funding to 11 out of 16 project proposals submitted by CRC's research groups. The year's accomplishments included:

- Significant advances in reducing the cost of satellite earth terminals related to Ka-band technologies. These advances will enable field trials as Anik-F2 Ka-band transponder capacity becomes available;
- Progress on the use of licence-exempt technologies for point-to-multipoint broadband distribution in the 5 GHz range resulted in the MILTON (Microwave-Light Organized Network) system being readied for field trials; and,
- Advances in the area of broadband access through digital television (DTV). Next year, the DTV projects will be consolidated to develop a complete system prototype for demonstrations and field trials by 2007.

Projects in the RRBA's third year will focus on:

- MILTON field trials for high-capacity broadband access in suburbs, rural towns and villages;
- WiFi® below 1 GHz for extension of the "hot spot" concept to less densely populated rural areas, for fixed and nomadic use;
- DTV-based broadband access for low-cost deployment of broadband in less densely populated rural areas using DTV receiving equipment; and,

■ Ka-band technology to reduce the equipment and installation cost of broadband access earth terminals. CRC also provided technical support to

two Industry Canada programs that are addressing the extension of broadband access to rural and remote areas – the Broadband for Rural and Northern Development pilot program and the National Satellite Initiative.

Wireless Systems

- **Spectrum** – New research investigated adaptive approaches for spectrum use, particularly at frequencies below 1 GHz. The concept involves the use of non-contiguous unoccupied radio channels in which signal waveforms adapt to the propagation and interference environment. CRC researchers developed a flexible OFDM waveform concept that is highly suited to non-contiguous variable bandwidth operation.
- **Antenna research** – Multi-layered antenna structures were developed to solve transmit/receive isolation issues for multi-beam antenna systems. Spatial power combining techniques were studied in collaboration with universities, and a high gain reflect array structure was developed to generate circularly polarized antenna for small satcom terminals.
- **Broadband Services** – Researchers continued to develop technology for the MILTON system, a new high-speed wireless link technology. Field trials will be conducted near Ottawa in 2004-05. Cognitive software, which includes interference mitigation, network control and power control, will be developed and tested in the second stage of the trial.

- **Ultra Wideband (UWB)** – Evaluation continued on the cumulative effects that UWB device emissions have on the ambient noise levels of the electromagnetic environment. An electromagnetic compatibility assessment methodology was developed to determine the potential interference of UWB devices on radio communication systems, and to measure potential interference of UWB on cell phone systems.
- **Multi-Input Multi-Output (MIMO)** – CRC developed an experimental MIMO system for channel characterization and testing of signal processing concepts for mobile communications. Signal processing advances include the development of adaptive channel-tracking and iterative algorithms for high-capacity MIMO communications, and the evaluation of generic algorithms for multi-user detection using antenna arrays. MIMO systems promise capacity and performance gains for both civilian and military communications applications, particularly in urban areas.



“For the Canadian broadcasting industry, CRC is a treasure-trove of world-class and globally-acknowledged expertise, internationally-accepted laboratory facilities and expert independent evaluation and testing facilities.”

Broadcast Dialogue, November 2003

- **Monolithic Microwave Integrated Circuit (MMIC)** – CRC hosted three National Science Council researchers, in collaboration with Taiwan, to study efficiencies in delivering broadband services to rural and remote areas using 30 GHz satellite systems. The team developed several MMIC designs incorporating novel uniplanar structures that demonstrate the feasibility of producing much smaller integrated circuits.
- **Software Defined Radio (SDR)** – CRC continues to gain worldwide recognition for its expertise in SDR, a new radio technology that will help police, firefighters and other emergency personnel communicate with each other during a crisis. Since producing its open-source reference implementation of the Software Communications Architecture (SCA) in 2002, CRC has developed a complete portfolio of software tools for developing SDR technology. Within Canada and abroad, CRC has provided instructional courses to industry, licensed its tools and participated in the improvement of the SDR standards.

Broadcasting and Interactive Digital Multimedia

- **Digital Television Transmission** – CRC conducted field tests in Montreal following similar ones in Ottawa to confirm the indoor reception quality of DTV within cities. The tests were performed in collaboration with the Canadian Broadcasting Corporation (CBC) and Canadian Digital Television.



- **Multiple Transmitter Networks** – CRC continued working with the Advanced Television System Committee in the U.S. to develop a Recommended Practice for Design of Multiple Transmitter Networks. Once in place, these networks could significantly increase the coverage of digital television services, making it easier to implement multimedia broadcasting and other new services.
- **Single Frequency Network** – CRC installed the Digital Television Single Frequency Network in downtown Ottawa. This innovative network configuration could result in better DTV coverage using less spectrum.
- **CRC-PREDICT** – The CRC-PREDICT propagation model was further validated by comparing measurements with predicted contours and analyzing the discrepancies between the various versions of the CRC-PREDICT propagation model presently in use by licensees. The evaluation resulted in an improved version of the software that is more accurate.
- **CRC-COVLAB** – CRC developed a new module in CRC-COVLAB coverage prediction software, accounting for antenna polarization and cross-polarization discrimination in the predictions.
- **Digital Audio Broadcasting (DAB)** – CRC has completed the first version of an experimental DAB datacasting inserter called CRC-Dr.MUXLAB. This flexible platform allows development and testing of DAB datacasting applications and services. Its software-based architecture enables many typical DAB services to be generated and multiplexed on a single PC.
- **Compression Technology** – CRC developed a new image compression algorithm based on a novel idea it calls *Curved Wavelet Transform*. This algorithm performs better than current compression technologies such as JPEG-2000.

- **Video-Telephony** – CRC completed experiments to examine the role of scene background, focal lengths, and scene contents on perceived naturalness and sense-of-presence in stereoscopic video-telephony.
- **Digital Television (DTV)** – CRC worked on the development of a DTV datacasting system to investigate data and multimedia transmission over digital television channels, for multimedia broadcasting as well as rural and remote broadband access applications.

Photonics Technologies

- **Bragg Gratings** – CRC developed a new process to fabricate high-quality Bragg gratings in optical fibres and crystals. The technique does not require the target material to be photosensitive in the traditional sense, making it useful for high temperature sensor applications. The work resulted in five publications in international peer-reviewed journals, three international peer-reviewed conference publications, the formal filing of one U.S. patent, a filing of a continuation in part on that patent, and the provisional filing of a third U.S. patent. Collaborations with several national and international labs have also been established.
- **Optical Switching** – CRC has designed and fabricated prototype, waveguide switches to demonstrate optical switching. These injection current-based switches have on-off extinction ratios of better than 20dB and exhibit sub-microsecond switching times, several

orders of magnitude faster than those currently available with commercial optical switches. The potential applications for broadband optical networks are significant, including network re-configuration and fault restoration.

- **Fibre Fabrication** – Ultra-long fused-tapered fibres (up to 90 mm in length, 1 micron in diameter) have been successfully fabricated, in collaboration with local universities and government labs. Potential applications include the generation of frequency combs, used for frequency standards and broadband optical sources.

- **Planar Lightwave Circuits (PLCs)** – Materials for PLCs have been developed and characterized and devices incorporating these optimized materials are being designed and fabricated for both in-house projects and outside clients. Applications include process optimization through refractive index monitoring, Bragg grating inscription and Mach-Zehnder devices for optical network functions.

Network Security

■ **Research Network Systems (RNS) Prototype Network Analysis and Monitoring**

– CRC continued to modify and enhance this monitoring tool, in partnership with the Defence R&D Canada Information Operations Section. Research on active and passive monitoring focused on the use of the passive network monitoring tools together with intrusion detection systems to obtain a

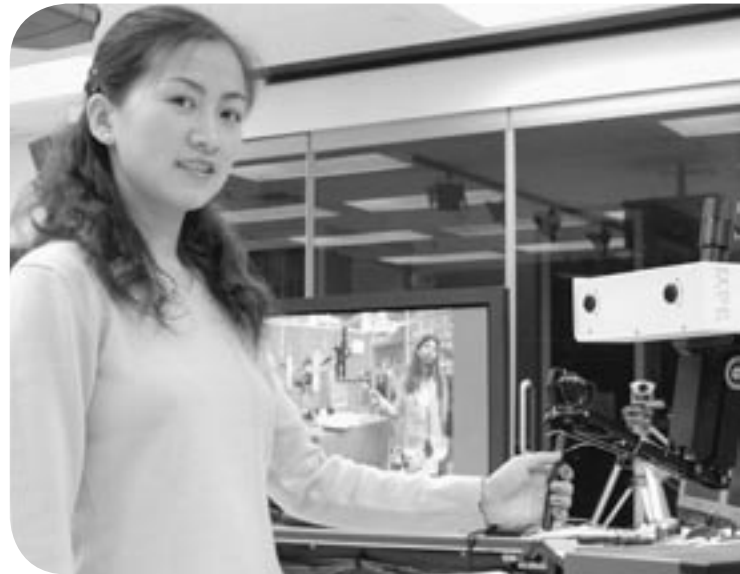


real-time picture of network status under the threat of a cyber attack. This capability could alert defence organizations to a cyberwarfare situation, while helping civilian organizations protect critical network infrastructure.

- **Mobile Ad Hoc Network (MANET)** – CRC and the British Columbia Institute of Technology collaborated on the investigation, implementation and demonstration of MANET secure routing, as well as initial investigations into secure authentication techniques for entry to mobile ad hoc networks.

Application Demonstrations

- **Broadband Book Club** – Two successful events took place in collaboration with Library and Archives Canada and school libraries across Canada. The Broadband Book Club is developing tools to provide broadband cross-Canada access to the Library collections. These tools could also stimulate multi-site, interactive discussion forums on Canadian literature.
- **MusicGrid** – The \$1.6M CANARIE-funded MusicGrid program was successfully concluded in March 2004. Using CA*net 4, MusicGrid enabled, expanded and enriched Canadian music education programs in urban, rural and remote



communities and demonstrated key principles for the future of large-scale broadband e-learning. The MusicGrid community included eight Canadian schools located in Kangiqsualujuaq and Buckingham (Quebec), Iqaluit (Nunavut), Gander and St. John's (Newfoundland and Labrador), and Ottawa (Ontario).

- **Broadband Demonstrations** – CRC managed the broadband applications demonstration for the Canadian Pavilion at the ITU World Telecom and World Summit on Information Society in 2003. Demonstrations showcased Canadian capabilities in tele-robotic surgery and tele-haptics, as well as jazz musicians from Newfoundland and Geneva playing together in real-time across the Atlantic Ocean.



Government Clients

As the Canadian government's primary laboratory for advanced communications R&D, CRC provides valuable technical expertise to its main government clients: Industry Canada, Department of National Defence and the Canadian Space Agency.

CRC also works with other government departments on global communications technology issues and challenges. Its partners include Public Safety and Emergency Preparedness Canada, the Canadian Security Establishment, the Department of Foreign Affairs and International Trade, Agriculture and Agri-food Canada and the Federal Government's Science & Technology Integration Board.

2003-2004 highlights:

Industry Canada

- CRC provided input for the new UWB, SDR and MIMO technologies described in this report.
- CRC completed technology development for the transmission of RF signals on optical fibre to eliminate re-modulation at the end of an optical fibre distribution system.
- Work continued on the extension of the signal analysis and modulation recognition capabilities of the Spectrum Explorer™ for spectrum monitoring.
- Research continued to improve DTV coverage without increasing transmitter power. Work focused on receiver capabilities in a multipath environment and their operation in the presence of on-channel repeaters.
- A digital audio broadcasting (DAB) receiver characterization program was set up to verify the performance of receivers arriving in Canada, and their optimal use within the Canadian DAB frequency allocation plan.

- Research was conducted on the development of low-cost satellite earth terminal antennas designed to use dual feeds or special reflectors to produce specific nulls in their pattern. The technology would accommodate closer satellite spacing in the 12 GHz Fixed Satellite Services band for satellite broadcasting (Star Choice).
- RF fingerprinting of wireless LAN is being developed as a means of enhancing wireless security.

Department of National Defence (DND)

- CRC concluded a major study aimed at improving the efficiency of DND networks over protected military satellite systems. A network interface protocol has been implemented to provide application quality of service, improved file transfer response time and more efficient use of satellite bandwidth.
- Trans-Atlantic demonstrations are providing valuable insight for the design of future global coalition networks. The experiments, conducted as part of the multinational Interoperable Networks for Secure Communications project, examined for the first time the technical and architectural issues associated with the migration from IPv4 to IPv6 for military use. The technical information will help DND develop a national response to recent policy directions for IPv6 migration issued by the U.S.
- CRC is investigating techniques to reduce interference between military tactical VHF/UHF radios co-located on mobile vehicles. In typical operations, close-in high-level RF signals from transmitters can prevent signal reception. Analysis of field-based measurements of antenna coupling of radios was completed and co-site radio interference mitigation techniques have been identified.



- With Defence Research and Development Canada Ottawa, CRC is developing the Military Digital Analysis System (MiDAS-LD) spectrum measurement and monitoring technology under a \$1.5M U.S. contract with the U.S. Marine Corps. An extension of the Spectrum Explorer™ technology, the technology is better able to address challenges in a tactical military environment.
- CRC's WISELAB demonstrated an effective and reliable network-centric warfare broadband military communications system for the Canadian Forces Experimentation Centre. The system centred on an Uninhabited Airborne Vehicle and involved terrestrial, airborne and marine operations.

Canadian Space Agency (CSA)

- CRC is providing CSA with program and technical expertise for the Payload Flight Demonstration Program. Launched in mid-2004, the Anik-F2 satellite will allow the use of advanced multimedia technologies capable of providing high-speed services anywhere in Canada.
- Under a \$2M Memorandum of Understanding with CSA, CRC is providing program and technical management support for the new four-year CSA/Technology Partnerships Canada Cascade Payload Technology Demonstration Program. CRC's efforts will be directed towards the CASSIOPE mission, a joint Canadian science and telecommunications mission scheduled to fly in 2007.



Commercialization

From the labs to the Market

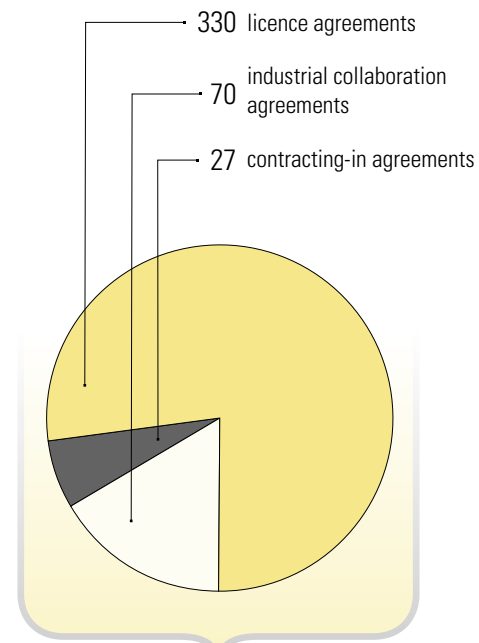
CRC is shaping the future of global telecommunications and transforming technology and knowledge into commercial opportunities for Canadian companies.

CRC continues to maintain a solid revenue stream, despite the global downturn in telecommunications. During 2003-04, CRC earned \$2.43M through an active program of technology licensing, contracted research and industrial collaborations with some 212 companies.

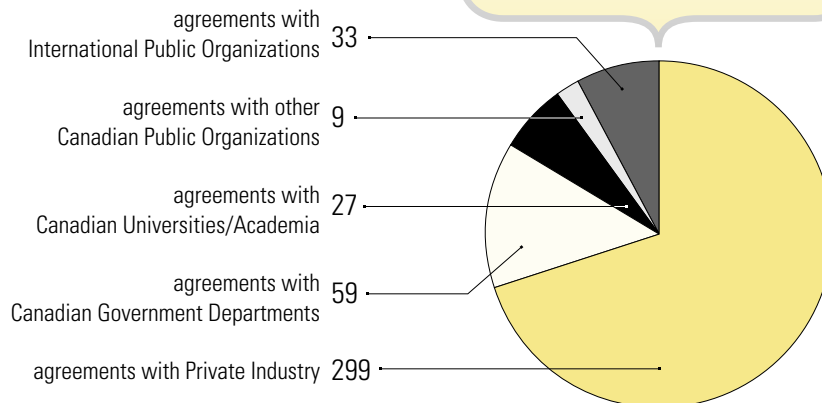
Companies benefited from CRC's expertise and technologies in several areas, including: advanced error correcting techniques; modem technology; Spectrum Explorer™; RF propagation prediction software; linear power amplifier technology; fibre Bragg gratings; optical couplers; web-based training software; helium speech processing; rectenna technology; bus safety technology; HF block equalization; CRC-FRC, (a video frame rate conversion algorithm); CRC-SEAQ (audio quality assessment); CRC-COVLAB, (a broadcast coverage prediction software); Software Communications Architecture for Software Defined Radio; electromagnetic scanning; and, video testing.

Technology Transfer, Industrial Collaboration and Contracting-In Agreements

During the period from March 31, 2003 to March 31, 2004, CRC had 427 active technology transfer, industrial collaboration, and contracting-in agreements.



The total of 427 active agreements are with the following types of clients:



Licence Agreements

- The fibre Bragg grating portfolio continued to be CRC's largest licence and royalty revenue generator, earning approximately \$500,000 over the year. This total includes significant fees paid to CRC by its cross-licensing partner, United Technologies Corporation. UTC successfully implemented an enforcement licensing program, in partnership with CRC, through the retention of an intellectual property law firm (NSHN) in the U.S. NSHN signed licence agreements with Weatherford, Luna and K2 Optronics and is currently negotiating with a fourth company.
- Software for the subjective evaluation of audio quality testing (CRC-SEAQ) and CRC-COVLAB, a program for broadcast transmission analysis, continued to be licensed worldwide, generating \$120,000 in revenues for CRC over the year. Major customers include Dolby Sound of the U.S. and Nippon NTT Telegraph Telephone of Japan.
- CRC-Predict radio propagation software is internationally recognized for its prediction accuracy. The software generated \$128,000 in licence and royalty fees last year, and continues to be widely used by several organizations.
- CRC's patented advanced frame rate conversion technology (CRC-FRC) has been licensed to Algorith, a spin-off of Montreal-based Miranda Technologies. Algorith has integrated CRC-FRC into its specialized software – a “plug-in” for popular compositing and special effects software such as Apple's *Shake*, Eyeon's *Digital Fusion*, and Adobe *After Effects*.
- As a result of its expertise and international reputation in this field, CRC was selected by the SDR Forum in New York to develop the second version of the reference implementation of the SCA. CRC's proposal was endorsed by NASA, Rhode and Schwarz, Mercury Computer System, ISR Technologies and the U.S. Department of Defence Joint Tactical Radio System Project Office.
- Growing interest in Software Defined Radio has resulted in several licences for CRC's Software Communications Architecture (SCA), including ISR Technologies of Montreal (full version), Ottawa-based IP Unwired (baseline version), and Toronto-based Array Computer System (trial version).
- CRC's Forward Error Correcting codes were licensed to several companies, including Advantech, Vistar, Square Peg, and Advanced Mobile Phones, to enhance the performance of their wireless products. The technology includes a newly developed Soft-In-Soft-Out decoding technique for block codes.
- A new version of Spectrum Explorer's™ signal analyzer and modulation recognition software was developed and licensed to Interactive Circuits and Systems Ltd. of Ottawa. The company's affiliate, SensorCom Inc., is integrating the software into a product being sold to a U.S. government organization. The military version of Spectrum Explorer™ was licensed to the U.S. military through a collaborative effort involving Defence Research and Development Canada - Ottawa. This multi-million-dollar project is expected to extend over several years as the system is customized to meet military requirements and evaluated for operational implementation.
- Two technologies – a direct Transmitter Compensation Technique and Linearization Technique for Power – have been licensed to Advantech AMT of Dorval (Quebec).
- British Technologies Group (BTG) International has licensed CRC's fibre coupler portfolio as part of an assertion licensing program. Over the years, CRC has suspected widespread infringement of the patents, but has been unsuccessful in broadly licensing them. Reverse engineering conducted by CRC for BTG on infringing products has shown promising results and is expected to attract new licensees for this established CRC technology.
- CRC collaborated with Skywave Mobile, Avendo Wireless, Redline Communications and other Canadian companies to develop advanced customized planar antennas.
- CRC helped Genesis Microchip, Intel, NASA and other organizations test and evaluate advanced digital video systems and technologies.

Patents

As of March 31, 2004, CRC had:

- 226 active patents and applications covering 94 inventions that are either licensed or available for licensing
- 25 new patent applications filed and 11 patents awarded

New patents were issued for the following technologies:

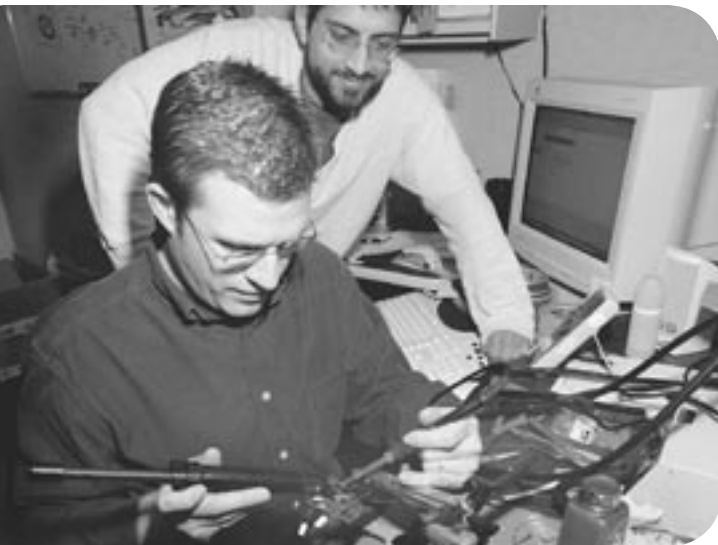
- Method and Device for Reducing Polarization Dependence in an Optical Component or Optical System
- “Magic-Tee” for reduction in power loss and component size for microwave and millimetre wave antenna and RF subsystems
- Broadband Circularly Polarized Dielectric Resonator Antenna
- Broadband Nonhomogeneous Multi-Segmented Dielectric Resonator Antenna System
- Antenna Array Feed for Axially Symmetric and Offset Reflectors
- File Transfer Using Facsimile Modem
- Interpolation of an Image Sequence Using Object-Based Image Analysis (CRC-FRC – Advanced Frame Rate Converter)
- Reducing Polarization Dependence in Optical Components using tilted gratings
- A Method for Calibrating a Wideband Direction System (Spectrum Explorer™)
- Bandwidth Reduction for Stereoscopic Imagery and Video Signals (3D TV)

New patent applications were filed for the following technologies:

- Amplifier linearization technique
- Bit Rate Reduction in Audio Data Encoders
- Transmitter Identification System
- Gimbaled Antenna Mounting Platform
- Bragg Grating and Method of Producing a Bragg Grating Using a Femtosecond Laser
- Error correcting technique - Soft Input Soft Output Decoding for Linear Block Codes
- Radio beam processing using Thick Volume Hologram for Microwave Frequencies
- Estimation of Unreliable Digital Speech Samples
- Ultra-Wideband Monopole-Dielectric Resonator Antenna
- OFDM Wireless System with Improved Bandwidth Efficiency
- Channel Estimation/Characterization Technique for OFDM Wireless Systems
- Temperature Compensation Through Packaging for Planar Lightwave Circuits
- Fibre Bragg Grating with Cladding mode Suppression and Method of producing a Fibre Bragg Grating with Cladding mode Suppression Using an Ultrafast Laser
- MIMO systems channel modeling technique
- Image and Video Compression using wavelets
- Microwave chip size reduction – Size reduced Uniplanar Transmission Line

“The CRC Innovation Centre was a major catalyst for the early growth of Nimcat Networks. We had ready access to expert research, world-class test facilities and even networking opportunities that were instrumental in bringing our Peer-to-Peer call processing software to the marketplace.”

*Mahshad Koohgoli
President and CEO
Nimcat Networks Inc., Ottawa
Graduate of the CRC Innovation Centre*



Incubation – The CRC Innovation Centre

For the past decade, the CRC Innovation Centre has worked closely with small- and medium-sized enterprises to build a strong Canadian economy. This unique facility helps young, dynamic companies to develop their potential through on-site technology incubation. Companies receive office space, access to unique test beds, facilities and expertise on a fee-for-service basis, as well as vital linkages to a gamut of services and funding. The Centre also accepts established companies requiring CRC expertise or facilities to carry out R&D on a new product.

Since November 1994, 40 companies have benefited from the services and facilities provided through the Centre. Clients in 2003-2004 included:

- Bristol Aerospace Ltd.
- Data River Networks Inc.
- Electronic Test Centre
- EMS Technologies Inc.
- Gain Microwave Corp.
- GenieView Technologies Inc.
- Okulus Networks Inc.
- Nimcat Networks Inc.



Collaboration: Educational Institutions and Other Organizations

From coast-to-coast, CRC is assisting universities and other organizations in meeting their R&D objectives. Here are just a few examples:

- CRC and five major wireless centres founded the Canada Network of Wireless Centres (CWCNet) – a resource for small- and medium-size enterprises to demonstrate and test products and services in a real-life environment.
- CRC is collaborating with the University of Ottawa and Université de Sherbrooke on opto-electronics research.
- CRC worked with the Memorial University of Newfoundland, National Research Council, University of Ottawa, various Canadian school boards and conservatories from around the world to develop and evaluate music teaching using broadband technology (MusicGrid Project).
- In collaboration with Université Laval, CRC is studying techniques such as antenna diversity that would enable digital television to deliver multimedia applications to portable devices. Using a broadcast transmission system would allow for more efficient spectrum use.
- CRC and Simon Fraser University provided C-Band satellite communications support to the B.C. Forest Protection Service during the 2003 fires in southern B.C., and to the 2003 Houghton Mars expedition on Devon Island.





- CRC and the University of Ottawa are jointly developing a User-Controlled Lightpath Provisioning (UCLP) System, under a contract awarded by CANARIE. The UCLP System will enable end-to-end lightpath services to be deployed on the national CA*net 4 research and education network. The beta version of the UCLP System software was delivered to CANARIE in February 2004 and is currently undergoing acceptance testing.
- CRC, the University of Ottawa and the National Research Council received a \$450,000 Strategic Grant award from the Natural Sciences and Engineering Research Council for a three-year research project studying “Virtual navigation using image-based rendering techniques”.

Standards Bodies and Technical Committees

ITU

- CRC assumed international leadership roles within ITU-R, serving as Chair of the ITU-R Study Group 4 dealing with Fixed Satellite Services and as vice-chair of the Working Party-6Q (Quality Assessment) and of Study Group 3 (propagation and HF systems).
- CRC played a lead role in the *Video Quality Expert Group* on the evaluation of objective methods of picture quality assessment. This work resulted in the new ITU-R Recommendation “Objective perceptual video quality measurement techniques for standard definition digital broadcast television in the presence of a full reference”.

- AS part of ITU-R's activities to develop a method to automatically measure audio loudness, CRC was selected to carry out subjective testing and generate data to evaluate 10 proposed loudness meters. CRC also conducted a comparative evaluation of the proposed meters and has proposed one that outperforms other proposed methods. The CRC's proposal will become an interim ITU-R recommendation.

NATO

- CRC contributed to NATO Ad Hoc Working Groups on V/UHF Communications, Beyond Line-of Sight Communications, and Multimedia Communications.
- CRC chaired the NATO Task Group on Power Line Communications Interference to study the effects of emissions from power line communications on the HF spectrum.

DRRI, DRCG and CDTV

- CRC, Digital Radio Roll-out Inc. (DRRI), Digital Radio Co-ordinating Group (DRCG) and Canadian Digital Television (CDTV) renewed their partnership to foster the development of an efficient digital broadcasting infrastructure and the introduction of innovative services.
- In addition to supporting U.S. and Canadian companies in the evaluation of digital television (DTV) receivers for North America, CRC shared its expertise with Shanghai Jiao University (China) and Linx Electronics (U.S.) to evaluate a DTV system that could become a standard in China.
- CRC held and chaired inaugural meetings for the DRCG Ad Hoc Joint Working Group on the compliance of Digital Audio Broadcasting (DAB) receivers, and the Technical Group for DAB Datacasting demonstrations in Toronto.

- CRC represented Canada at the WorldDAB Technical Committee meetings in Europe. A global centre of expertise in subjective assessments of video quality, CRC has conducted several subjective tests for external clients and international standards bodies.

Radio Advisory Board of Canada (RABC)

- CRC chaired the RABC Licence-Exempt Sub-Committee (SC-B) dealing with fixed wireless communications issues.

ISO

- CRC and Philips are studying techniques to improve Philips' new parametric audio coding system, a pending ISO/IEC international standard.

IEEE

- CRC participated in working groups on the use of licence-exempt equipment in the V/UHF TV bands and on the development of a transmission standard for wireless metropolitan area networks.

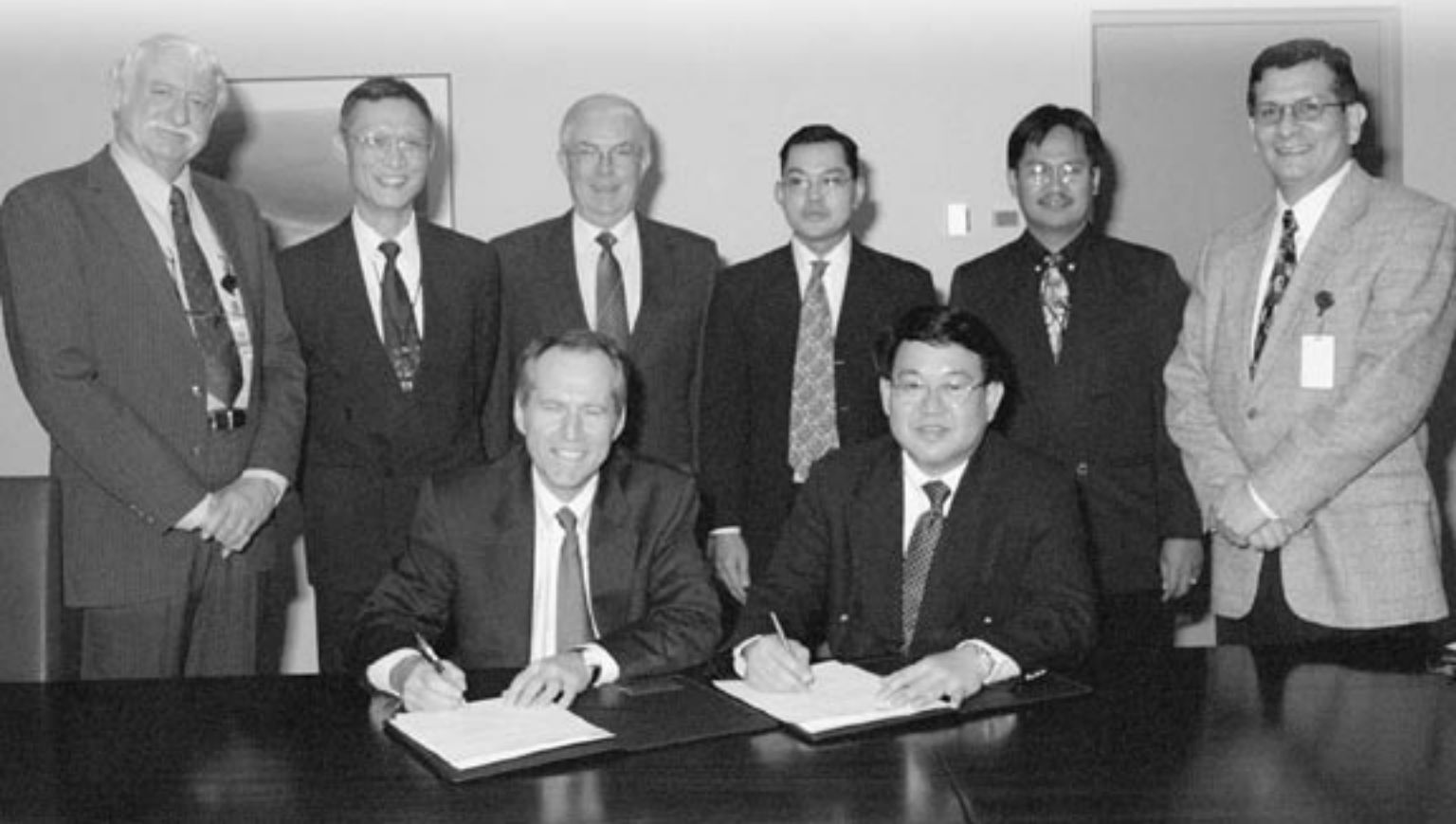


International Cooperation

- CRC became the Canadian National Contact Point for the Information and Communications Technology (ICT) sector in 2003-04. This role was transferred from the ICT branch of Industry Canada. Responsibilities included: gathering and disseminating information on international R&D opportunities; organizing R&D partnering events; and, in cooperation with the Department of Foreign Affairs and International Trade, the European Commission and others, facilitating over 20 R&D collaborative projects between Canadian and international public and private sector partners. CRC also led the Canadian delegation attending the annual European Union's Information Society Technologies conference held in Milan, Italy.
- CRC, NASA-Langley and Photronics Inc. fabricated specialty UV-induced fibre Bragg sensor gratings for use in systems that monitor atmospheric water vapour. The grating employed a special p-phase shift design that produced ultra narrow band "on-line" and "off-line" transmission bands which, under tension, could be tuned to the water absorption line of 946.0003 nm.
- CRC continues to represent Industry Canada at the APEC Telecommunications Working Group. Partnering with other Canadian stakeholders, CRC organized a successful IPv6 workshop for decision makers and regulators to discuss issues relating to the next-generation Internet. The workshop resulted in new sales and commercial opportunities with large Asian carriers for Hexago Inc., a small Sainte-Foy QC company that manufactures IPv6 equipment. CRC also secured APEC funding for a Smart Communities workshop, and the Algonquin College in cooperation with the Ottawa Centre for Research and Innovation won a contract to organize the workshop.



- Participating in the Technical Cooperation Program, CRC contributed a critical system component to help manage communications in a military coalition deployment. Under DRDC's Defence Communications R&D Program, CRC developed a Low Bandwidth Manager (LBM) prototype that provides more capacity to end-user traffic by controlling traffic management over bandwidth-impooverished links such as satellite. Working with Australian and U.S. partners, the LBM was integrated into a policy-enabled Coalition Network Management System. The project published a series of technical reports upon its completion in early 2004 and held a final demonstration and field trial involving CRC, the U.S. Air Force Research Labs (Rome, New York), Defence Science and the Technology Organisation Laboratory in Australia.
- CRC participated in the Second Alliance Icing Research Study at Montreal's Mirabel Airport in collaboration with the Meteorological Service of Canada, Transport Canada, National Research Council, DRDC and several Canadian and U.S. universities and institutes. CRC's objective was to improve propagation models at higher frequency bands by comparing information on atmospheric constituents with radiometer data.
- New collaborative agreements on radio propagation research were arranged with Eastern Asia University, Bangkok, Thailand, and the University of Cyprus, Nicosia. CRC renewed an existing agreement with Eindhoven University of Technology and Delft University in the Netherlands.
- Under Memoranda of Understanding with an intergovernmental framework for European cooperation in S&T research (EU COST), CRC contributed research results in Mobile Broadband Multimedia Networks (COST 273) and Propagation Impairment Mitigation for Millimetre Wave Systems (COST 280).



Special Guests and Outreach

- CRC made presentations to several foreign delegations from Australia, Chile, China, Japan, India, Korea, Spain, Thailand and other countries, as well as to private companies from Canada and abroad.
- Two students from the Technical University of Catalonia met with CRC's Broadband and Optical Networks team in March 2004 to discuss how CRC's network control strategy, developed with the University of Ottawa under CANARIE' program, could be adapted to manage the network elements of Spain's optical network testbed, i2CAT (UCLP Project).
- In October 2003, eight journalists and editors from Europe's top wireless and electronics publications toured CRC's facilities. In February 2004, CRC welcomed another group of 15 technology journalists, representing 11 European countries.
- Along with the Canadian Radio-television and Telecommunications Commission, Industry Canada and Canadian Digital Television, CRC welcomed a large Korean delegation to discuss the future of DTV and digital multimedia broadcasting in Korea and Canada.
- Spain's AD Telecom visited CRC for assistance in adapting its DTV technologies and products to the North American market. The company has expressed interest in collaborating on DTV datacasting.
- Namho Hur, a visiting scientist from ETRI in Korea, joined CRC for a year to work on view interpolation for Multiview 3D video systems.
- Professor Jong-Soo Seo, Director of the new Centre for Advanced Broadcasting Technology at Yonsei University in South Korea, spent one month at CRC to learn about broadcasting technologies from an established and recognized research organization.

CRC's Engine of Expertise

CRC's people form an engine of expertise that shares knowledge and technical advice in areas relevant to the Canadian and world economies. Numerous researchers have won awards for their publications and innovations leading to technology transfer and commercialization. Many have shared their expertise through conference and workshop presentations, technology demonstrations, and information sessions.

Awards

- Dr. Stephen Mihailov won the Under 40 Award for Researchers in Photonics from the National Capital Institute of Telecommunications for furthering the development of fibre Bragg grating components. He was presented with the award at the Ottawa Centre for Research and Innovation Awards Dinner on April 7, 2004
- Barry Felstead was the first Canadian and the first non-American to receive the 2003 IEEE MILCOM Technical Achievement Award for significant technical contributions in military communications.
- CRC received two awards at the 2003 IEEE Broadcast Symposium, including the Scott Helt Memorial Award for the best paper published in the IEEE's Transaction on Broadcasting.
- Executive Vice-President Veena Rawat received the prestigious "Woman of the Year" award from Canadian Women in Communications in February 2004 for her outstanding leadership and support of the advancement of women.





- CRC's Technology Transfer Office won a Leadership Award from the Federal Partners in Technology Transfer in May 2003 for its achievements in protecting and commercializing CRC's intellectual property.

Events

- Louis Thibault, Research Manager for CRC's Advanced Audio Systems group, demonstrated the latest research in DAB and DTV at the International Broadcast Convention in Amsterdam, September 2003.
- Collaboration between CRC, CBC, Telesat and CDTV resulted in the first HDTV transmission of a hockey game over the air in Ottawa.
- CRC demonstrated CRC-COVLITE at the Western Association of Broadcast Engineers annual conference in Edmonton.

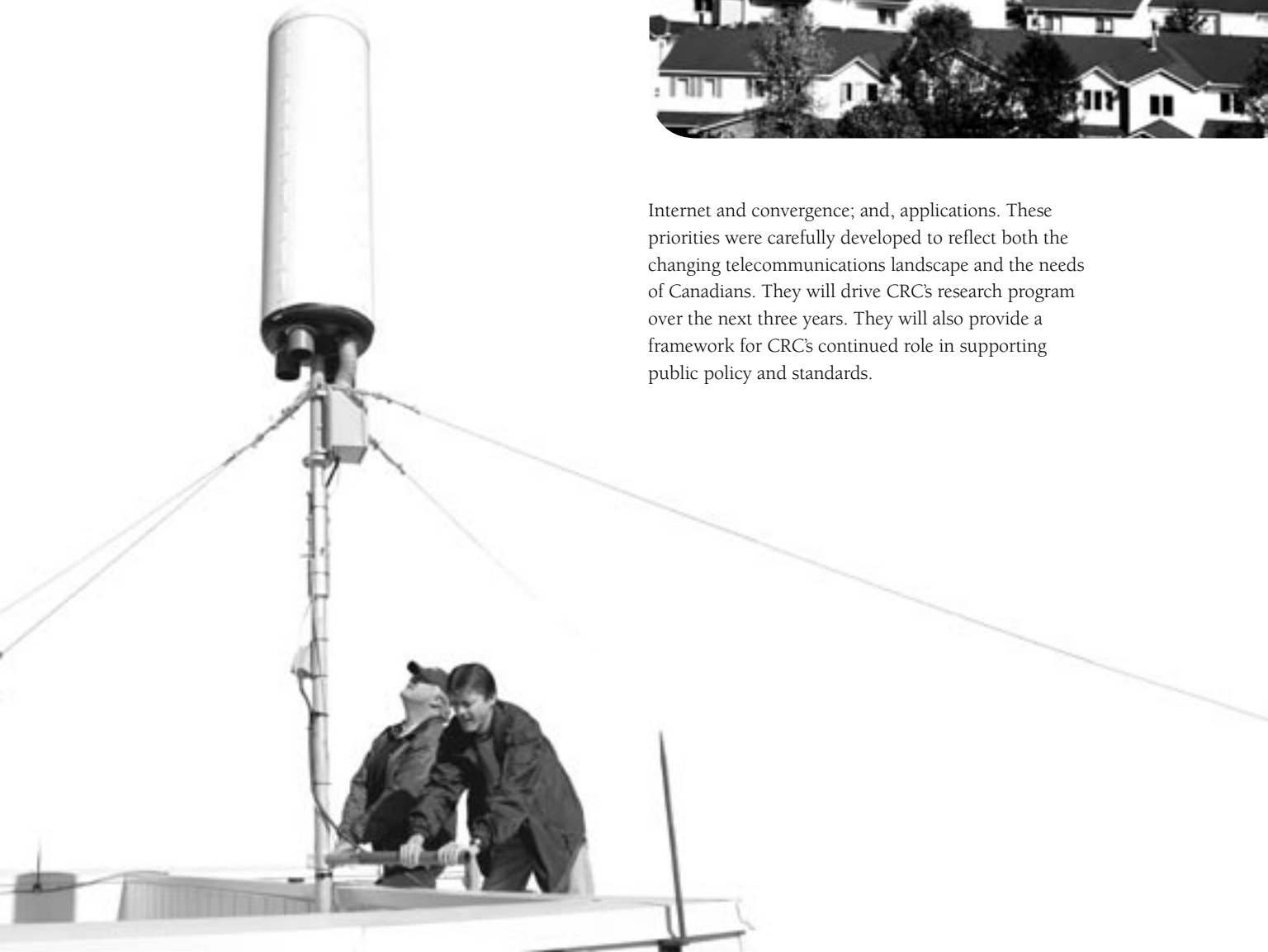
A Look Ahead

CRC continues to plan and shape the future of telecommunications and information technologies. In a world of constantly evolving innovation, it is important to anticipate change and prioritize R&D efforts accordingly.

To meet this challenge, CRC consulted with Industry Canada, other major clients, board members and management, and identified six major strategic priorities: broadband access; radio spectrum; defence communications; network security and public safety;



Internet and convergence; and, applications. These priorities were carefully developed to reflect both the changing telecommunications landscape and the needs of Canadians. They will drive CRC's research program over the next three years. They will also provide a framework for CRC's continued role in supporting public policy and standards.



Within the context of these priorities, CRC anticipates many exciting R&D projects over the coming year. Key research areas will include:

- Continued development of Software Defined Radio
- Evaluating the impact of Ultra Wideband
- Licence-exempt applications and spectrum efficiency
- Technologies for systems beyond 3G
- Broadband access to rural and remote communities using terrestrial and satellite technologies
- Network management and security
- DVB-RCT technology as a wireless return channel for interactive television
- HDRadio to add digital capabilities to existing AM and FM analog services
- Ongoing research related to convergence of digital broadcasting with other wireless technologies and services

CRC is also upgrading laboratory facilities. The Research in Advanced Antenna Technologies Laboratory (RAATLab) is moving its near-field antenna measurement facility to a new lab over the coming year. Design and construction of a new laboratory wing for photonics-related research is also proceeding. The additional space will improve our workspace, enhance safety features and allow for the addition of new equipment.

Since its early years, CRC's reputation for technology transfer has grown steadily. CRC will continue to enhance and improve Canada's score card for technology transfer and commercialization.

Here's to another successful year ahead!

EXPENSES

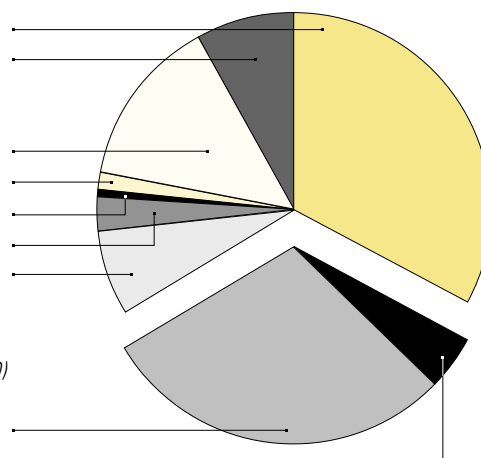
Direct Research	23.74
Research Support	5.15
Total Research	28.89

Site Operations	10.00
Administration	1.97
Repayment Previous Construction	0.30
Payment in Lieu of Taxes	1.01
CRC Construction Fund	5.85
Total.....	48.02

Expenses Reported under Other Government Departments (OGD)

CSA - Payload Flight	
Demonstration Program	21.22
DND - Research	3.03
Total OGD Expenses	24.25

TOTAL EXPENSES **72.27**



Notes:

(1) CRC receives funding from a number of government and non-government sources. In 2003-04, Industry Canada provided 54% of CRC's funding. Other government funding was provided by the Canadian Space Agency and the Department of National Defence to carry out R&D, and to cover costs related to their residence on the CRC campus. Revenue from the private sector is generated through the licensing of intellectual property and contracted R&D.

(2) Construction will begin next year on the Laboratory for Photonic Components & Systems Research and will be completed in 2006-07. Other construction projects currently underway include the RAATLab and a number of Health & Safety projects, such as improvements to the electrical distribution system and the water distribution system. The costs of the Health & Safety projects are shared with the CRC Campus tenants and will be completed over a two year period.



2003-2004 Revenues and Expenses

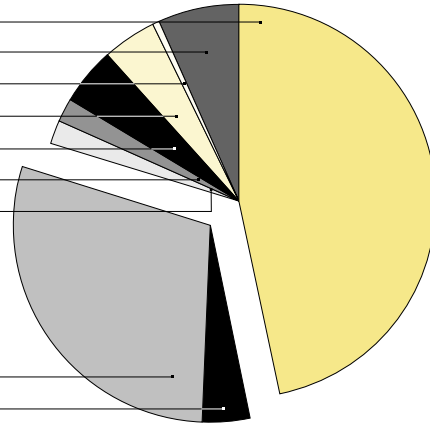
(\$ millions)

REVENUE

Industry Canada - Operations	33.81
Industry Canada - Capital Assets	4.77
Industry Canada - Spectrum Research	0.43
DND - Research	3.46
Cost-recoverable Tenant Services	2.79
Contracting-In	1.35
Licensing	1.41
Total.....	48.02

<i>Revenue Reported under Other Government Departments (OGD)</i>	
CSA - Payload Flight	
Demonstration Program	21.22
DND - Research	3.03
Total OGD Revenues.....	24.25

TOTAL REVENUES 72.27



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