



communications research centre

CRC

1995 - 1996 annual report



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Cat. No. C 105-1996

ISBN 0-662-62643-5

Design: Quy Luong

Photography: John Brebner, Janice Lang

Editing and writing: Beatrice Baker, Kevin Shackell

## *O u r M a n d a t e*

"To conduct communications and related research and development to serve the national need, with or on behalf of Industry Canada, other federal government departments and agencies, provincial governments, academia, and the private sector."

## *O u r M i s s i o n*

"To conduct communications and innovative engineering which contribute to the orderly development and accessibility of communications technologies, systems, and services for the benefit of all Canadians."

## *O u r V i s i o n*

"Leadership and excellence in communications research."

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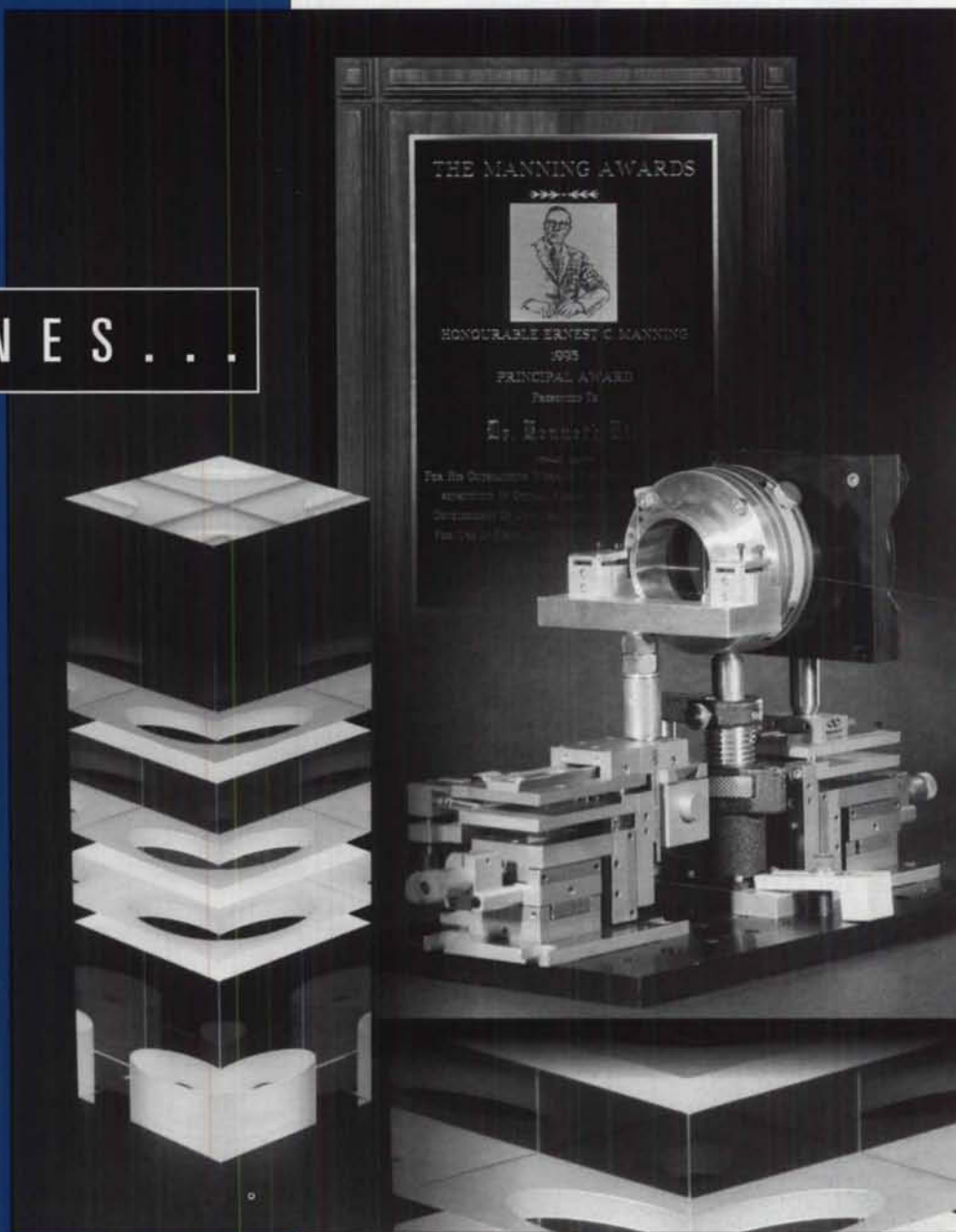
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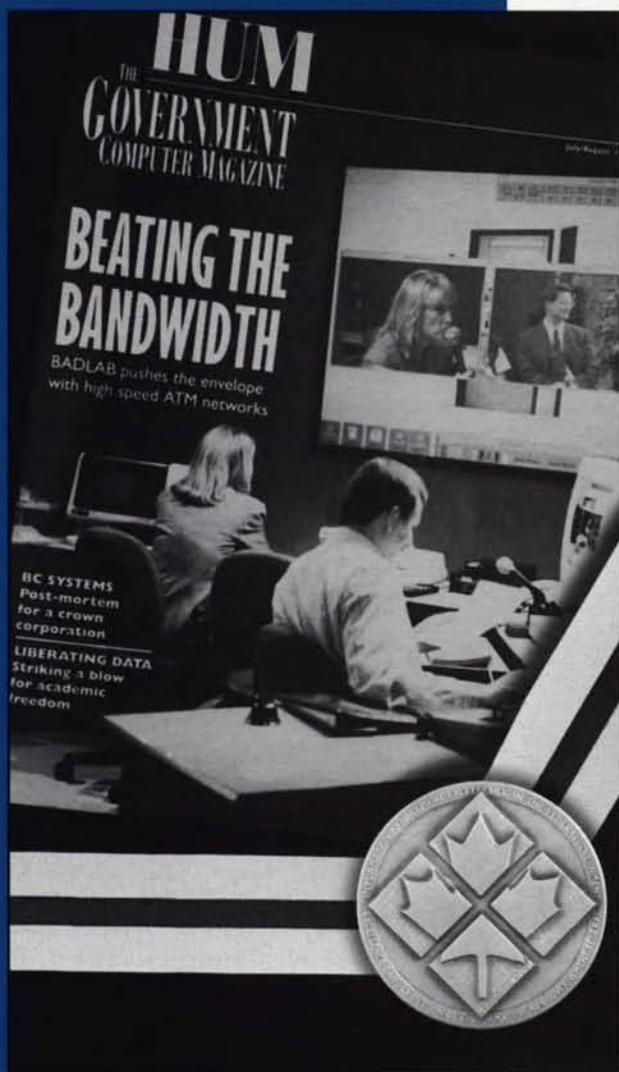
We're  
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HEADLINES...

CRC used to be a well-kept secret...or as one journalist put it, "a hidden jewel." In the last year, we've made headlines and won awards. The recognition is gratifying, but even more satisfying is the growing linkage between CRC and Canadian industry. Not only has CRC become more entrepreneurial, it has been helping new companies get started in technology development.



Recognition for achievements in science and technology is sometimes slow to arrive. It took almost twenty years before the significance of Dr. Kenneth Hill's discovery and exploitation of photosensitivity phenomena in optical fibre received recognition. The work of Dr. Hill and his colleagues makes CRC a world leader in photosensitivity technology. His contribution to world science earned him the 1995 Manning Foundation Principal Award and the 1996 John Tyndall Award.



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On the road to information highway development, CRC has been setting some speed records. After a little over a year in business, the BADLAB, or Broadband Applications and Demonstration Laboratory, won gold in the 1995 federal Technology in Government Awards in the "Building Partnerships" category. The lab is working with collaborators from across the country and around the globe to build a high-speed network for the information highway.

## Some Intellectual Property Statistics for 1995-1996

The portfolio of active intellectual property agreements increased from 212 to 236 during 1995-96. Of these, 98 agreements generated a gross amount of more than \$800 000.

Seventy-four contracting-in agreements were executed during 1995-96 and the gross revenues totalled over \$2 million.

The patent portfolio consists of 185 active patents.

In 1995-1996, applications were filed for 15 new patents.

Four new patents were issued and five trademarks registered this past year.



CRC is proud to contribute to the federal government's jobs and growth agenda by helping Canada's communications industry develop new technologies. Of particular interest to small and start up firms is the CRC Innovation Centre. Since opening in late 1994, the CRC Innovation Centre has provided a temporary home to a dozen companies as they develop innovative products prior to breaking into the marketplace. In 1995, one of its first clients, Linmor Information Systems Management Inc., outgrew its CRC quarters and is now located in Nepean. A spin-off from Nortel Technology (formerly Bell Northern Research), Linmor has expanded to 23 employees with annual sales of \$1M for its network and system management products.

## CHAIRMAN'S MESSAGE



As Chairman of the Board, I am pleased to present the 1995-1996 Annual Report of the Communications Research Centre.

It has been a year of notable achievements at CRC. On behalf of the Board, I extend congratulations to Dr. Kenneth Hill. His work in fibre gratings has opened up a magnitude of possibilities for exploitation. Congratulations are also due to everyone connected with the BADLAB. The BADLAB has succeeded far beyond our expectations, and its contributions to national and global broadband communications are only beginning.

The CRC Innovation Centre celebrated its first anniversary in November 1995 at full capacity. Having established that small and medium-sized enterprises and high tech start-ups can benefit from this type of facility, we will be examining the possibilities of expanding our capacity to meet greater demand.

The pattern of growth established during the past three years continues at an accelerated rate as CRC forges new partnerships, alliances and collaborations with Canadian industry, and with other R&D organizations, associations and coalitions both nationally and internationally. The benefits to CRC and to Canada's growing communications sector are already apparent and show every indication of increasing.

On behalf of the Board, I thank CRC's first President, Jacques Lyrette, who has moved on to other challenges, for having built a solid foundation for CRC as it began its new life as a research institute. Jacques' strong and dynamic leadership made a significant impact which will continue to be felt long after his departure. In the interim, guidance of CRC's affairs has been managed by the Executive Vice President, Stu McCormick. As Interim President, Stu has used his more than 30 years of experience as a CRC employee and researcher to keep things on track.

I congratulate the staff for maintaining CRC's standing as a world leader in communications R&D and for continuing to push the boundaries of technology, and I thank the volunteer members of the Board for their time and energy. We welcomed four new members this past year: Irving Ebert, Nortel Technology; Eric Manning, University of Victoria; Linda Rankin, LMR Enterprises; and Industry Canada's Deputy Minister, Kevin Lynch. Most certainly the Board of Directors provides valuable advice and, with its diverse membership, an enriching and varied perspective.

Bill Dunbar

A handwritten signature in dark ink, appearing to read 'Bill Dunbar', written in a cursive style.

Chairman

## INTERIM PRESIDENT'S MESSAGE



This annual report presents in the briefest space highlights of CRC's year; it can in no way do justice to the extent of CRC's activities. In each of our six main research areas there have been significant achievements.

Over the decades of CRC's existence, it has consistently maintained the highest standards of research and quality of work. What is most gratifying to witness, as I come to the close of 30 years at CRC, is first, the fruition of some long-term research. One case in point is the recognition awarded to Dr. Ken Hill's discovery nearly 20 years ago of photosensitivity in optical fibre and the tremendous technological opportunities his discovery opened up. Secondly, it is satisfying to see CRC becoming publicly recognized as a world class communications R&D institute.

While it has always been our mandate to work with the communications industry, the flexibilities granted by our institute status, our raised profile, the continued addition of new testbeds and facilities, and the substantial increase in technology transfers, means that members of the communications industry from all around the globe now come knocking at our door. To help keep this edge, CRC has entered its second year of a rejuvenation program to replace retiring staff. As one who will soon be leaving, I offer my appreciation to all CRC staff, past and present, with whom I have had the good fortune to work. I offer my best wishes to those who will shortly be joining CRC; I know that they will continue the standards of excellence for which CRC is known.

Dr. Stewart McCormick

A handwritten signature in dark ink, appearing to read "Stewart McCormick". The signature is written in a cursive, flowing style.

Interim President

## MAKING CONNECTIONS

CRC is designing innovative technologies today to meet the communications challenges of tomorrow. To maximize its effectiveness, CRC engages in a wide range of activities, both nationally and internationally, involving other R&D organizations, industry, academia, and professional associations. These activities include licensing technologies to industry, forming collaborations, offering courses, sponsoring conferences, and sitting on international standards committees among others. Staying at the forefront of communications technology development is important to Canada's competitive position in the global marketplace and CRC is leading the way.

**The CRC Innovation Centre** opened in November 1994. It allows small and medium-sized enterprises and high tech start-ups to locate at CRC for up to two years to access CRC's expertise, technologies and unique facilities. Companies are provided furnished offices and access to labs and technical support. Co-location accelerates the transfer of technologies and assists the development of innovative communications products and services.

From its first year, the Centre has been operating at capacity and it has accommodated 12 clients to date. One of its first clients has already successfully "graduated." The CRC Innovation Centre has also nurtured two spin-off companies created by former CRC employees. Encouraging entrepreneurial efforts among CRC's own researchers is yet another strategy to enhance the commercialization of CRC inventions.

**Unique Facilities and Testbeds** - Among CRC's lab facilities and testbeds are a number which can provide research capabilities unique to Canada and North America. (A complete list of these facilities is available on CRC's web site.) Their capabilities encompass satellite communications, radio science and radio

communications, broadcast technologies, microelectronic technologies and applications, and our information highway testbed, the BADLAB.

The Broadband Applications and Demonstration Laboratory (BADLAB), was designed to further the development of Canada's information highway and to provide a testbed for industry to test product interoperability. In collaboration with Telesat, BADLAB was the first R&D facility in Canada to integrate satellite links with high-speed asynchronous transfer mode (ATM) networks to test and demonstrate information highway applications.

In recognition of its excellent groundbreaking work, BADLAB received a gold medal from the federal Technology in Government Awards. The medal acknowledged BADLAB's numerous successful joint

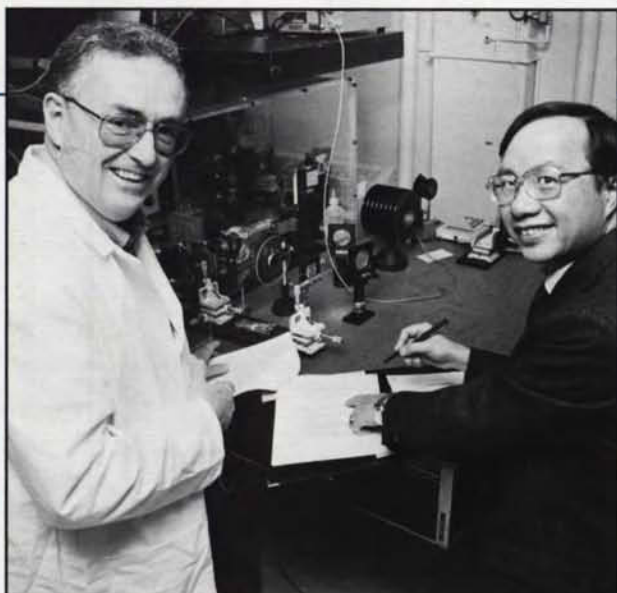


Ted Grusec conducts a listening test in one of CRC's newest testbeds, the digital audio listening room.

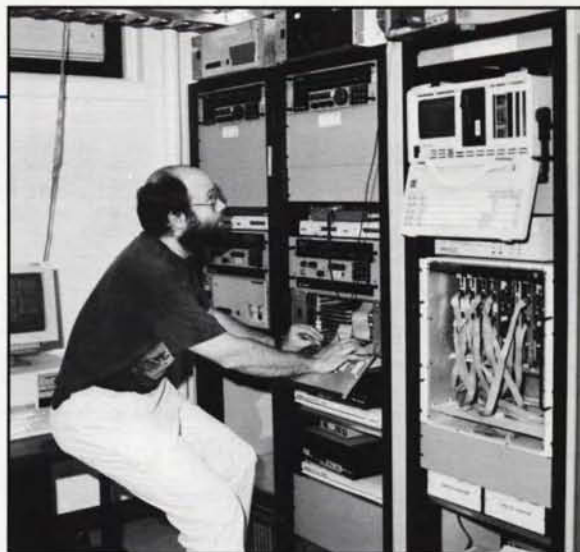
applications demonstrations over various broadband ATM networks with organizations in the Ottawa-Carleton community, across Canada and in Europe.

Collaboration agreements covering broadband communications are now in place with MPR Teltech, Telelobe Inc., TR Labs, Telesat, NorthwesTel and the Government Telecommunications and Informatics Service. These strategic partnerships build on the respective strengths of each organization for the benefit of continued Canadian leadership in ATM which is emerging as the new standard in developing the information highway.

**Collaborative agreements** enhance the R&D process, as each party brings their expertise and resources to bear on a particular problem. Among the many collaborative agreements signed this past year was one with Nortel to determine the effects of ATM network random errors and packet losses on the image quality of MPEG-2 coded video sequences. This research makes use of CRC's expertise in video coding, error correction and error concealment techniques, and the expertise of Nortel on ATM network modes and statistics.



CRC's Dr. Kenneth Hill (left) and Peter Kung, President of QP Semiconductor Technology Inc., sign a licence agreement for fibre grating technology.



CRC's Donald Haines operates a data terminal for adaptive HF radio communications.

On the international side, CRC signed a collaborative agreement with Daimler-Benz Aerospace of Germany to develop modem technology for the proposed new NATO standard interoperable HF communications system. This system will employ fast channel selection and tracking schemes currently under development, and will offer integrated voice, data, facsimile and network services. CRC developed and demonstrated a technique to provide full-duplex voice service over half-duplex channels.

**Intellectual Property** - CRC has over 100 technologies available for licensing. Each year CRC researchers add to this list and each year some of these technologies are licensed to industry. In recent years, it has become apparent that in complex fields where technological breakthroughs occur seemingly overnight, single patents do not provide the flexibility, strength and productivity of a portfolio of patents. In the fields of communications, optoelectronics and photonics, CRC has realized significant benefits from cross-licensing.

In 1994, a cross-licence agreement was signed with United Technologies, a major US company, to combine optical fibre Bragg grating processing patents for worldwide marketing of fibre Bragg grating fabrication

technology. As a result of this agreement, four Canadian and six foreign licences have been issued to date. Among the licensees is a former CRC employee who has formed a spin-off company currently situated in the CRC Innovation Centre. To help them get started, some of the Canadian licensees received "hands-on" experience in CRC's labs this past year.

**Defence Communications** - Since 1969, CRC has conducted a communications R&D program for the Department of National Defence (DND) on a cost recovery basis. This program addresses Canada's requirements for global, secure, reliable communications. An additional and important aspect of this program is the international, collaborative R&D CRC conducts with Canada's military allies through NATO's research groups and its Technical Cooperation Program.

During the past year, networking projects focussed on the extension of broadband communications services to a tactical environment and on improved interoperability with Canada's allies. In radio communications, research addressed military requirements for robust communications in difficult channel environments, low angle earth-space radio propagation, narrowband voice communications and adaptive antenna techniques for interference cancellation.

A project begun in 1996 will provide analysis, modelling and simulation support for the DND Tactical Command, Control and Communications System. This project will provide a viable integrated means of battlefield communications in support of Canadian military deployments worldwide.

Satellite communications R&D carried out for DND concentrated on methods to enhance robustness, with emphasis on optical methods, advanced spread spectrum, and novel interference suppression techniques.

**Information Highway Initiatives** - CRC's technical expertise and its leading-edge research in information highway technologies places it in a position to offer advice for developing policies for Canada's information highway. To this end, CRC has been actively involved in the Information Highway Advisory Council's working group on research, applications and market development. The technical knowledge available at CRC has been helpful in discussion of issues such as privacy, security, access to the information highway (especially in rural and remote regions), and applications for education and health care.

To further the cooperative efforts of key players concerning some of these information highway issues, CRC in September 1995 organized the first meeting of the CEOs of Canada's leading non-profit information technology research institutes for a one-day brainstorming session. A follow-up meeting was held in November.

## **IMSC '95**

### **INTERNATIONAL MOBILE SATELLITE CONFERENCE 1995**



**JUNE 6-8, 1995  
OTTAWA, CANADA**



CRC's colourful and chatty mouse, Emil, takes Scott, Erin and Anna Shackell on an internet tour of some of CRC's labs.



Pro or con? Eighth grade Ottawa students hold a real time interactive debate with eighth grade students in Basil, Switzerland using the BADLAB facilities.

### **Conferences, Workshops and Other Learning Opportunities**

- Each year CRC sponsors, co-sponsors and participates in a number of national and international conferences. In July 1995, CRC co-sponsored and participated in Wireless '95. This seventh international conference on wireless communications was once again held in Calgary and attracted participants from around the world.

In June 1995, CRC co-sponsored, with the US National Aeronautical and Space Administration and the US Jet Propulsion Laboratory, the Fourth International Mobile Satellite Conference (IMSC '95). With over 400 attendees from twenty countries, 100 technical papers presented, and senior representation from industry and government organizations, the conference was assessed as the most successful yet. Taking place every two years, IMSC '95 was hosted by CRC in Ottawa.

CRC and its various research groups also organize and lead workshops as the need arises. This past year CRC offered a number of courses in hypertext mark-up language until local private sector organizations were able to offer them.

Staff at CRC are very aware of the need to foster interest in science and technology in young people. For the third year, CRC has participated in Destiny 2000, a week-long, local science and technology exhibit for all area ninth graders. Recognizing that students younger than high school need to be attracted to science, a group of CRC staff volunteered time to create and put up on CRC's web site an introduction to CRC especially geared to primary school children. A colourful and chatty mouse named Emil guides children through some of CRC's labs explaining the importance of the work done here.

## COMMUNICATIONS SYSTEMS RESEARCH

**The Communications Systems Research Branch focuses its R&D efforts on three main areas.**

Mobile satellite communications systems develops systems and subsystems emphasizing mobile and personal communications, and manages government-funded technology development contracts.

Advanced satellite communications does research and development for emerging technologies, including wideband terminals and on-board processing, and supports the development of a comprehensive commercial viability and implementation plan for spacecraft and space component development in Canadian industry. In addition, the Satellite Communications Applications Program (SCAP) is managed to facilitate, together with industry and users, the development and demonstration of new satellite communications services.

Communications systems components does research and development on, and fosters an industrial capability in, antennas, integrated electronics and optoelectronic technologies.

**Technology Development and Transfer to Industry** - CRC plays a vital role in the burgeoning area of mobile satellite communications, working with Canadian companies in transferring technology and contracting R&D for clients including Inmarsat and the European Space Agency. Activities included designing the communications signaling systems for mobile satellite data broadcast, land mobile satcom antennas development, and establishing a new modulation standard for aeronautical satellite communications. Under contract, CRC also analyzed one of the major personal satcom systems proposed for launch at the turn of the century.

In March 1996, CRC, in collaboration with Inmarsat and CAL Corporation, successfully completed 40 hours of flight trials which rigorously tested and demonstrated new CRC modem, antenna and antenna tracking technologies for aeronautical satcom use. These technologies were developed to meet MSAT and Inmarsat standards and have been licensed to Canadian companies.

During the past year, a five-year scientific exchange program with DLR, a German research establishment, was completed. Through shared efforts, both institutions increased their knowledge of communications signal coding theory. CRC will continue to build on this to develop unique and powerful decoding techniques.

**International Mobile Satellite Communications Program** - Currently, CRC manages and provides technical leadership to the International Mobile Satellite Communications Program on behalf of the Canadian Space Agency. This 10-year cooperative venture between government and the private sector will develop



B. Icmieciaic (left) of Innotech Aviation Ltd., inspects the Aero-I aeronautical antenna radome with CRC's C. Archard.

and deliver state-of-the-art personal/mobile satellite communications technologies, products and services. Canadian industry was invited to submit proposals targeted at market-driven technology requirements and applications. To date, ten contracts totalling approximately \$14 million have been placed with the private sector for the first three years of the program. The federal government's share is \$6.9 million and industry funds the remaining \$7.1 million.

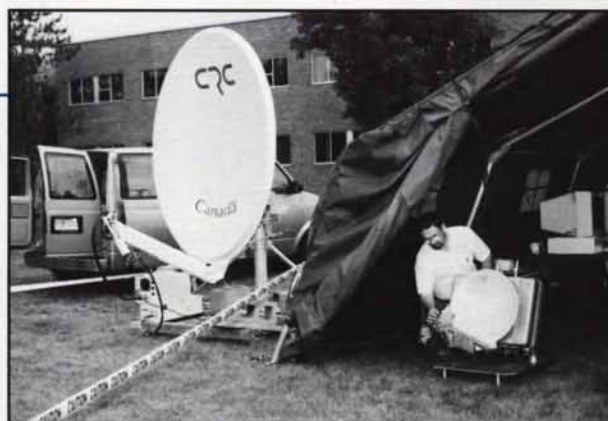
**MSAT** - In early spring of 1996, the launch of TMI's MSAT-1 began a new era of mobile satellite communications services for Canadians. CRC was instrumental in initiating the MSAT program and demonstrating the technologies to prove economic viability of the program. The program was transferred to industry, led by TMI Communications. The Government Telecommunications and Informatics Services will market the MSAT services to government users. CRC continues, through its MSAT Applications Development Program, to provide engineering assistance to TMI and to work at the international level preparing for the next generation MSAT.

**Network Extension** - CRC continued to promote satellite extension of multimedia networks by running a number of applications demonstrations for various clients. Among these were tele-robotics demonstrations for the Canadian Space Agency and its contractors, and international military field trials using both Telesat's Anik satellite and the NASA Advanced Communications Technology Satellite (ACTS).

CRC is supporting the Global Interoperability for Broadband Networks (GIBN) project, which resulted from the G-7 conference on the Information Society. CRC has proposed two projects for inclusion. The first of these is a five-node multimedia teleconferencing demonstration and the second is a multimedia cultural exchange between children in Canada, the USA, Japan and Norway. CRC will also support Japan in two of its experiments.



RCMP Corporal P.J. Thompson using a Melco briefcase unit on a snowmobile in the Yukon.



CRC's Corey Pike makes adjustments to suitcase terminal during broadband over satellite experiments.

**Ka-band Suitcase Terminal** - A major demonstration of desktop video teleconferencing took place using NASA's ACTS satellite and several CRC Ka-band terminals, including a 0.5 metre prototype suitcase terminal. As a result of this demonstration, CRC signed a collaborative agreement with the US Air Force's Rome Labs for the further development of the Ka-band suitcase terminal.

**The Advanced Satcom Program** - Initially approved by Cabinet in 1994 as part of the Long-Term Space Plan and funded in part by the Canadian Space Agency, this program is managed by CRC and supported through internal system studies and R&D activities related to satellite on-board signal processing and Ka-band terminal development.

### **Microwave, Millimetrewave and High Speed Digital Circuits and Antennas** - Through

collaborative R&D agreements and contracts, Canadian firms continue to benefit from CRC's expertise in microwave technology. Several firms have developed new RF product capabilities. These include a 24 GHz planar array for traffic monitoring and a broadband, low profile PCS transmitter antenna. CRC continued to offer substantial support in the area of microwave device noise measurement and millimetrewave device characterization.

Several 29 GHz monolithic circuits were completed for a cooperative project with the Canadian Institute for Telecommunications Research to demonstrate wideband in-building communications. One of these, a switch, gave lower loss than any previously published at this frequency. A successful three-way collaboration with VISTAR and Nanowave Technologies culminated in a very innovative integrated feed system for Ku-band terminals which delivered 10 watts of power, higher than any solid-state alternative, and at lower cost than conventional approaches.

Research highlights include major new antenna concepts in the area of dielectric antennas, an area in



Aldo Petosa makes an adjustment during RF testing of a dielectric antenna.

which CRC is the world leader, and development of flexible microwave software programs for general purpose antenna and circuit design. A wideband receiver ASIC operating at over 500 MHz clock speed was completed, as well as oscillators and amplifiers using high temperature superconductors. Also a very high dynamic range receiver for digital radio broadcast reception was developed.

**Optoelectronics Technologies** - CRC's Dr. Kenneth Hill received the 1995 Principal Manning Award, an annual prize recognizing excellence in Canadian innovation, and the ninth John Tyndall Award, presented during the International Optical Fibre Communication Conference. Both awards recognized his discovery of photosensitivity phenomena in optical fibres and his outstanding contributions in this field. Through his leadership in fibre optics, CRC has become one of the world's leading laboratories in photosensitivity technology.

In cooperation with several Canadian organizations, CRC is developing a multi-wave length optical network demonstration for broadband intracity communications. This testbed will showcase Canadian capabilities in optical components.

Working closely with a Canadian client, CRC is designing, fabricating and testing a novel high-frequency optoelectronic receiver. These receivers are currently being used in the performance characterization of low-loss fibre optic/microwave links for signal distribution in space-based phased-array antennas, wireless LANs and ground station antennas.

Scientists at CRC have successfully demonstrated prototype low-loss polymer waveguides, splitters and optical taps on semiconductor substrates. These structures were fabricated using processing techniques that can be readily adapted to high volume processing and are expected to play a key role in the development of high-performance optoelectronic integrated circuits.

## RADIOCOMMUNICATIONS AND BROADCAST RESEARCH

**The R&D program of the Radiocommunications and Broadcast Research Branch is focused on the following areas:**

**Radio Science:** study and quantification of the physical limits to the reliability and performance of wireless communications systems including propagation effects, interference, noise and electromagnetic compatibility.

**Radiocommunications Systems:** research into terrestrial wireless technologies, systems and networks to meet emerging civil and military requirements for fixed, mobile and personal communications services.

**Broadcast Systems:** investigation of digital television and digital radio and their integration into a broadband communications environment, including interoperability among delivery media and services.



Tricia Willink analyzes data for an ionospheric propagation experiment.

**Communications Networks:** exploration of the interconnectivity and interoperability of radio and satellite networks including their use in the extension of fibre-based, asynchronous transfer mode technology.

**Propagation Prediction** - During the past year, CRC has developed worldwide techniques for predicting clear-air fading distributions on low-angle, earth-space links and for predicting clear air interference distributions on trans-horizon links. These techniques have been adopted by the ITU-R. As well, CRC's VHF/UHF prediction program, which is used extensively by other organizations, was improved to allow better prediction of location variability and median path loss.

**Modelling and Performance Predictions for Digital Radio Channels** - A closed form analysis technique has been developed by which performance on North American IS-54, and higher data rate QPSK channels, can be predicted on time series measurements of wideband radio channel data. Such a technique has never previously been available, except for low data rate cases where flat rather than selective fading takes place.

**Modelling Near-fields** - Significant progress has been made in developing and validating models of the fields produced by portable transceivers when used by a human operator. Modelling of the near-field characteristics of cellular transceivers on dielectric objects was done and the results validated.

**MPEG-2 Video Over ATM** - CRC collaborated with two OCRI net partners to investigate the transmission of MPEG-2 compressed video over ATM networks. A PC-based, client server system, capable of transmitting pre-compressed MPEG-2 bit streams, was developed and transmission tests were successfully conducted using BADLAB and OCRI net.

**Ionospheric Propagation Research** - CRC is the principal investigator for the successful sounding rocket payload which was launched in November 1995. This collaborative effort between CRC, CSA and NASA involved more than 20 scientists and will expand radio science knowledge important to designers of communications services for the Canadian North where the ionosphere can variously refract, absorb or scatter waves. The experiment involved the separation of two payloads connected by a 1.2 km tether.

**Radio Modem Technology** - Signal design and processing research, sponsored by DND, has led to the development of an improved method of adaptive equalization for signalling over time-varying, dispersive radiocommunications channels. For HF, this technique will double, and even triple, the data rates available with existing modem technology, and will also improve reliability of difficult circuits such as those found in Canada's North. Potential application of this technology to the digital cellular environment at VHF/UHF is being investigated.

#### **Adaptive Antenna for Interference Cancellation**

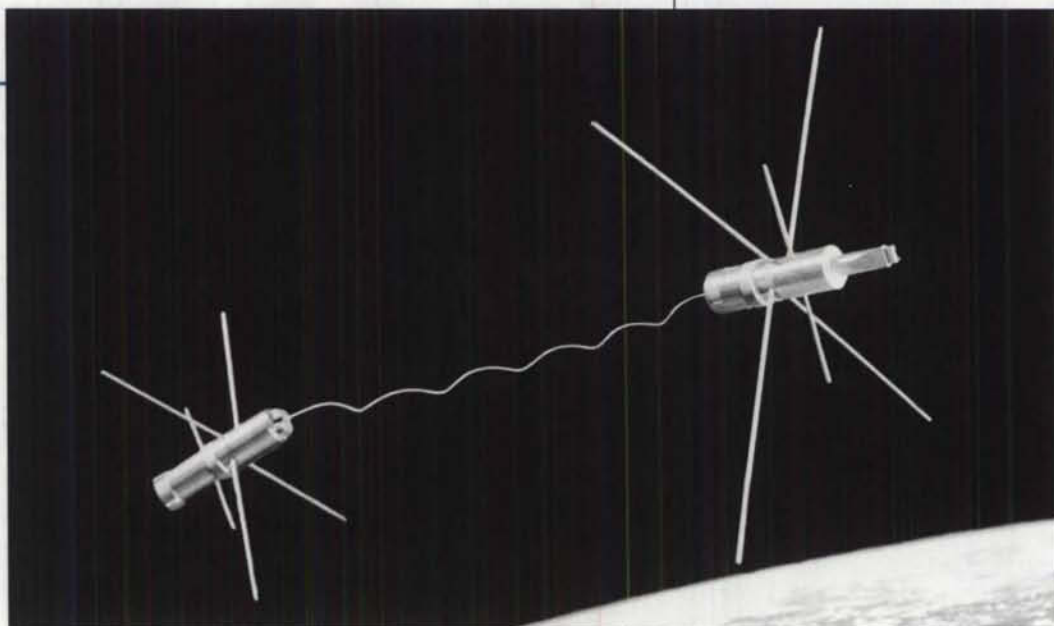
CRC is collaborating with industry to build an advanced prototype of a naval adaptive antenna receiving system

which will increase communications reliability in very high interference environments. Based on a sophisticated digital signal processing technique developed at CRC with National Defence funding, the system adaptively cancels unwanted interference and is highly responsive to changing conditions.

Implementation of a testbed is underway to extend the use of this technique to cellular radio to improve effectiveness of spectrum utilization and signal quality.

#### **Standardization of a Digital Audio Radio System**

CRC completed work sponsored by the Electronics Industries Association and the National Radio Systems Committee to carry out subjective audio assessment tests of proposed digital audio radio systems. The contract was awarded because CRC was recognized as having the appropriate expertise and the only reference listening facility in North America capable of conducting such assessments. The testing required unprecedented accuracy in measuring small differences between the sound quality produced by the various systems. Objective tests were conducted in the United States and CRC's expertise in characterization of wideband transmission channels in a mobile environment was instrumental in supporting those tests.



Composite of the Earth and a model of the Oedipus-C spacecraft successfully used in November 1995 during ionospheric propagation research.

Photo of earth provided courtesy of NASA



Advanced Television Evaluation Laboratory employees Ron Renaud and Annu Chopra record colour coordinates of a high definition television image in the ATEL viewing room.

### Digital Television System Standards Development

For nearly a decade, CRC has contributed to defining the North American requirements of a high definition television system through development of laboratory and field testing methods and evaluation of various prototypes. In the past year, CRC completed contract work for the Grand Alliance by carrying out the crucial subjective evaluation tests to prove that the system was meeting the target requirements. Throughout the testing program, CRC resolved many technical and procedural difficulties without compromising the accuracy of the results or the schedule established by the United States' FCC Advisory Committee on Advanced Television Service.

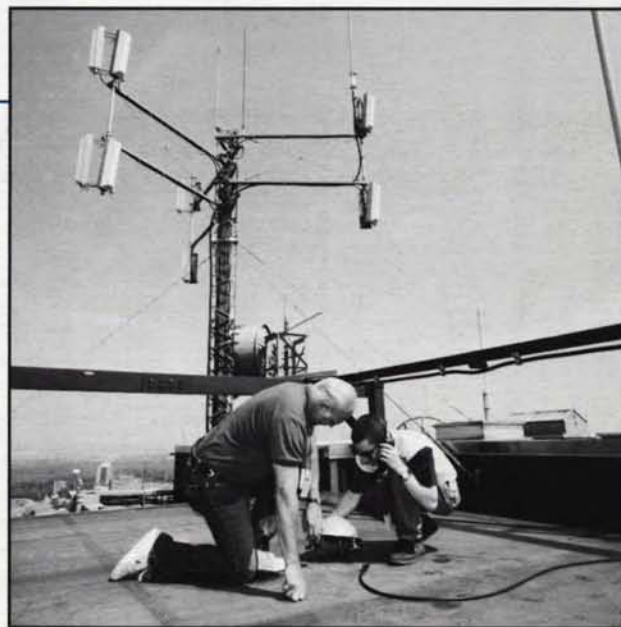
### First Digital Terrestrial Television Broadcast in Canada

- Because of CRC's extensive expertise in digital television transmission, a consortium of American, Brazilian and Canadian broadcasters contracted CRC to assess the benefits of using COFDM as an alternative to the currently proposed VSB transmission scheme for digital terrestrial television broadcasting. In carrying out this study, system parameters to meet North American channel and broadcast requirements were defined and then validated in laboratory tests using a prototype system.

Performance was further confirmed in an Ottawa field trial which constituted the first digital terrestrial television broadcast in Canada.

**Multimedia/multinetwork Technology** - As a prime participant in a three-year project involving six NATO countries, CRC has successfully completed its part to demonstrate and evaluate multimedia/multinetwork command, control and communications interoperability. The technology is now being deployed on some US Navy platforms. In Canada, CRC has undertaken a second phase which will lead to sea trials by the Canadian Navy.

**Digital Radio Broadcast Standard** - CRC has been instrumental in establishing the sound technical basis that allowed for a new transmission mode to be added to the European-developed Eureka 147 digital audio broadcasting standard. This mode, which permits doubling the spacing between on-channel transmitters and thus reducing implementation costs and increasing flexibility in locating transmitters, will now be included in all receivers manufactured for the world market. Industry Canada has formally adopted this standard for digital radio broadcasting in Canada.



CRC's Jean-Denis Parent and Francois Gauthier conduct final checks on the Digital Audio Broadcast transmission facility installed on a high-rise roof in Hull, Quebec.

## IN SUPPORT OF RESEARCH...

**Some Quick Facts** - Located about 20 kilometres from downtown Ottawa, the CRC site at Shirleys Bay is close neighbours with a number of high tech firms. On its 600 hectares of land there are 72 buildings, 13 kilometres of road, and approximately 400 permanent CRC employees. The site was first used by the Defence Research Board in 1952 and communications-related R&D has been conducted there ever since. Today, National Defence and the Canadian Space Agency, with a combined staff of about 250, also occupy the site.

**Support Services** - The research community at CRC receives essential research and corporate support services from approximately 130 staff. In addition, another 60 maintain the buildings and operate the site, providing services to CRC, the Defence Research Establishment Ottawa, and the Canadian Space Agency's David Florida Laboratory.



Bonnie Lethbridge examines a printed circuit board in CRC's Plating Lab.

Whether building integrated circuit boards or operating the central heating plant or providing security services, much work is done behind the scenes to help maintain CRC's reputation as a world-class centre of excellence in communications R&D. From the stock room to the mail room, CRC's employees support the work of the engineers, scientists and technicians.

Model Shop and Technical Services staff design and manufacture prototypes. Procurement and Materiel Management provide purchasing support and manage the substantial assets of the site. CRC's Library provides researchers with access to some 13 000 technical documents, 400 current subscriptions and on-line access to technical and trade data banks.

Finance oversees the expenditure control systems, and Human Resources is responsible for all staffing matters. The Business Development Office provides marketing and public relations assistance while the Technology Transfer Office assists with contracts, licensing, and IP matters.

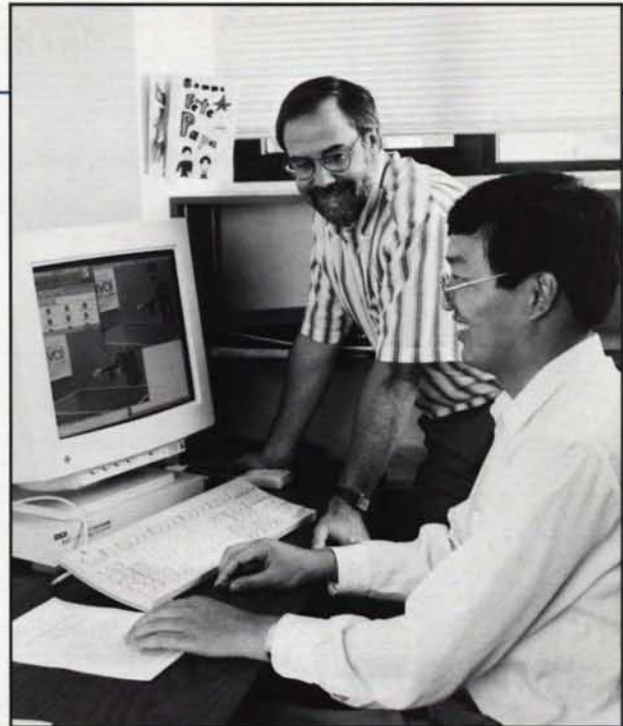
**CRC's Rejuvenation Plan** - CRC is into its second year of a rejuvenation plan to replace the large numbers of staff who have or who will soon be retiring. The plan identified innovative recruitment methods to accelerate the hiring of young researchers and technical staff. It also created a mentor program to help ensure that research continuity is maintained between scientists.

Also of concern is the recruitment of more women into the scientific and engineering communities. Under the direction of the Board of Directors, a group of CRC researchers examined the challenges facing women researchers at CRC. The group's report and its recommendations have been widely circulated and are available on CRC's web site. An action plan was developed and, within the scope of existing authorities, recommendations are being implemented.

**Energy Management Update** - It was costing approximately \$2 million annually to provide utility services to CRC. Over the years, utility costs had risen faster than CRC's funding base. Aging buildings and infrastructure made it necessary to explore options for reducing energy and other operating costs.

In November 1995, CRC entered into an agreement with Honeywell Limited to undertake a \$3.1 million project for the energy efficiency retrofit of its facilities. Under this agreement, Honeywell provides the financing, engineering and implementation of the project. No funding is required from CRC as the project is paid for through the savings that result from the implementation of the energy efficiency measures.

Immediate benefits have been realized in upgraded building controls, energy efficient lighting, environmentally compliant central air conditioning and heating, and reduced water consumption. At the end of the payback period, estimated at 8 years, CRC will retain the savings which are estimated at \$611 000 annually.



Continuity in research is ensured as experienced scientists such as André Vincent (standing) introduce newcomers like Demin Wang to the CRC research community.



An aerial view of the Communications Research Centre campus.

## FINANCIAL REVIEW

For the year ended March 31, 1996

Carry over from 1994-95 (\$M)	0.0
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### REVENUE (\$M)

Industry Canada	33.5
Other Government Departments (R&D Recoverables)	6.3
Non-government Sources	2.8
Major Government Programs (Note 1)	44.7
Site and Technical Services (Tenant Recoverables)	4.1
<b>TOTAL REVENUE</b>	<b>91.4</b>

### EXPENSES (\$M)

Research Program (Note 2)	24.7
Corporate Services (Note 2)	5.7
Site Operations	7.1
Services to Tenants	1.6
Major Government Programs (Note 1)	44.7
Special Projects	0.5
CITI Operating Costs	5.4
<b>TOTAL EXPENSES (\$M)</b>	<b>89.7</b>

Carry over to 1996-97 (\$M)	1.7
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**Note 1:** These funds are allocated to the MSAT program and to CRC's participation in Canada's Long Term Space Plan project.

**Note 2:** Both the Research Program and Corporate Services expenses for 1995-96 include non-recurring costs associated with the Early Departure and Early Retirement Incentives.

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