CRC Business Plan

1999-2000

CRC's Vision

National leadership in collaborative research and development on innovative communications, broadcasting and information technologies for a strong Canadian knowledge-based economy.

CRC's Mission

To be the federal government's centre of excellence for communications R&D, ensuring an independent source of advice for public policy purposes.

To help identify and close the innovation gaps in Canada's communications sector by:

- engaging in industry partnerships
- building technical intelligence
- supporting small and medium-sized high-technology enterprises

Cat. No. C 105-1/1 - 1999
ISBN 0-662-64337-2
52811B

Contents

Introduction

The Communications Research Centre Canada (CRC) is an agency of Industry Canada dedicated to applied research and development in communications and related technologies.

From its roots in the Defence Research Board, CRC was created as a civilian research centre under the former Department of Communications in 1969. CRC employs more than 200 researchers at its Shirleys Bay campus, west of Ottawa. The 600-hectare site, managed by CRC, is home to two other leading public sector laboratories: the Defence Research Establishment Ottawa (DREO), and the Canadian Space Agency's (CSA) David Florida Laboratory.

Special status as a Lortie Model Research Institute enables and encourages CRC to operate with a degree of independence that seeks to balance its important responsibilities in support of government priorities, with its unique role as a leading technical resource and catalyst for Canadian industry.

Industry Canada's Strategic Objectives

- Working with Canadian companies to increase Canada's share of global trade
- Improving conditions for investment in the Canadian economy
- Improving Canada's innovation performance in the transition to a knowledge-based economy
- Making Canada the most connected nation in the world
- Building a fair, efficient and competitive marketplace

The past few years have seen a number of significant changes at CRC. This business plan outlines how CRC is building on its illustrious history and technical depth and breadth, in pursuit of its vision to always be a national leader in communications technology research and development.

How CRC Responds to and Shapes its Environment

The public policy setting features continuous evolution of the role of government in the economy.

- Funded primarily by the federal government, CRC's top priority is to meet the needs and aspirations of it's major clients: Industry Canada, the CSA, and the Department of National Defence (DND). CRC is expanding its interaction with Industry Canada and other departments and agencies in order to anticipate their requirements and more effectively employ its capabilities to benefit Canadians.

- By exploring new opportunities in science and technology CRC can deliver expert, objective advice to help shape policies, regulations, standards and programs of the federal government. The prime example is management of the radio frequency spectrum, where clarity on technical issues is fundamental to Industry Canada developing sound policy and regulations. CRC also contributes in the areas of telecommunications, broadcasting, the Information Highway, science and technology, defence, space and health. Demonstrating the applications of new technologies is an important CRC contribution.

The Industrial/Business Environment is characterized by burgeoning growth and structural change in the drive toward increased access and mobility in broadband networks. As well,there are frequent changes in the positioning of key industry players and an unprecedented level of competition. This is coupled with regulatory changes such as the opening of new frequency bands and a shift to market-driven licensing decisions.

- CRC is continuing its tradition of strong linkages with companies of all sizes across Canada. Understanding the directions and requirements of Canadian industry helps CRC to design research programs, improve services and technologies, and be a better advisor to government and industry. Relationships take various forms, including bilateral and multilateral R&D arrangements, membership in associations, networks and consortia and participation in industrial seminars and trade shows.

Technological Change - provides abundant challenges and excitement in communications R&D, there is persistent uncertainty concerning which technologies will emerge as dominant; demands and applications are evolving rapidly; and a special challenge for the federal government is its effort to provide some stability in communications standards and infrastructure.

- The main trends are outlined in the accompanying box. CRC's R&D program, targeted at some of these trends, is constantly being adjusted to ensure that, within its resources, CRC is able to meet its obligations,and provide a mix of activities that will enable CRC to anticipate and shape change. By participating in scientific conferences, international science networking and standards-setting bodies, CRC is able to foresee and understand technological trends.

Technology Trends in Communications, published by CRC in 1998, identified six global trends driving communications science and technology:

Ubiquitous Communications - offering access to anyone, anywhere, at anytime, and driven by the need to connect terrestrial wireless services to mobile and portable users.

Global Communications/Networking - featuring exponential growth of the Internet and worldwide expansion of R&D in networking.

Machine-Machine Communications - spurred by increasing demand for high-bandwidth data communications services.

Natural Human-Machine Interfaces - including the widespread adoption of common user interfaces that offer simpler, quicker access to the world of multimedia information.

Broadcast, Information and Entertainment Services - a trend toward targeted delivery of a growing variety of digital services to mobile, sophisticated customers.

Convergence - in which consumers can look forward to fewer different pieces of equipment, fewer user interfaces, less variation in the range and quality of services offered by different modes, and fewer service providers.

The R&D System is affected by growth of telecommunications R&D in Canada, including large investments by multinationals, a flourishing community of R&D-intensive start-ups and spin-offs, the growing influence of research networks and alliances, and a constant challenge to public and non-profit laboratories to define new roles and demonstrate value-added contributions.

- CRC is continuously refining its special role in the national innovation system. Flexibility is the key. Partnerships with other R&D organizations, sometimes based on testbeds or applications demonstrations, are crucial and are being strengthened. The CRC Board of Directors exerts an important influence.

The International Environment features increasing interdependence of nations and communities through communications, foreign investment, trade, standardization and other factors. As a result, CRC's opportunities are expanding. There is a growing world-wide awareness of the capabilities of Canadian companies and research organizations.

- CRC's international ties take many forms, ranging from scientific relations, to demonstration projects,R&D partnerships, technology commercialization, R&D service contracts and standards setting. CRC has many international opportunities, and is acting on them judiciously to play an effective international role that benefits Canada.

Human Resources Supply and Demand is characterized by intense competition for highly skilled people, who are mobile, highly computer-literate, and accustomed to new patterns of learning and working.

- CRC, like all high technology organizations,is faced with staffing challenges. Awards to inventors, and support from reserve funds for innovative new research directions help foster an environment that rewards researchers' initiative. Educational partnerships such as the **VirtualClassroom** and the proposed **National Capital Institute of Technology** encourage young people to pursue careers in communications technology. Numerous co-op and graduate students and post-doctoral researchers work at CRC each year.

Research and Development, 1999-2000

This business plan outlines numerous creative and innovative initiatives CRC is undertaking to deliver value. Everything that CRC does — whether it is conducting R&D, granting licenses, building testbeds, incubating companies, demonstrating applications or working with secondary schools — is founded on a tradition of research excellence.

As an agency of Industry Canada, CRC uses its scientific and technical competencies to create value for Canadians. CRC offers clients:

- in-depth knowledge and experience in the research underpinnings of modern communications technology for civilian and military applications;
- the ability to provide engineered solutions for entire communications systems, through multidisciplinary approaches and collaboration;
- expertise in the interoperability of the wireless, satellite and wireline continuum that will define future broadband networks;

CRC's Core Scientific and Technical Competencies

CRC's research program reflects technological and market opportunities. Cutting across organizational divisions and projects are the following core competencies, which are essential to the successful execution of this business plan.

Modulation & Channel Coding

Optoelectronics & Photonics

RF Systems & Analysis

Speech, Sound and Video Source Coding

Propagation

Network Systems

RF Components

Antennas

Audio and Video Quality Evaluation

Electromagnetic Compatibility

- a particular perspective on the benefits of military communications technology and their civilian applications.

CRC's R&D program and key planned outputs are described within this plan in terms of two major aspects: the research itself,and the projects and relationships that build bridges to the marketplace and lever resources from other organizations. The latter section includes research projects that feature collaboration, the use of testbeds as research tools, and demonstration projects. The treatment here is intended not to be exhaustive, but representative.

Research: Building on the Fundamentals

To resolve technical issues, explore new concepts, and develop new techniques and tools, by employing, building and focussing on core technical competencies.

Much of the research related to this objective is done in support of Industry Canada and the Department of National Defence. Research results are widely disseminated through publication, presentation and collaboration, with due attention to protection of intellectual property. Often, the results are fed directly into the formulation of international standards, or developed for industrial clients. Concepts and technologies developed at CRC have application in a broad range of military, government and commercial uses.

Satellite Communications Research

As the government's leading centre for satellite communications technology, in which Canada has long been a world leader, CRC plays a key role in helping Canada be the world's most connected nation. Satellite communications will be critical to the delivery of multimedia networks across Canada's enormous geography. Continued public and private R&D investment will help ensure Canadians continue to benefit from the world's most sophisticated telecommunications infrastructure and that our industries capture a share of the growing global market. CRC's research program features support to government clients, development and transfer of technology, applications development and demonstrations,and direct industrial support through contracts and collaborations.

Industry Canada continues to fund spectrum-related tasks to supplement CRC's internally funded R&D effort and complement work done for other clients such as DND. CRC provides simulation results and expert opinions to help spectrum managers formulate policies related to interference among satellite systems and between satellite and terrestrial systems.

CRC manages satellite communications industry development programs funded under the Long Term Space Plan. New programs will be initiated under the Long Term Space Plan III (LTSP III) which will be funded in 1999/2000. CRC continues to perform R&D tasks funded by CSA,including on-board technologies such as RF-optical subsystems.

Key Outputs: A new partnership with the Canadian Space Agency for development and implementation of the satellite communications portion of Long Term Space Plan III.

Terrestrial Wireless Systems Research

This program develops concepts and technologies for fixed, mobile and personal wireless communications systems. Clients include DND, Industry Canada, wireless service providers, and Canadian manufacturers. The program covers a wide range of expertise including communications signal design, broadband and narrowband system concepts and technology, monolithic microwave integrated cir-

cuits, high speed microelectronics, voice processing, and adaptive antennas, in frequency bands ranging from HF to EHF.

> ***"Connecting Canadians is an agenda to build a Canada that can be a global leader in the 21st century knowledge-based economy."***
>
> - *Industry Minister John Manley, address to the Canadian Advanced Technology Association, June 3, 1998*

Terrestrial military and civilian radio R&D concentrates on broadband mobile wireless, adaptive antennas, communications privacy and security, and position determination (geolocation). Antenna space and polarization diversity arrangements are being exploited for military and civilian PCS systems. These smart antennas result in improved performance and increased capacity for wireless networks and mobile wireless systems. Integration of equalization and adaptive antenna technologies is also under way. Broadband wireless multi-carrier transmission techniques are being investigated to provide efficient, high-data-rate mobile communications. Adaptive antenna beamforming and receiving techniques promise to improve capacity and performance of wireless systems. Combined signal processing and encryption, and novel transmitter signature analysis offer enhanced communications privacy and security and improved spectrum surveillance. CRC is improving the accuracy and reliability of systems to geo-locate fixed and mobile transmitters for spectrum monitoring.

Key Outputs: Adaptive antennas for interference cancellation and improved performance in VHF/UHF bands; strategy for more accurate mobile transmitter position determination; prototype radio transmitter signature analysis system for spectrum surveillance applications; demonstration of a 28.8 kbps independent sideband HF modem, capable of sending compressed video over HF; a 64 kbps VHF prototype modem in support of battlefield digitization; technologies for high data rate capabilities in PCS bands, exploiting frequency and antenna diversity.

CRC is developing advanced technologies for wired and wireless voice communications in the demanding military and government domain for clients including DND, the Communications Security Establishment and the world aerospace industry, and participating in international standard-setting bodies such as NATO. Specializations include narrowband voice coding, voice acoustics, and encryption. Projects encompass digitizers, noise cancellers, underwater communication, situational awareness for ground troops, and secure voice over the Internet. These dual-use technologies are frequently licensed to private industry.

Key Outputs: New expertise in voice coding, the recovery of voice signals from noise and distortion, and contributions to military voice communications capabilities over a broad range of applications.

To aid development of a range of new communications and broadcast services and networks, CRC researchers are making advances in integration, miniaturization, interconnection and packaging of microwave, millimetrewave and digital circuits. They are pursuing design methodologies for microwave modules operating up to and including EHF frequencies that integrate three microwave technologies — gallium arsenide monolithic microwave integrated circuits (MMICs),silicon micromachining, and low temperature co-fired ceramics.

Key Outputs: Microwave and digital circuits for such applications as EHF phased array radar, wideband receivers, and group demodulators for military satellite communications; an application-specific integrated circuit in GaAs gate array technology for wideband and radar applications.

Broadband Network Technologies Research

A ubiquitous broadband network for Canada's Information Highway needs complete interconnection and operability between networks. This program addresses operability between wireline and wireless

services, network standards and security, and the convergence of communications, broadcast and computer technologies. Network systems research supports Internet technology, high-performance networking, and user interface components, using both broadband and narrowband systems. Emphasis is placed on collaborative industrial, university and multinational projects. A complementary research program in optoelectronics and photonics develops enabling technologies to increase network capacity and versatility.

Network systems research has a military and a civilian component. Military research emphasizes wireless and mobile networking; the civilian portion is developing an optical networking thrust. The program supports the development and implementation of new technologies; the integration of communication resources of widely different natures; new and improved networks and services; and the provision of advice and prototypes to clients.CRC is exploring advanced technologies including asynchronous transfer mode (ATM), optical networking, multicasting and real time protocols, and CA*net II and III. Research also includes Internet Protocols for distributed network management, Quality of Service (QoS) provisioning, network routing, user interface design and human factors, distributed interactive virtual environments, IPv6 and mobile IP.

Key Outputs: Deployment of multimedia networking and ATM technology to Canadian and allied forces networks; performance measurements for collaborative virtual reality over CA*net II.

Advanced Networking Research Program

To focus on technical issues related to the Internet Protocol (IP) and optical networking, this program will initially combine CRC's expertise in network systems and photonics, with new staff and graduate students to be added as the work accelerates. An associated laboratory will be set up in a highly visible location and synergies established with BADLAB, research on information and networks (including military), applications projects such as VirtualClassroom and IT Showcase, and various CRC testbeds. Synergies will also be established with networking and photonics research programs such as those under CANARIE and OPCOM. Initially, the program will consist of two major elements: a shorter term component with an emphasis on Quality of Service provisioning, including network security; and a longer term project on 'last mile' broadband delivery systems using fibre optics.

Optoelectronics and photonics research at CRC results in components which increase the capacity, versatility and performance of fibre optic broadband networks. One particular emphasis is on technologies which support the evolution of multi wavelength optical networks which are expected to become a main supporting infrastructure for high bandwidth transport and switching. The ability of photonics to support very large bandwidths and to cost-effectively partition this bandwidth dynamically, will be a cornerstone in the evolution of backbone network technology and will facilitate new types of network services. Research areas include: Bragg grating components; fibre optic multiplexers, demultiplexers and filters; laser array and detector subassemblies; optical switches; components for dispersion compensation in fibres; and cost-effective packaging techniques based on polymer and glass waveguides.

Key Outputs: New optoelectronic and photonic components for high capacity networks and interfaces to wireless systems.

Broadcast Technology Research

CRC is the only Canadian laboratory with a comprehensive broadcasting R&D program. The program encompasses advanced television and digital radio broadcast systems, video and audio coding and datacasting. Research ranges from developing psychophysical tools and basic technologies for digital broadcast systems, to enhancing existing systems and conducting field trials. Outputs include tools

and facilities, and technologies for transfer to equipment manufacturers and service providers. The research also generates technical knowledge used by Industry Canada for spectrum engineering, including avoidance of interference between broadcast and wireless services.

> ***"The Ottawa-based Communications Research Centre has provided a strong Canadian presence in the advanced television system debate in North America and around the world, and was a key player in the establishment of the A53 digital television format . . . . In some respects CRC has been Canada's engineering ace-in-the-hole, ensuring not only a Canadian presence but providing unique technical facilities and testing capabilities."***
>
> *- Broadcast Dialogue, July/Aug 1998, p. 11*

In 1999, the broadcast industry is formally introducing in Canada the first digital radio broadcast (DRB) services. Canada-wide implementation requires further technology development. Research at CRC includes development of alternative coverage strategies to provide better, lower-cost service and spectrum efficiencies, investigation of new service opportunities offered by digital broadcast technology, and studies on distributed emission,interference considerations and indoor reception.

Key Outputs: A report on the advantages of a distributed DRB emission system compared to a single transmitter system; preliminary results on DRB reception improvements through advanced COFDM demodulation techniques and adaptive directional receive antennas; identification of error correction requirements for very low bit rate audio compression systems in mobile wireless transmission.

Digital broadcast systems can distribute entertainment programs and data simultaneously and very efficiently to a large number of users. The digital radio broadcast system being implemented in Canada is particularly suitable for datacasting of information to mobile and vehicular receivers.

Key Outputs: preliminary results on acceptable error rates and traffic for different datacasting services; analysis of return channel alternatives and interfaces between the broadcast system and the telecommunications infrastructure.

Canadian broadcasters plan to launch digital television (DTV) services in 1999. While the basic standards are now in place, more R&D is needed to implement the technology and take advantage of its capability to offer innovative new services. Emerging broadband wireless systems will also be used for delivery of digital television and interactive services. Work is required to identify cost-effective,spectrum-efficient technologies and exploit the underlying technologies for other services such as tele-education, tele-health, electronic surveillance and multimedia. The research also encompasses development of 2D-compatible stereoscopic video systems as an enhancement to digital television services and for application to new services such as tele-health; objective video quality metrics compatible with subjective quality assessments; return channel requirements and technologies for interactive television services; and modulation technology alternatives for upstream and downstream channels for MCS and LMCS systems.

Key Output: Efficient algorithms for very low bit rate video that will permit implementation of a software codec on PC's for multimedia application.

Radio Science

Radio science deals with the study and quantification of the physical limits to the reliability, quality and performance of radio systems. CRC is the only establishment in Canada with a comprehensive program of inter-related activities on propagation effects, radio noise and interference, electromagnetic (EM) compatibility, and antenna technology. The program involves extensive interaction with

Canadian industry, academia and other national and international organizations. Research and advice is provided by CRC to Industry Canada and the radiocommunication industry, and it strongly influences spectrum allocation decisions made by the International Telecommunications Union - Radiocommunications Sector (ITU-R).

CRC is researching the electromagnetic environment arising from the increased use of the RF spectrum, to better understand its impact on electronic equipment used in communication, business, medical and military applications. Projects include measurements of base noise levels at VHF/UHF frequencies, and modelling of near and far-field radiation from portable radios such as cellular or PCS telephones.CRC researchers are pioneering novel concepts and simulation techniques, such as the application of lattice gas automata and the use of new computational electromagnetic codes for the design and characterization of broadcast antenna arrays. Work is also under way on wireless power transmission, especially the EMC and safety aspects. CRC is also working with DND on EM hardening, and the use of high-power microwaves for land mine neutralization.

Key Outputs: A new statistical model on EM field coupling into enclosures and onto printed circuit boards, and a software package for solving complex three-dimensional EM field problems involving antennas and circuits.

CRC's antenna R&D activities cover hardware and software pertinent to state-of-the-art, low profile, active and passive antennas and array technologies for applications from L-Band to millimetrewave. High performance, low-cost, compact size and antenna/electronics integration are among the key research goals. An example is wideband, planar active, phased array antennas for personal communications via terrestrial or satellite links.

Key Output: Improved EM simulation tools to aid in understanding the performance and radiation characteristics of antennas and to ensure operational compatibility.

Propagation research at CRC spans a range of radio frequencies and link geometries used by a variety of communications services. Industry and the military are interested in using bandwidths in the 20 to 100 Ghz range, where propagation information for new applications is sparse. New services such as digital broadcasting and digital mobile require more detailed propagation knowledge and channel models than analog systems. Experiments and modelling are coupled with the investigation of new approaches such as computer-based ray-tracing to improve the design capabilities of mobile and multipoint systems. Research on ionospheric, tropospheric, environmental clutter and ground effects will result in more efficient spectrum management and link design, better understanding of propagation media and mechanisms, techniques to overcome adverse effects of propagation, and improved system reliability.

Key Outputs: Model of rain-fade duration for earth-satellite paths; measurement/modelling results to improve the capability of CRC-Predict; narrowband propagation model for high data rate digital mobile radio; report on transmission of very high data rates around obstructions in LMCS-type systems; new urban data on levels and characteristics of VHF/UHF background noise.

Bridging Research and the Marketplace

Testbeds, Applications Development, and Demonstrations

To expand, enhance, integrate and deploy CRC's unique research facilities for collaborative research.

To demonstrate new concepts, and new applications of communications technology, in collaboration with public and private sector partners.

To strengthen capabilities for testing and characterization of monolithic microwave integrated circuits (MMIC's),this year CRC is inaugurating a new facility designed to foster closer collaboration with universities, other research organizations and companies, regardless of location.

Key Output: Installation and investigation of the operational requirements, capabilities and limitations of a wafer prober facility for testing MMIC's under remote control over high speed wideband data networks.

Other testbed initiatives are being undertaken in network systems research.

Key Outputs: establishment of a testbed to evaluate voice over ATM (radio) networks, an IPv6/mobile IP testbed and performance measurements for collaborative virtual reality over CA*Net II.

CRC's satcom applications program is being restructured under the Satellite Multimedia Applications Research and Trials (SMART) Program, focussing on next generation applications for broadband systems. Relationships with service providers and users such as provincial and regional health centres, and with government initiatives that address access issues in remote communities, are key. Collaborators include international partners such as NASA and ESA in demonstrating broadband communications over international satellite links.

Key Outputs: A restructured satellite communications applications program; high bandwidth satellite applications demonstrations, achieved through international collaboration.

CRC is embarking on an extensive demonstration program to deploy and test a number of 5.2/5.8 GHz license-exempt technologies designed to provide point-to-point and point-to-multipoint broadband wireless multimedia connectivity. Tests will initially focus on 45 MB/s wireless ethernet bridging technology. The bridging will link wireline LAN's typically used within schools, libraries and hospitals and which are geographically separated by 5-10 km. Building on the experience and knowledge obtained in deploying the wireless ethernet bridges, CRC will embark on a more prominent and advanced concept, achieving connectivity with the concepts embodied in the MILTON (Microwave/Light Organized Network) system.

Key Output: Proof of concept testing of MILTON prototype, a wireless, broadband, bi-directional, high capacity, multimedia system deployed in a widely dispersed urban and suburban environment.

Research on multimedia mobile datacasting is aimed at building on the technology's potential, demonstrated in collaboration with industrial partners.

Key Output: Experimental services in partnership with service providers and broadcasters to evaluate technology and determine requirements for standards and protocols.

Networking projects raise CRC's profile and provide opportunities to work on leading-edge technologies in fields such as ATM networking, multimedia networking, network management and routing, QoS provision and performance monitoring. Ongoing trials are an essential element of the broadband networking program involving the BADLAB and other CRC facilities. International projects include Communications System Networks Interoperability (CSNI); Advanced Command and Control Operations Research Demonstrator (ACCORD); Joint Warrior Interoperability Demonstration

Wireless and Inter-networking Systems Experimentation Laboratory (WISELAB)

The year 1999-2000 will see the implementation of WISELAB, CRC's distributed broadband wireless testbed, designed to test and demonstrate broadband communications techniques and concepts, and to evaluate systems, technologies and applications. The testbed infrastructure and network connections are in place. It is accessible by industry, IC and DND, in support of collaborative R&D efforts.

(JWID); EXPERT (National Host testbed in Switzerland); National Hosts Interconnection Experiments (NICE); VirtualClassroom; and Multimedia Education and Conferencing Collaboration over ATM networks and Others (MECCANO).

Key Output: A trial to implement differentiated services over CA*net II; a trial of a TDMA-based LMCS alpha network; an international demonstration of advanced multimedia networking and ATM technology in Canadian Forces networks (JWID 99).

The technical parameters for introducing digital TV broadcasting in 1999 have been developed in the past years based on the results of extensive laboratory tests. The performance of the system needs to be validated now under real world conditions. The Canadian TV broadcast industry, under the leadership of Canadian Digital Television Inc. (CDTV), working in collaboration with CRC, will carry out a variety of joint research projects.

Key Output: Installation, in collaboration with CDTV Inc., of the Ottawa datacasting field trial system, development of detailed test procedures,and analysis of preliminary UHF band test results, in order to validate coverage and spectrum allocation assumptions.

VirtualClassroom

VirtualClassroom is a CRC program that uses leading-edge communication technologies and broadband networks to explore new learning models. Connecting to high-speed networks through CRC's BADLAB, Ottawa-Carleton school students have been able to collaborate with international partners on a variety of projects. Since 1996 students from Confederation, Samuel Genest and Sir Wilfrid Laurier High Schools have linked with students from Singapore, Switzerland, Ireland and Austria. A world of learning possibilities is being explored.

Transferring and Commercializing Technology

To accelerate the commercial uptake and application of CRC technologies.

Canada, as a leading supplier of telecommunications equipment, is well-positioned to exploit advances in optoelectronics and photonics incorporated into products and services for the world marketplace. In more than 20 years of research, CRC has accumulated a valuable intellectual property portfolio and a worldwide reputation for research excellence and technology transfer. Commercialization efforts are continuing, focussed on partnerships with key players, targeted marketing, international cross-licensing arrangements, and the world-wide enforcement of CRC patents.

Key Outputs: Licences with Canadian and foreign companies; R&D collaboration and partnership agreements.

CRC has established state-of-the-art antenna test facilities. The R&D combines in-house,university and industry participation. Technology transfer to industry, a primary objective, is achieved through collaboration in knowledge transfer, licensing of prototypes and training graduate students for industrial employment. Technical and engineering design expertise is provided to government and industry on diverse systems such as PCS, Local Multipoint Communications Systems (LMCS), and EHF satellite communications.

Based on the CRC/DREO-developed read-to-quadrature demodulator ASIC technology, industry is developing a wideband digital radar receiver.

CRC is increasing the marketing and commercialization of its satellite communications technologies. A dramatic example is the multiple licensing and distribution of channel coding technologies using the Internet and CD-ROM. Satellite terminal sub-systems, including various broadband terminal sub-

systems (e.g. direct receiver and transmitter technology) and narrowband modems are also being developed, demonstrated, and licensed to the private sector.

Key Outputs: Increased transfer of satellite terminal subsystem technologies; licensing of CRC's coding technology, including deep space communications applications; more detailed analysis of CRC's rain-fade counter measures important to applications at Ka-Band, with the goal to demonstrate and transfer the technology.

CRC is strengthening its relationship with DND by delivering on the military's requirement for reliable, higher data rate tactical and strategic mobile communications systems in the HF, VHF and UHF frequency bands. These "dual use" technologies can also be readily transferred to civilian applications, facilitating the goal of adopting commercial off-the-shelf equipment in the global military communications infrastructure. CRC is also exploiting extensively the commonalities of the military and civilian components of its network systems research.

Key Outputs: Transfer of high data rate HF technology to industry; transfer of robust data links for helicopter communications.

CRC is accelerating its commercialization of the successful CRC-COV software and development of the next generation product, CRC-COVLAB.

Key Outputs: Release of sub-products of the CRC-COVLAB coverage prediction software, including software for the DND IRIS project and a Windows NT version of CRC-COV for beta testing.

Expanding Partnerships

To expand and strengthen CRC's many partnerships in support of CRC business and R&D objectives.

Special emphasis is being placed this year on ensuring that CRC has strong, productive partnerships with organizations that have a big influence on its future.

First among these is Industry Canada. An important goal is more effective integration of CRC's R&D performance and its advisory role with spectrum management and telecommunications policy officials. CRC can be even more effective when participating in long-term policy development, by virtue of its outlook on the emergence of, and interaction with, new technologies.

The longstanding relationship with the Chief, Research and Development, Department of National Defence continues to be an important focus for CRC. This program is evolving in step with changes in R&D organization and DND priorities. CRC is increasing its efforts to migrate military communications expertise and technology toward civilian applications, in a manner consistent with obligations to military customers.

Partnerships with industry are central to the Advanced Satcom and International Mobile Satcom programs. The goal is to develop new world-class Canadian products and technologies for the multi-billion-dollar international satellite communications market over the next four to eight years. CRC is finding a consistent and growing demand for contracting-in for its satellite communications expertise and technologies.

> ***"We will build creative partnerships between the public and private sectors to accelerate the adoption of innovative technologies in all sectors of the economy."***
>
> - *Hon. Romeo LeBlanc, Governor General of Canada, Speech from the Throne, Sept. 23, 1997.*

Key Outputs: Completion of major portions of the $65 million Advanced Satellite Communications Program announced in 1997; expansion of R&D in support of the Military Satellite Communications (MilSatCom) Program,specifically in signal designs for narrowband and broadband military satellite standards.

In broadband networking research, CRC is putting increased emphasis on the development of core expertise in optical networking. A number of major programs are at the project definition stage: OPCOM, CANARIE, the National Capital Institute of Technology and OCRInet. All of these have a major interest in photonics and optical networks and all are seeking CRC partnerships. CRC's research program is designed to build on CRC's strengths while addressing the partners' goals. This new thrust will become an important component of the Advanced Networking Research Program.

CRC is working with centres of excellence such as the Canadian Institute for Telecommunications Research in the development of advanced integrated electronics for LMCS and broadband satellite communications applications. Discussions have been initiated with other national laboratories such as Japan's Communications Research Laboratory in order to establish R&D collaboration that would supplement existing collaboration in other fields.

CRC Innovation Centre

To foster the growth of Canadian companies, particularly start-ups, and the development of their products and services, through collaboration with CRC scientists, engineers and technical staff, and access to CRC expertise, facilities and technologies.

A highlight of this year is implementation of a new strategic plan for the CRC Innovation Centre, with renewed and updated goals and policies. Construction of a $5 million building at the front of the campus to accommodate Industry Canada's Certification and Engineering Bureau and provide the CRC Innovation Centre, with 9,000 square feet of new space is under way. This project illustrates Industry Canada's commitment to "highest and best use" of the Shirleys Bay land, and clearly demonstrates support for creating an environment conducive to transfer technology to small companies. Redevelopment at the front of the campus demonstrates CRC's ongoing commitment to the high technology community. Further, it affirms CRC as a key stakeholder in Industry Canada's goal of improving Canada's innovation performance in the transition to a knowledge-based economy.

Key Outputs: Productive relationships with 10-15 client companies during the year; several new clients to optimize occupancy by year-end in existing space and the new building; mutual support agreements with the National Research Council and other incubators and research centres across Canada.

Marketing and Communications Priorities

To continue to be the federal government's centre of excellence for communications R&D, CRC must ensure it has the resources to build on the fundamentals of its research programs.

The key business goal of CRC is to sustain or increase investments from its three major partners: Industry Canada, National Defence and the Canadian Space Agency.

The objectives of CRC's marketing and communications program in support of this goal are:

- To win broad support from key stakeholders for CRC's evolving role and contribution in communications R&D;

- To build client and public awareness of CRC's specialized facilities, testbeds, and applications demonstrations.

- To accelerate the transfer and commercialization of CRC technologies, by creating relationships whereby companies, especially SMEs,can exploit CRC technologies, expertise and facilities to create jobs and economic growth.

- To expand partnerships and collaboration with other R&D institutes that maximize resources while furthering CRC's research objectives.

The CRC Marketing Division provides leadership, facilitation and service to support these objectives. Responsibility for marketing, business development and technology transfer is broadly distributed within CRC. Innovation and creativity in these areas are strongly encouraged, within a framework of corporate goals and policies as outlined earlier in this business plan.

Major Client Groups

Key Government Clients - a central element of CRC's client focus this year is a broader corporate commitment to understand and respond creatively to the requirements of Industry Canada,DND and CSA. Emphasis on relationship building will require expanded, judicious participation in departmental committees, task forces and project teams. CRC will also seek greater profile with its major clients through selective distribution of information to officials about CRC's capabilities and achievements, and more frequent presentations.

Other Government Departments and Agencies - relationships with other federal organizations are typically research-driven. Collaboration and R&D services enable CRC to support government objectives (such as national security) while advancing its own research program. However, CRC recovers costs for R&D services provided to all clients. At the same time, CRC has many cooperative relationships with government organizations in which there are in-kind contributions between the partners. This year CRC is continuing to seek opportunities to work with and for government organizations in the national interest. Existing agreements with the National Research Council, Canada Centre for Remote Sensing and other organizations are being more fully implemented.

Companies - CRC's door is open for business with companies of all sizes. Relationships with companies create channels to commercialize CRC technologies and deploy CRC's knowledge and expertise for economic benefit. These relationships also build CRC's industrial understanding, positioning it better to provide expert, objective advice to Industry Canada.

A special effort is directed towards small and medium-sized enterprises, many of which can accelerate their business by accessing CRC's capabilities. To realize its national mandate, CRC has always made good use of other networks to create business relationships with SMEs across Canada. The National Research Council's Industrial Research Assistance Program (IRAP) is a key network. CRC provides project evaluations,and IRAP creates a link to CRC for companies. The CRC Innovation Centre is also a key CRC instrument to support SMEs.

Universities - university cooperation helps advance CRC R&D objectives, while contributing to the development of highly qualified people. Linkages include membership in the Canadian Institute for Telecommunications Research,a renewed commitment this year to Communications and Information Technology Ontario and partnership in the proposed National Capital Institute of Technology.

International Clients - International collaboration generates revenues, knowledge exchange and provides CRC with the ability to influence international standards. It also opens international markets for

CRC and its clients. Care is taken to ensure that international commitments are not detrimentral to Canadian SMEs.

Special Marketing Initiatives

Technology Transfer - CRC is broadening its relationships with third parties, such as technology brokers and venture capital companies, to accelerate technology commercialization. Excellent results have been achieved through cross-licences with foreign corporations. Streamlining and increased target marketing of CRC's revenue-yielding patent portfolio is being done this year.

Testbeds and Special Facilities - through collaboration among R&D branches and the Marketing Division, CRC will showcase testbeds and special facilities through applications development and demonstrations.

Promoting R&D Investment in Canada - CRC's involvement in investment promotion, primarily through support for Investment Partnerships Canada,has grown in recent years. As part of Canada's R&D infrastructure, CRC can help influence corporate investment by playing an advisory role on investment opportunities in telecommunications.

Human Resources Priorities

Working together, we want to create an organization that adds value to Canada, our clients and our employees.

Leadership in research is predicated on competent individuals and teams. To ensure CRC is the federal government's centre of excellence for communications R&D requires sound strategic human resource management practices.

In 1999-2000, CRC is focussing on two priorities contained in the long-term human resource management plan.

- Redesign of the existing performance appraisal system into CRC Performance Management, a more comprehensive process for setting standards, establishing development activities, giving feedback, and allocating rewards based on performance.
- Identification of the competencies for leadership at CRC, and training and development of middle managers.

Site Operations

In addition to CRC research laboratories,the Shirleys Bay campus is home to other government departments and agencies, as well as a dozen private sector companies engaged in leading edge R&D in a variety of activities related to communications.

Underpinning and facilitating this R&D are an extensive physical infrastructure and special-use facilities, co-ordinated site management and development, and the on-site provision of technical and other support services required by the R&D community for its day-to-day business operations.

Restructuring in 1998 resulted in an Operations Branch with four main roles:

- maintenance and repair of existing facilities and infrastructure;
- identification and management of campus-wide business requirements;
- provision of technical and other support services to the R&D community; and
- long-term capital investment planning.

Heating plant modernization is well into its second phase. Capital investment in new infrastructure has made the plant efficient to the point where resource reductions and salary savings have accrued. This frees scarce resources which are being redirected to R&D. The second phase involves the installation of automated system monitoring and troubleshooting services.

A recently concluded business process re-engineering review has identified improvements to the procurement of goods and services. These improvements,now being implemented, will result in savings in the order of several hundreds of thousands of dollars. As similar reviews are completed in other areas, and as outsourcing opportunities are identified and implemented, additional savings will be realized for redirection to R&D.

Following Through

1998-99 was CRC's first year of operation under a realigned management structure. The five branches reflect the areas of opportunity for CRC technologies and expertise. In addition to the ongoing research program, CRC is following through on previous commitments and new initiatives launched in 1998-1999. Examples are outlined below.

Information Highway Access Technology (IHAT) - In 1998, CRC announced the establishment of a reserve fund, created from revenue generated through IP licencing and contract research, to support dynamic R&D proposals submitted by the research branches for R&D initiatives that improve access to Canada's Information Highway. Several projects were supported and more will be endorsed this year.

WISELAB - This year will see full implementation of this wireless testbed announced by Industry Minister John Manley in November 1997.

Revenues - Following several years of increasing revenues through R&D service contracts and technology licensing, CRC has boosted the target for the current year to $3.5 million.

Energy Efficiency - CRC invested $4.254 million to upgrade its heating plant with a view to reducing annual operating costs. The retrofit was completed in 1997-98 and savings this year (labour and energy costs) will total $530,000.

Millennium Project - A new building, conceived and designed through a partnership with Industry Canada's Spectrum, Information Technology and Telecommunications Sector, is being constructed at the Shirleys Bay site in 1999 to house the department's Certification and Engineering Bureau and CRC Innovation Centre clients.

CRC Innovation Centre - A full review of the CRC Innovation Centre conducted in 1998 has resulted in a new strategic plan which will be implemented in 1999.

Business Process Reengineering - Implementation of measures identified in 1998 by teams of employees under the direction of the newly appointed Comptroller and General Manager of Operations will offer streamlined and more efficient services, saving up to $300,000 in annual non-research operating costs. Further analysis will be conducted in 1999, with the participation of the Marketing Division.

Y2K - CRC is ensuring that all its mission critical systems are Year 2000 compliant.

CRC Financial Plan, 1999-2000 ($ million)
Projected Expenditures and Sources of Funding

Revenues (Funding Sources)		Projected Expenditures		
Industry Canada		**Research Program**		
Annual Allocation	$26.8	CRC-directed research		$17.5
Spectrum Research	0.8	DND-directed research		5.4
Department of National Defence (DND)	5.4	CSP-directed research		1.2
Canadian Space Agency (CSA)		Spectrum-directed research		0.8
Canadian Space Plan (CSP)	1.2	**Sub Total: In-House Research**		**24.9**
IP and R&D Service Contracts	3.5	**Research Support**		3.9
Tenant and Support Services Revenue	3.2	**Sub Total: CRC Research Program**		**28.8**
Sub Total: Funds Managed by CRC	**40.9**	**CSP Contracted-out Research**		18.6
Flow-through funds:		**Sub Total: Research**		**47.4**
CSP contract funds managed by CRC on behalf of the CSA	18.6	**Administration and Support**		
		Site Services provided to CRC	4.6	
		CRC Administration	3.9	
		Tenant & Support Services	2.5	
		Payment in Lieu of Taxes	0.8	
		Installment - Millennium Project	0.3	
		Sub total: Administration and Support		**12.1**
Total Revenues	**$59.5**	**Total Expenditures**		**$59.5**