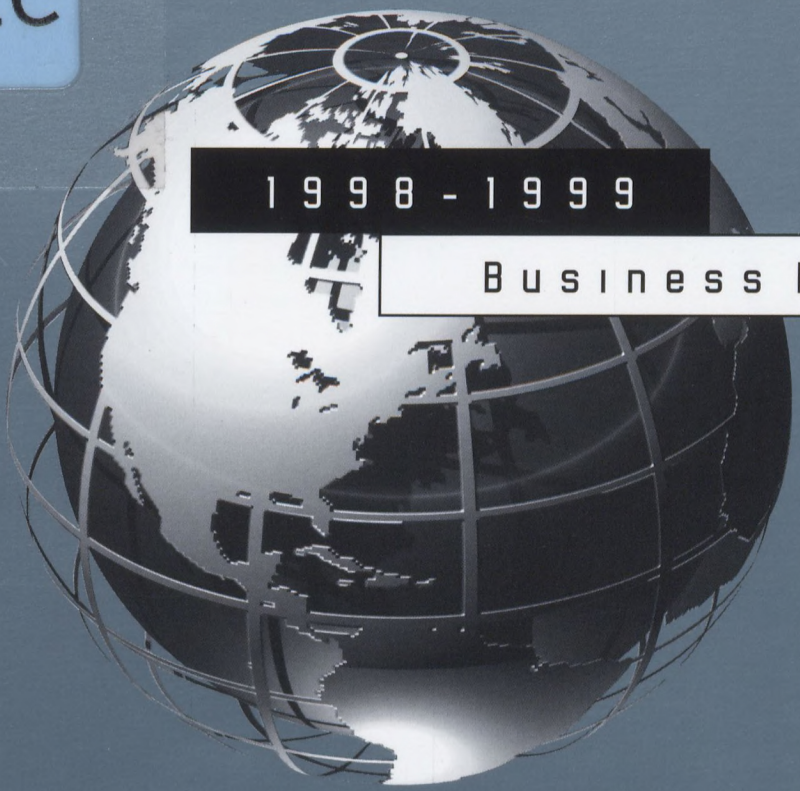
CRC

The Communications Research Centre



1998-1999 Business Plan

Industry Canada Industrie Canada

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Introduction

The Communications Research Centre (CRC) as an institute of Industry Canada, is dedicated to research and development in a multidisciplinary field of communications and related technologies. As a member of Industry Canada, it is attached to a Department with 4,800 employees and an annual budget of approximately $1 billion. Industry Canada is part of the Industry portfolio, which consists of more than a dozen federal government entitites dedicated to economic development and marketplace management, with 15,000 employees and an annual budget of $3.2 billion.

CRC is situated on a 600-hectare site at Shirleys Bay, west of Ottawa. Founded on primary capabilities in radio propagation and radio communications, CRC's R&D has been driven over the years by the need to provide communications and broadcast services to all Canadians, wherever they live or work. The research program has historically featured a high degree of industrial participation. CRC has gained a world-wide reputation as an authority on communications-related technology through 50 years of scientific publication, industrial innovation and participation in international fora.

CRC has contributed substantially to the development of telecommunications infrastructure in Canada. Building on core competencies in satellite communications, radio science, terrestrial wireless services and broadcasting, CRC is focussed on wireless communications as its principal line of business in 1998-99. As Canada seeks to build a knowledge-based economy at the dawn of the new millenium, CRC's special capabilities in broadband communications, wireless access and applications demonstrations will become vital to developing the networks of the future.

CRC Vision

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

CRC's Operating Environment

The telecommunications business environment in Canada is positive for investors and consumers alike as government policies have opened up new opportunities. Canada's traditional strength in telecommunications puts it in a good position to take advantage of emerging markets around the world as the era of deregulation takes hold. CRC is committed to helping Canada maintain its leadership position, so that all Canadians can continue to enjoy telecommunications services that are the envy of the world.

Rapid technology change, favourable government policies on trade and competition, and increasing private sector investment in telecommunications R&D, are all factors challenging CRC to be creative and adaptive. In developing its R&D program, CRC plays a supporting role in the federal government's goal of making Canada the most connected nation in the world.

This business plan positions CRC in response to current national and global forces, while focussing on research activities that have a medium to long term development horizon. Aggressive investments in emerging technology areas are underway, to complement the basic competencies that have been the traditional underpinning of CRC's considerable

technical experience. CRC aims not just to respond to change, but to anticipate it and thus be in a better position to help shape it.

As an institute of Industry Canada, CRC is governed by the Department's policies and principles. At the same time, CRC must exercise flexibility to partner with industry and collaborate with a host of organizations. CRC seeks a balance between public sector accountability and the private sector need for bottom-line results. The institute is an active participant in a variety of committees and task forces that are re-engineering the public service in science-based departments to be a more responsive and effective force in the years to come.

CRC 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.

Research and Development Plan

Introduction

The Communications Research Centre has been committed to applied and basic research in communications and related technologies since the late 1940s. Over the last 50 years many scientific and engineering milestones have been achieved, contributing to Canada's position as a world leader in wireless and satellite communications and broadcast technologies.

An institute of Industry Canada since 1993, CRC has maintained its tradition of excellence in managing technical issues concerning the radio spectrum, the deployment of wireless communications and broadcast services, and the development of new technologies and knowledge for exploitation by Canadian industry. CRC is the federal government's main research centre for communications technology R&D. Through its Broadband Applications and Demonstration Laboratory (BADLAB) and associated testbeds, it is also the federal government's leader for Information Highway R&D. CRC is a facilitator in connecting Canadians to participate in the global knowledge-based economy of the 21st century.

In its final report, Preparing Canada for a Digital World, the Information Highway Advisory Council recommended that the Communications Research Centre: "....priorize its research efforts and resources around those areas of critical importance to securing the competitive position of Canada's high technology sector. These are:

- emerging wireless broadband services such as LMCS, digital radio and television broadcasting;
- delivery of multimedia services to remote regions by satellite;
- applications of photonics to increase network capacity and versatility;
- components and subsystems for wireless broadband hardware; and
- demonstration of applications with national and international partners."

To continue to strengthen its position in these areas, CRC has developed a plan that embraces the institute's traditional strengths, while addressing the realities of the rapid evolution in wireless and broadband communications.

Info Highway Access Technology — A new CRC Program

Recognizing that the Information Highway is revolutionizing the way the world communicates and redefining the economy of the future, CRC will embark on a new program called Info Highway Access Technology (IHAT). Under this program, financial resources from the President's Reserve will be used to fund dynamic R&D proposals generated by the research branches for wireless technologies that improve access to Canada's Information Highway.

Research Objectives

CRC's principal line of business will continue to be wireless communications R&D. The institute's core competencies in radio science, satellite communications, terrestrial wireless, broadcast technologies and networking create a solid foundation as a centre of expertise in wireless communications. There is increasing linkage between CRC's core competencies and Broadband Networking and Applications Demonstrations to foster development of Canada's Information Highway during this period of rapid technological change.

Four global objectives frame the activities that will be undertaken by CRC's research branches in fiscal year 1998-1999. The objectives of the individual projects are consistent with the global objectives:

- **Build and disseminate new knowledge to maintain CRC's unique role as expert, objective advisor to government and Canadian industry**

  Scientific and technical knowledge underpin many important decisions of government -- such as the promulgation of new telecommunications policies and regulations, the issuing of licences for new services, the development of standards, and the implementation of communications systems in the public interest, such as those required for national defence. In addition, CRC's knowledge dissemination to Canadian industry stimulates growth in new products and services. CRC also participates in many international fora where expert knowledge is important to advancing Canada's interests.

- **Stimulate and support the initiatives of private sector clients by working with them to realize commercial applications of CRC technologies, expertise and tools**

  Among federal government laboratories, CRC is second to none in its technology transfer track record. The success, attributable to the special efforts of the research teams and the marketing division, is facilitated by the effective use of tools such as patents, licences, partnerships, and programs such as the National Research Council's Industrial Research Assistance Program (IRAP). Building on success in its first three years of operation, the CRC Innovation Centre, an incubation facility for small companies, will be enhanced in scale, scope and profile. The transfer of technology to companies, featuring increasing use of testbeds, will be an integral and important element of CRC's research program.

- **Nourish collaborative research partnerships to pool resources, extend the reach of CRC's research program and assure access to the latest knowledge**

  CRC is continuing to expand its web of regional, national and international R&D collaborations with universities, centres of excellence, research institutes and international organizations. Such relationships have delivered excellent value in the past and are now essential for CRC to realize maximum return from its investment in the fast-moving field of communications research.

- **Challenge and inspire Canadians to explore the possibilities offered by emerging communications technologies**

  The Government of Canada is committed to making Canada the most connected nation in the world to compete in the Information Age of the the 21st Century. The demonstration of leading-edge communications technologies and the development of new applications for them is an important CRC function, as it seeks to raise the awareness level of industry, academia and the public to the potential of these technologies.

The following information details the programs and activities of the five research branches: Satellite Communications; Radio Science; Terrestrial Wireless Systems; Broadband Network Technologies; and Broadcast Technologies.

CRC is the Canadian government's leading centre of expertise in satellite communications. It performs leading-edge R&D to help determine the evolution of future satellite communications (satcom) networks and aids industry development through technology transfer. On behalf of the Canadian Space Agency, CRC manages the implementation of the satcom component of the current Long Term Space Plan (LTSP). It serves as the contract and technical authority on multimillion dollar industrial development contracts. CRC also coordinates government and industry participation in the development of the Long Term Space Plan III, a major federal program expected to commence in early 1999. CRC also collaborates with satellite service providers and users by developing and demonstrating applications such as telemedicine and tele-education.

Systems Research and Technology Development

Satcom R&D focuses on system analysis and design; communications signal processing; and earth terminal and applications development. Industry Canada, National Defence, the Canadian Space Agency (CSA) and Canadian industry are the major clients.

Future broadband satellite networks will operate at Ka-Band frequencies (20/30 GHz) and beyond. One of the technical challenges for these systems will be the availability of reasonably priced user terminals and the performance of satellite links at these frequencies.

CRC has a number of key terminal technologies under development including direct modulation/demodulation, novel receiver designs, and transportable earth terminal subsystems. CRC is studying ways to improve system availability and mitigate effects of rain attenuation and to determine levels of interference between geostationary and non-geostationary satellite systems.

The goal of communications signal design research is to develop efficient and robust transmission schemes for challenging propagation environments for mobile and fixed satellite, voice, data and multimedia applications. CRC's technical leadership in modulation, coding, synchronization, detection and multiple access techniques generates a significant amount of technology transfer and contract work.

Major Satcom Program Management

On behalf of the Canadian Space Agency, CRC manages major federally funded satellite communications development programs. These include the Advanced Satellite Communications Program (ASCP) and the International Mobile Satellite Communications Program (IMSCP). CRC contributes technical leadership and managerial expertise in the management of these complex, high technology projects, which typically include broad participation among a number of leading companies from the Canadian space industry. CRC ensures that the Canadian taxpayer gets maximum value for the federal funding that is invested in these programs. The satcom management expertise at CRC has been developed over many years and features a high degree of industry collaboration, combined with in-house research and development activities.

The ASCP is a $65 million program, funded 75 percent by CSA and 25 percent by Canadian industry, aimed at the development of wideband, multimedia satellite communications technology and services. Five major contracts with Canadian companies will be completed over the next three years.

The IMSCP develops next-generation mobile satellite communications technology, with industry paying about half the costs. Ten contracts are currently under way, with approximately $6 million budgeted annually under the program.

Testbeds and Applications

The Satellite Communications Applications Program (SCAP) develops new applications of satellite communications technology and services in partnership with potential users or service providers. While projects typically have a long

commercialization time or limited customer base, they address essential public services such as telemedicine and tele-education. The projects usually involve remote, rural or northern communities and require relatively high data rates or other capabilities not commercially available. Most projects are associated with multimedia services and feature close collaboration with domestic and international satellite service providers.

With funding from the European Space Agency, CRC and its partners ComDev, Spar Aerospace, and Telesat Canada are proposing to implement the Broadband ESA Satellite Testbed Laboratory (BESTLAB). After leading the definition and design phase, CRC proposes to act as prime contractor in the bid for the multimillion dollar second phase implementation. Under this phase, each partner will establish a node linked by satellite to test and develop broadband satcom technologies and applications.

Major Outputs

The following outputs are expected during the 1998-1999 fiscal year:

- modulation, coding and receiver technologies transferred to industry;
- Long Term Space Plan III submission to Cabinet;
- Ka Band terminal technologies for proof of concept demonstrations and transfer to industry;
- completion of satcom systems analysis for Industry Canada;
- development of technologies for delivery of multimedia services via satellite to mobile terminals;
- signal design techniques for RF spectrum analysis and monitoring for military and Industry Canada clients; and
- improved technologies for signal transmission and reception.

Radio Science

CRC's radio science program focuses on the study and quantification of the physical limits to the reliability, quality and performance of radio systems. R&D is conducted into propagation effects, radio noise and interference, electromagnetic (EM) compatibility, and antenna technology. CRC is the only research establishment in Canada that has a comprehensive program of interrelated activities in these areas.

This program involves extensive interaction with Canadian industry and academia, as well as other national and international organizations. Research results provide needed information and advice to Industry Canada and the radiocommunication industry to plan, develop and implement radio systems and services. In addition, position papers and other submissions based on this work strongly influence spectrum allocation decisions made internationally by the International Telecommunications Union – Radio (ITU-R).

Propagation

Propagation research is being carried out over a broad range of radio frequencies and link geometries used by a variety of communications services. This research involves investigation of ionospheric effects at the lowest frequencies, tropospheric and environmental clutter effects at the highest frequencies, and various ground effects at all frequencies. Much of the work is directed towards the development of better techniques for spectrum management and link design applications. A smaller, but no less significant portion, seeks a better understanding of propagation media and mechanisms.

The increasing demand for wireless communications necessitates the exploration of ways to improve efficiency in the use of the radio spectrum, develop techniques to overcome adverse effects of propagation, and to improve system

reliability. There is strong interest from both industry and the military in using greater transmission bandwidths that are physically realizable in the 20 to 100 GHz range, where propagation information for new applications is sparse. At the same time, new wireless services such as digital broadcasting and digital mobile (terrestrial and satellite) communications, require radio propagation knowledge and channel models in much more detail and in different forms than was the case for analog systems.

Propagation experiments and modelling in all bands, coupled with the investigation of new approaches such as ray-tracing, are important aspects of ongoing work. In particular, new methods are being used extensively in research pertinent to mobile and multipoint systems. This work is useful in the analysis of techniques and engineering tools that can be applied to improving the design capabilities of future systems.

Electromagnetic Compatibility

As the spectrum becomes more fully utilized, there is increasing probability of interference among users and electronic equipment malfunctions as a result of electromagnetic fields (EMF) radiated by a wide range of devices. Research to enable the prediction of near and far field radiation from UHF/VHF portable radios, such as cellular or Personal Communication Service (PCS) telephones, is a primary focus. Measurement of EMF to ensure levels conform with Health Canada's safety standards is of critical importance. In addition, research is conducted to establish EMF tolerance zones for the operation of electronic equipment.

Both measurement and mathematical modelling are being conducted to enable better understanding of the impact of EM waves on equipment used in communication, financial, medical, and military applications. Such equipment is increasingly dependent on electronic controls, with a resulting greater susceptibility to strong EM fields. To provide protection, interference mechanisms must be understood and characterized. As well, the effectiveness of shielding techniques must be evaluated.

Novel concepts and simulation techniques, such as the application of lattice gas automata are being pioneered. Work is also under way to develop a near-field probe and probe arrays to allow instantaneous automatic field mapping. In related areas, CRC is working with DND on research concerned with EM hardening and the use of high-power microwaves for neutralization of land mines. In addition to R&D, consulting services and validation measurements are being carried out on behalf of Canadian industry.

Antennas

Antennas are key components in all radiocommunication systems. CRC's antenna R&D activities cover hardware and software investigations pertinent to state-of-the-art, low profile, active and passive antennas and array technologies for applications from L-Band to the millimetrewave band. High performance, low-cost, compact size and antenna/electronics integration are some of the key research goals. An example is the wideband, planar active phased array antennas for personal communications via terrestrial or satellite links. Improvements are being made to existing EM simulation tools used for the analysis of complex antenna and field problems. Such tools are used to aid in understanding the performance and radiation characteristics of antennas and ensure compatibility in their operational environments.

To carry out this work, CRC has established state-of-the-art antenna test facilities. The R&D is conducted through a combination of in-house, university and industry participation, with technology transfer to industry being a primary objective. This is achieved through collaboration in knowledge transfer, licencing of prototypes and in 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.

Major Outputs

In addition to interim reports and development prototypes in most R&D areas, the following

major outputs are expected during the 1998-1999 fiscal year:

- new data for the planning and design of commercial satellite services in the 20/30 GHz band and military satellite services in the 20/44 GHz bands;
- an improved, globally applicable technique for predicting precipitation attenuation distributions on earth-space links;
- market introduction of commercial software, based on CRC Predict, for PCS network design;
- a report on research findings concerning propagation issues in LMCS systems;
- a report on measured and predicted characteristics of signals radiated from cellular radios when used by a human operator;
- an improved technique for mapping EM fields radiated by PC boards;
- validation of the lattice gas automata technique for analyzing radiation by geometrically complex structures;
- high gain reflectarray antenna designs for single frequency, dual polarization and for dual frequency, dual polarization operation; and
- design of low profile phased arrays of dielectric resonator antennas for wideband applications.

Terrestrial Wireless Systems

CRC's terrestrial wireless R&D program advances understanding of and develops concepts and technologies for fixed, mobile and personal wireless communications systems. Clients of this program include National Defence, Industry Canada, wireless service providers, and Canadian manufacturers. This program covers a wide range of expertise including communications signal design, new system concepts, high speed microelectronics, voice processing, and adaptive antennas.

Broadband Multimedia Communications

CRC is developing new concepts for fixed broadband wireless communications that will meet future consumer requirements for bi-directional multimedia applications. Prototype system concepts which emphasize a high degree of spectrum reuse and bandwidth on-demand are being developed and tested. CRC's current intellectual property and in-house expertise will be applied to collaborations with industry and universities to advance technologies and to demonstrate the applications of broadband wireless networks, in bands from a few GHz to 10's of GHz.

Military Wireless Systems

With the military's requirement for reliable, robust and now ubiquitous tactical communications, CRC is strengthening its relationship with DND. There is a growing requirement to provide strategic information in a mobile battlefield environment, demanding higher bandwidth radio systems to accommodate the need for faster and more accurate data communication. Voice coding and encryption technologies are being developed to meet the special requirements of military and civilian clients for secure and efficient voice communications. The 'dual use' approach being adopted by the military means CRC's military communications research can more readily be transferred to the civilian domain and vice versa.

Radio Technologies

CRC, supported by Industry Canada and wireless service providers, is conducting studies on transmitter identification and detection of fraudulent cell phone transmissions.

Development of adaptive antenna technologies is continuing. By using 'smart antennas' there is increased capacity and improved performance (lower bit error rate), especially in mobile networks. Advances in polarization diversity are being pursued for military and civilian PCS systems.

Microelectronics

Advanced wireless requirements for reconfigurable transceivers translate into the need for novel highly integrated microelectronic devices and modules to minimize power use, size and cost. To achieve circuit integration of the order of subsystem or system on a chip or multichip module will require that circuit design issues be addressed at the device, cell, macrocell and system level. Specific topics include the exploration and development of emerging technologies for broadband wireless including, gallium arsenide and silicon germanium semiconductor components for microwave receivers, transmitters and mixed analog/digital functions, high speed ASICs for broadband systems and FPGA technology for baseband and large scale parallel signal processing.

Testing and Demonstrations

An important element of CRC's R&D is the establishment of the Distributed Broadband Wireless Testbed, accessible to industry, for testing new techniques, technologies and applications and the operability between wireless and wireline networks. This test bed is an amalgamation of current and planned test facilities.

Major Outputs

The following major outputs are expected during the 1998-1999 fiscal year:

- high frequency components and high speed digital circuits to meet the demand for these technologies from Canadian industries addressing the current LMCS markets and future broadband wireless networks as well as the DND and the Advanced Satcom program requirements;
- new concepts in broadband wireless networks for bi-directional multimedia applications;
- radio signature analysis techniques for spectrum surveillance, on behalf of Industry Canada;
- advancement of knowledge in the area of communications signal processing and contributions to military communications capabilities and standards in the HF and VHF/UHF bands;
- adaptive antenna techniques for military and civil applications, such as direction finding and interference cancellation;
- voice communications technologies (i.e. secure voice and audio systems) for dual-use applications;
- expanded client base including licensed wireless service providers and increased collaborations with manufacturers and universities; and
- technologies for high-data-rate capabilities in the HF and VHF/UHF and PCS bands, exploiting diversity (frequency, and antenna space and polarization) wherever possible.

Broadband Network Technologies

One of the key issues facing the implementation of a ubiquitous broadband network for Canada's Information Highway is the need for complete interconnection and operability between existing and emerging communications networks. CRC's broadband network technologies program focuses on addressing key issues such as: operability between wireline and wireless services; network standards and security; and the convergence of communications, broadcast and computer technologies. A strong and complementary research program in optoelectronics and photonics develops enabling technologies to increase network capacity and versatility. Close working relationships with the other branches and the various CRC testbeds provide national and international connectivity and the opportunity to conduct demonstrations of future network technologies.

Network Systems and Applications

The network systems research program has a military and a civilian component. The military component supports the implementation of DND's new network technologies; the integration of military communication resources; the provi-

sion of new and improved military networks and services; and the provision of timely advice and prototypes to DND.

The civilian portion supports the evolution of Canada's Information Highway; specifically its internet technology, high-performance networking, and user interface components. The overall program exploits the commonality between the military and civilian components wherever possible, with a strong emphasis on collaborative industrial, university and multi-national projects. Both broadband and narrowband systems are included.

Internationally recognized for its internet expertize, CRC has developed a solid track record of achievement for its leading-edge demonstrations, tracing its involvement to the early 1980s. For example, the first international leased line from the ARPAnet was connected to Canada at CRC in 1983. As well, CBC Radio became the first national broadcaster to place regular programming on the Internet in 1993 after CRC facilitated proof of concept trials. Currently CRC is actively exploring next generation technologies including asynchronous transfer mode (ATM), M-bone, multicasting and real time protocols, and CA*net II. Research activities also include Internet Protocols for network management, Quality of Service (QoS) provisioning, network routing, user interface design and human factors, distributed interactive virtual environments, and IPv6.

Participation in international activities has provided an opportunity for CRC to make significant contributions in the areas of ATM networking, multimedia networking, network management and routing, QoS provision and performance monitoring. Such projects raise CRC's profile and provide opportunities to develop and experiment with leading-edge networking technologies. These international activities include projects such as:

- Communication System Networks Interoperability (CSNI) project;
- Advanced Command and Control Operations Research Demonstrator (ACCORD);
- Joint Warrior Interoperability Demonstration (JWID);
- EXPERT (National Host testbed in Switzerland);
- National Hosts Interconnection Experiments (NICE);
- SPOCK (German acronym for Rapid Prototyping via Optimized Computer-based Communication); and
- Multimedia European Research Conferencing Integration (MERCI).

CRC has also taken a leadership role in high-speed communications by implementing its Broadband Applications and Demonstration Laboratory (BADLAB) which is connected to the Ottawa Centre for Research and Innovation's OCRInet, and through the national test network CA*net II, to the rest of Canada, the USA and to Europe. CRC will be implementing connectivity to CA*net II through an on-site GigaPOP and is also in the process of providing campus-wide CA*net II connectivity to the desktop.

Optoelectronics and Photonics

CRC's optoelectronics and photonics research program develops components which increase the capacity, versatility and performance of fibre optic broadband networks. One particular emphasis is on those technologies which support the evolution of multiwavelength optical networks which are expected to become a main supporting infrastructure for high bandwidth transport and switching. The ability of photonics to carry very large bandwidths and to cost-effectively partition this bandwidth dynamically will be a cornerstone in the evolution of emerging backbone network technology and will facilitate new types of network services.

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. CRC's photonics-related R&D programs are of interest to university and government laboratories, and to a growing industrial

sector. CRC has been active in this area for over 20 years, accumulating a valuable intellectual property portfolio and a worldwide reputation for research excellence and technology transfer.

The research program targets those components which enhance optical network performance: fibre optic multiplexers/demultiplexers/filters; Bragg grating components; laser array and detector subassemblies; optical switches; components for dispersion compensation in fibres; and cost-effective packaging techniques based on polymer and glass waveguides.

One of the major thrusts for the coming year will be the establishment of a fibre optic testbed using multiwavelength technology. This testbed will have connectivity to both the satcom facility and to the BADLAB, and as a result, it is expected that synergy between the photonics research, other CRC testbeds and the network systems program will be increased significantly. CRC is also continuing to develop working partnerships with other establishments possessing complementary strengths in order to enhance photonics research in Canada, and with international organizations for developing and marketing intellectual property.

Major Outputs

The following major outputs are expected during the 1998-1999 fiscal year:

- deployment of multimedia networking and ATM technology to Canadian and allied forces networks;
- network performance measurement tools and QoS management methodologies;
- advanced real-time interactive internet services and user interfaces to multimedia systems;
- a proposal to the ATM Forum and the ITU for an ATM connection-level priority and pre-emption standard;
- new optoelectronic and photonic components for high-capacity networks and interfaces to wireless systems;
- a testbed to evaluate component technologies for multiwavelength optical networks; and
- a GigaPOP facility at CRC/BADLAB connecting to the CA*net II research network.

Broadcast Technologies

Broadcast technology R&D encompasses advanced video and digital television (DTV), digital radio broadcasting (DRB) and datacasting services to be carried over terrestrial off-air channels, satellite, cable, multipoint distribution system (MDS) and local multipoint communications systems (LMCS). The services using off-air and some satellite channels are to be designed for vehicle, portable and fixed reception. Those using satellite, cable, MDS and LMCS are aimed at fixed reception. Compatibility and operability between the various delivery systems and their integration with broadband communications is an important objective of the research.

The program directly supports the broadcast industry in the implementation of advanced broadcast systems by participating in standards committees, field trials and equipment testing for proof of concept and design improvements. It also transfers technology to industry for the development of new products and services. Significant support is provided to the Department's Spectrum Engineering Branch in the development of spectrum allocation for digital broadcasting and new broadcast services.

Digital Radio Broadcasting

Although first generation technology and associated DRB standards are now in place, significant work remains to be done on practical implementation. The concept of using multiple on-frequency repeaters and gap-fillers to provide effective service coverage remains to be fully demonstrated through field trials. Refinements of concepts and coverage prediction tools are required.

The Ottawa DRB Field trial site, provided by the broadcast industry, and for which CRC was cho-

sen as the custodian to conduct tests, will provide valuable data to help industry launch the new DRB service in 1998. It will also provide more empirical propagation data to improve the prediction tools being developed at CRC by the Radio Science Branch. Advanced demodulation techniques for Coded Orthogonal Division Multiplexing (COFDM) will be researched, to extend the operation of DRB receivers at L-Band for vehicular use at higher speeds.

Further research in audio coding and compression is required for DRB in L-Band to determine if higher capacity data services can be combined with the more highly compressed audio transmission, potentially permitting broadcasters to deliver more revenue-generating information products, in addition to the audio programs traditionally carried by radio.

Digital Television and Video Systems

A digital television standard based on the international ISO/IEC MPEG-2 standard has been chosen in both the U.S. and Canada. Additional field measurement data needs to be gathered before the spectrum allocation plan can be finalized and the new service can be launched with reliable service coverage. CRC is planning terrestrial off-air field trials in collaboration with public and private broadcasters. Further study is required on compatibility and connectivity of various delivery media, including common carrier networks. CRC and its Canadian industry partners will also study transmission and delivery of digital television over MDS and LMCS. The packetized MPEG-2 transport stream makes digital television transmission compatible with broadband networks, thus studies are required on the effects of sending compressed video over such networks.

To support further enhancements to video services as well as bandwidth requirements for future communications services, research in video coding will continue. The next enhancement in television is expected to be stereoscopy (3D-TV). Research will focus on gaining a better understanding of human perceptual aspects, which is the key to acceptance by viewers. Collaborative research is planned with INRS and IMAX Corporation in Canada, and leading research laboratories in Japan and Europe.

Research on video compression and very low bit rate video coding will continue to address the needs of non-broadcast video applications such as delivery of wireless multimedia services over narrow bandwidth transmission channels and over the Internet. Initially collaboration with Canadian universities and academic institutions in other countries is planned, with technology transfer to industry in future years.

Datacasting and Interactive Services

The introduction of digital radio and television broadcasting will result in a new infrastructure with significant technical capability for delivery of multimedia data services with various levels of interactivity. Several issues require research, including characterisation of the transmission environment for various service requirements and the definition and adoption of compatible protocols for other service delivery options. Another consideration is the implementation of the return channel to provide interaction. This will require research on its requirements and characteristics, as well as spectrum allocation.

Major Outputs

The following major outputs are expected during the 1998-1999 fiscal year:

- in collaboration with industry, extensive propagation and systems applications studies using the DRB testbed to support Industry Canada's spectrum planning requirements;
- advanced DRB demodulation technique development, refinement of DRB system design guidelines and components or subsystems;
- experiments with Internet access and interactive multimedia services to mobile users;
- studies, experiments and field trials in transmission of digital TV over various delivery media (UHF, ATM, LMCS, etc.) to determine their suitability and to support the department's spectrum planning;

- development of advanced coverage simulation software to evaluate new broadcast coverage concepts and study interference issues;
- definition of parameters for a practical 3D-TV system by carrying out psychovisual studies and stereoscopy experiments in human perceptual behaviour;
- studies of low bit rate video and sound compression algorithms in collaboration with international laboratories and standards organizations (ISO MPEG-4) for next generation broadcast systems and multimedia services; and
- subjective evaluation of video and audio quality of sub-systems and development of objective perceptual measurement methods.

Applications Development and Demonstrations

As part of the research program, CRC conducts a number of applications demonstrations across the five research branches, to stimulate interest in new communications concepts, technologies and techniques. Demonstrations are an excellent and often necessary way to prove CRC-developed technology and also give visibility to the organization. These demonstrations are often closely tied to specific R&D initiatives at CRC and frequently involve external partners.

A major outcome of the application demonstrations is the extension of CRC's R&D outputs to a broader community of users. This activity assists industrial partners in assessing applications for new communications technologies and helps to create business opportunities for small and medium-sized enterprises. For example, telemedicine and tele-education provided by satellite have a positive social benefit in extending essential services to remote communities. Working with the international community in applications trials also helps reinforce Canada's reputation as a major player in telecommunications research.

Major Outputs

The following major outputs are expected during the 1998-1999 fiscal year:

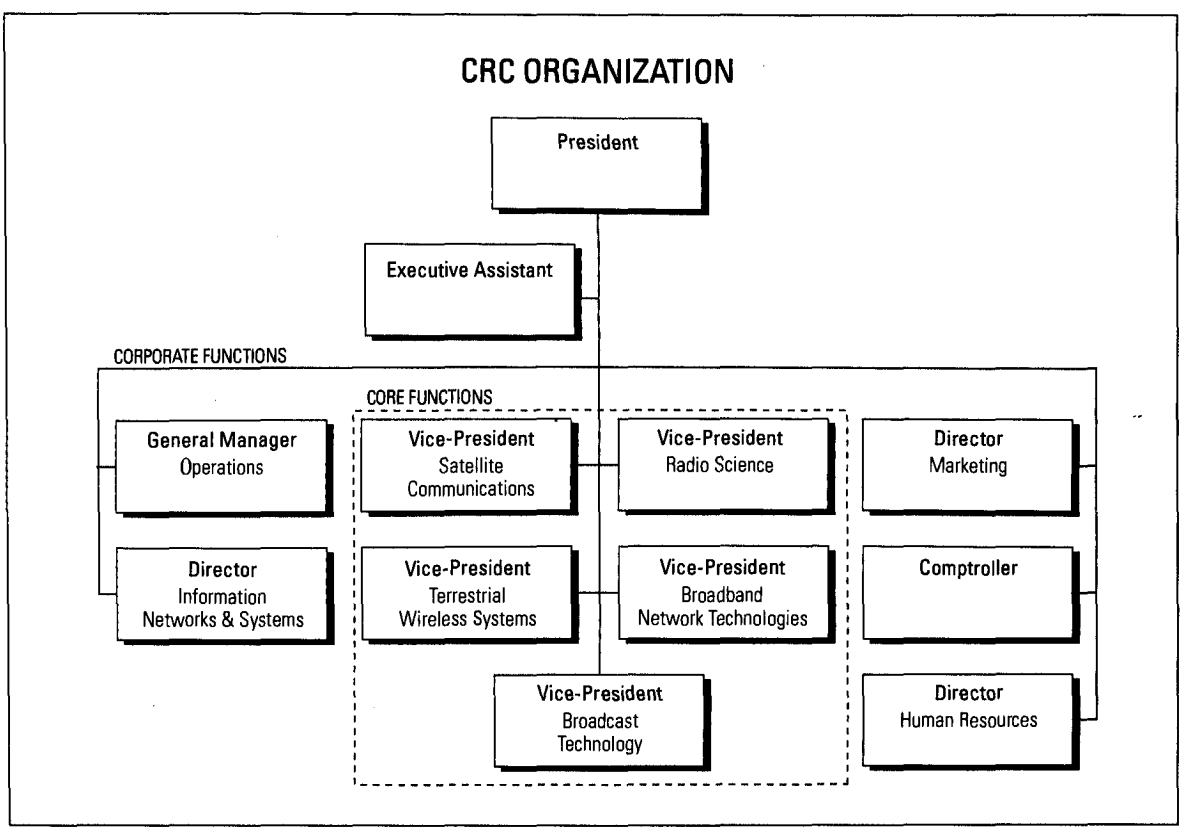
- contribution as a partner in the Ottawa Community Network program for the development of advanced network applications;
- implementation of the Virtual Classroom project involving high schools in Ottawa, across Canada and internationally to demonstrate the use of broadband communications for distance education;
- participation in the APEC Telecom Ministerial Conference in Singapore to demonstrate Canadian tele-education and telemedicine expertise and capabilities;
- broadband connectivity to Eastern Europe for telehealth applications in partnership with the University of Ottawa Heart Institute; and
- Industry Canada Technology Showcase featuring "broadband internet" for business information.

The Team

The Communications Research Centre consists of approximately 400 people, with more than 60 percent dedicated to R&D. As manager of the Shirleys Bay site, which also accommodates the Defence Research Establishment Ottawa and the Canadian Space Agency, CRC is responsible for providing services to all tenants. The R&D team is also supported by dedicated staff in technical services, marketing, human resources, information systems, finance and administration.

In 1998-99, a new organizational structure is being implemented to respond more effectively to scientific and market opportunities. The new management team consists of five R&D Vice-Presidents who provide strategic and operational direction to the research programs, plus the heads of five associated functions, as shown in the accompanying chart. To foster teamwork and communication, the following committees have been formed.

- CRC Management Committee: comprising all those directly reporting to the President, plus the Chair of the Employee Advisory Committee; deals with a range of management issues.
- Research Committee: members include the President, five R&D Vice-Presidents and the Marketing Director; plans and coordinates the research and associated marketing programs.
- Human Resources Management Committee: comprising the President, the Vice-Presidents, the Directors of Human Resources and Marketing and the General Manager of Operations; responds to the priority of attracting and retaining top quality people.
- Employee Advisory Committee: elected by employees; provides a forum for employee issues and makes recommendations to management.
- Labour-Management Relations Committee: a forum for discussion and resolution of staff relations matters.

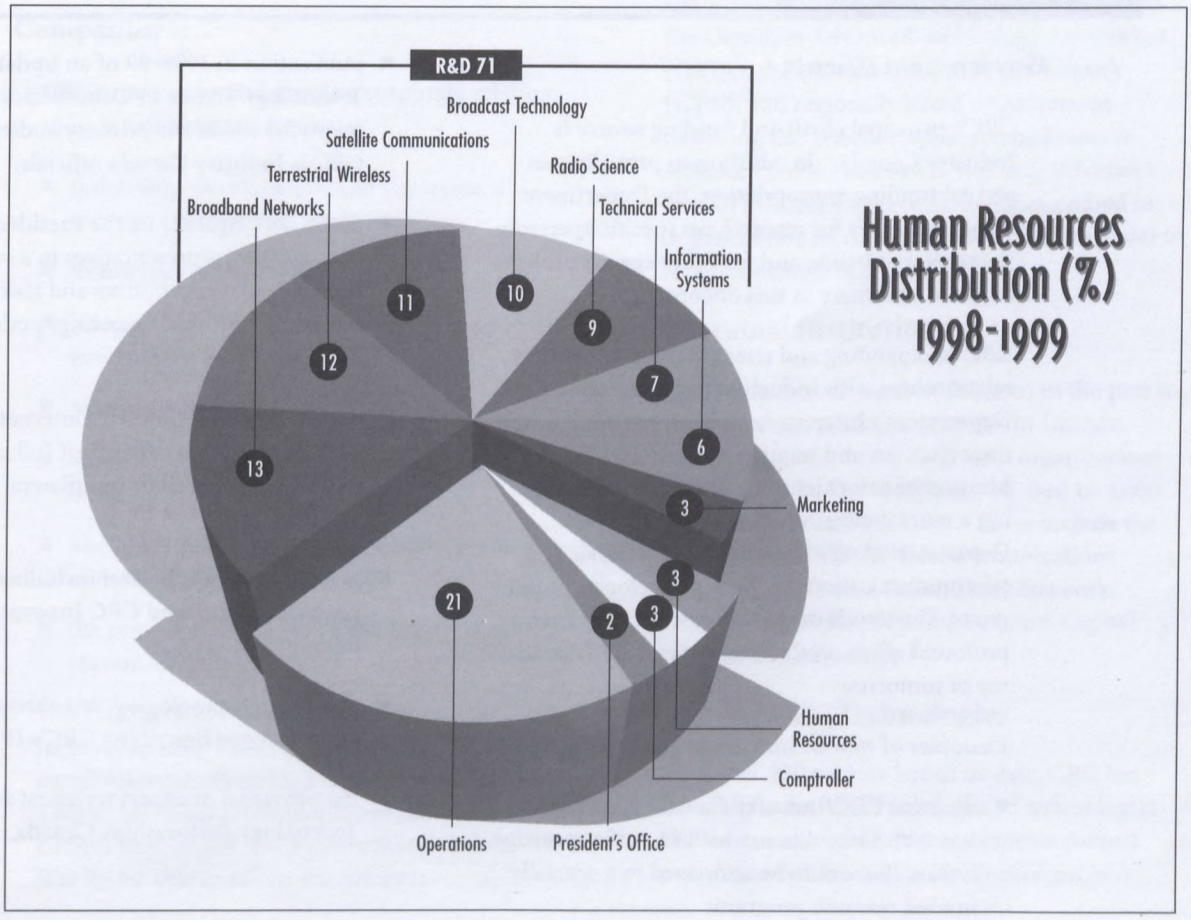


Labour market conditions have made human resource recruitment and retention a key CRC management concern. In the National Capital Region, the pace of growth in the high technology field has been dramatic. While CRC's total research staff complement has not grown in recent years, a rejuvenation program begun in 1994 recruited 69 new scientific staff. These results have been offset by increased turnover attributable to the dynamic, competitive labour market in which CRC operates.

While CRC prides itself in training industry-able researchers for Canadian companies, reversing the talent flow calls for creative solutions to ensure that CRC has the R&D staff to realize its vision. Special attention is therefore being devoted to ensuring that young researchers are available to succeed the exceptional group of senior researchers and managers who can retire in the next 10-15 years.

CRC is committed to aggressively address its human resources management challenges. In keeping with the creative, enterprising spirit associated with CRC's research institute status, the management team has resolved to make CRC the employer of choice among research organizations. Management's commitment to maintain a positive working environment is signalled by several specific people management projects which are being implemented this year. A competency-based management framework is being developed as the foundation for a new relationship with employees, with priority on the following initiatives:

- performance management system;
- career development and succession planning;
- rewards and recognition;
- scientific interchange program;
- women in science; and
- men and women working in partnership.



Investing to Drive Future Strategies

This year, CRC is making a number of investments in activities that will meet government policy objectives and address CRC's financial goals. Partnerships are a main feature, and in many cases, new ground is broken in forging CRC's role in the knowledge-based economy. All are made possible by CRC's basic competencies in R&D and associated functions, and in some cases by direct financial support from Industry Canada. These investments include:

- a cooperative, distributed broadband wireless testbed, announced by the Industry Minister in November 1997;
- a major upgrade of CRC's internal information networks to improve efficiency and systems compatibility with the department, and to support Industry Canada's priority on being a model user of information technology;
- an information technology showcase project at CRC to demonstrate how advanced technologies can make government information more retrievable and entertaining;
- installation of a GigaPOP at the BADLAB to support CRC's growing role in national communications networks including CA*net II ;
- further work to accelerate savings in the site energy management plan;
- a new integrated financial management system;
- a development plan for the Shirleys Bay site, initially to accommodate the Department's Certification and Engineering Bureau and to create new space for an expanded CRC Innovation Centre.

Marketing Priorities

Government Clients

CRC's principal client and funding source is Industry Canada. In addition to providing an annual funding appropriation, the Department allocates money for research on specific spectrum management issues, and for other special projects as noted elsewhere in this document.

CRC is expanding and strengthening its various relationships with Industry Canada to serve the Department's interests better and respond to new opportunities and requirements arising from Ministerial priorities. In addition, CRC is making a more concerted effort to provide Departmental officials with strategic advice on telecommunications for policy development purposes. The trends on today's horizon will have a profound effect on the knowledge-based economy of tomorrow.

Examples of new or intensified activities include:

- the joint CRC/Industry Canada Spectrum Research Committee, which identifies priority technical issues to be addressed in a specially funded research program;
- publication in 1998-99 of an updated Technology Trends in Communications document, for which the primary audience outside CRC is Industry Canada officials;
- active participation by the President and other management representatives in a variety of departmental committees and task forces, including hosting of meetings periodically at CRC;
- regular collaboration with international business development officials of Industry Canada to develop bilateral or multilateral agreements and projects;
- new marketing collateral including colour corporate brochure and CRC Innovation Centre folder;
- new "Hot Technologies" fact sheets and online catalogue describing CRC's IP portfolio.
- the provision of expert technical advice to Technology Partnerships Canada.

The Department of National Defence and the Canadian Space Agency have been major sources of funding and significant clients of CRC over many years. CRC's client focus for this year is on implementing a renewed Memorandum of Understanding covering the DND research program. Its relationship with the CSA is focussed on management of advanced satcom projects announced in late 1997. CRC also collaborates with both these organizations to conceive and plan future R&D strategies in military communications and satellite communications systems.

In addition, CRC has signed an agreement with the National Research Council for collaboration in R&D, technology incubation and industrial support.

In 1998-99, CRC is continuing to develop relationships with government departments and agencies where technical opportunities with common objectives exist and where significant resources are contributed by the partner.

Companies

CRC's numerous and growing corporate relationships are designed to facilitate:

- technology development and deployment through collaborative R&D;
- technology licensing;
- leverage of private sector activity in support of government priorities;
- revenue generation;
- access to CRC's unique facilities such as testbeds;
- a catalytic role in collaborative activities such as network development; and
- the provision of scientific and technical information and advice.

CRC will continue to develop relationships with large companies where its technologies or unique capabilities can stimulate job creation in Canada. This business contact also ensures that CRC is current with recent developments and is therefore better able to advise the Minister.

At the same time CRC is expanding its efforts to reach out to small and medium sized enterprises across Canada. CRC's technology diffusion to SMEs is important to help Industry Canada in its mandate to stimulate an innovative economy.

CRC has direct relationships with a dozen clients in the CRC Innovation Centre, the on-site incubation facility for technology transfer and R&D collaboration. Innovation Centre priorities this year include affirming service levels for existing clients, celebrating past and present client success stories and attracting new clients. Developing the Carling Avenue site to create more and better quality space is an ongoing goal. The Centre was recently expanded with financial assistance from Industry Canada.

In addition, CRC is enhancing its efforts to provide "incubation" services to growing young companies elsewhere in Canada which are unable to establish a physical presence at CRC. Relationships with organizations such as NRC's Industrial Research Assistance Program (IRAP), the Canadian Advanced Technology Association (CATA), the Canadian Technology Network (CTN), and regionally based organizations including the Telecom Applications Research Alliance (TARA) in Halifax will help this effort. Several possible projects are being examined to deploy advanced communications technologies to facilitate remote access to CRC.

Educational Institutions

CRC has made major contributions in the past to education and academic research in Canada. Relationships are being built with organizations in which CRC's knowledge can be used to train new engineers and scientists. These include the Canadian Institute for Telecommunications Research, the Ottawa Community Network, Schoolnet, and the proposed National Capital Institute of Technology.

Marketing CRC Technologies

With over 200 patents issued to date, CRC has successfully marketed a number of technologies and inventions. Over 300 agreements protect and commercialize CRC's intellectual property.

Leading the way are fibre optics technologies (Bragg gratings and fused biconical taper couplers), and CRC's proprietary propagation prediction software, CRC-COV. Together these account for the bulk of CRC's intellectual property revenues. Success of these technologies hinges on creative collaboration between CRC's inventors and its technology transfer and marketing specialists.

This year CRC is organizing targeted marketing campaigns for key technologies where there is further market potential. These efforts may include bundling CRC technologies or combining them with technologies from other sources to create more powerful portfolios. As always, the first order of business will be commercialization in Canada wherever possible. CRC is also entering into agreements with third party organizations which commercialize technologies in Canada and world-wide. These are part of a growing web of strategic alliances designed to help market CRC technologies and expertise.

International Collaboration

CRC continues to build on its reputation for scientific and technical excellence as a key laboratory in a country that is a world leader in communications technology. Participation in international standards bodies and multilateral technical activities in military and space communications will be augmented by more recent initiatives. Examples include G-7 Information Highway initiatives and agreements with R&D organizations in Japan, Korea and Germany. CRC is seeking opportunities for international collaboration to help Canadian industry and governments, while advancing its own research program. Revenue-generating projects will be pursued where there is exploitable commercial advantage for Canadian companies or other tangible benefit to Canada in support of government objectives. Special attention will be paid to the protection of intellectual property.

Marketing Tools

Access to programs such as the Satellite Communications Applications Program (SCAP), and facilities like the Distributed Broadband Wireless Testbed, and the BADLAB will be encouraged. These tools create access to CRC research and help forge new relationships with clients.

The World Wide Web is the primary vehicle for ongoing marketing and promotion. An updated "catalogue" of CRC technologies is on-line with a "Hot Technologies" synopsis available on paper. This information, along with other displays, will be featured at trade shows and exhibits where R&D and marketing staff work together representing CRC.

A Culture of Marketing

It is a fundamental principle of this business plan that responsibility for marketing, business development, communications and technology transfer are shared by the R&D and the marketing personnel. This principle is embodied in the new organizational structure.

Experience at CRC has shown that researchers are the most convincing salespersons for their own expertise and inventions. CRC R&D staff have had excellent success in developing business relationships with companies.

The five R&D Vice-Presidents have responsibility for marketing technologies and expertise in their areas of competence. The marketing division provides strategic leadership at the corporate level, identifies new opportunities and opens doors, facilitates licence negotiations and provides marketing services to CRC staff and clients.

This year training and feedback sessions are being provided to build marketing and communications skills and a marketing culture. Seminars in intellectual property management, licensing and marketing are being offered to scientific staff.

CRC researchers publish in dozens of international journals and attend numerous conferences and workshops. Each represents an opportunity to sell what CRC will actively be pursuing in 1998-99. The objectives are:

- to disseminate research results in the open literature to continue its tradition of research excellence;

- secure opportunities to achieve returns to Canada from its intellectual property; and
- to establish proprietary, revenue-generating relationships with companies.

Financial Plan

Each year, CRC receives revenue from a number of sources, both government and non-government. The key source of revenue is the annual allocation from Industry Canada, which this year stands at $26,817,600, accounting for 38% of incoming funds. This represents a reduction of $3.5 million from the 1997-98 level as a result of Program Review II. Other government funding is derived from contracted and tenant services and vote-netted revenues from R&D activities. Private sector revenue has two streams -- intellectual property, and contract R&D performed for clients.

Projected Revenues and Expenses, 1998-99 ($million)

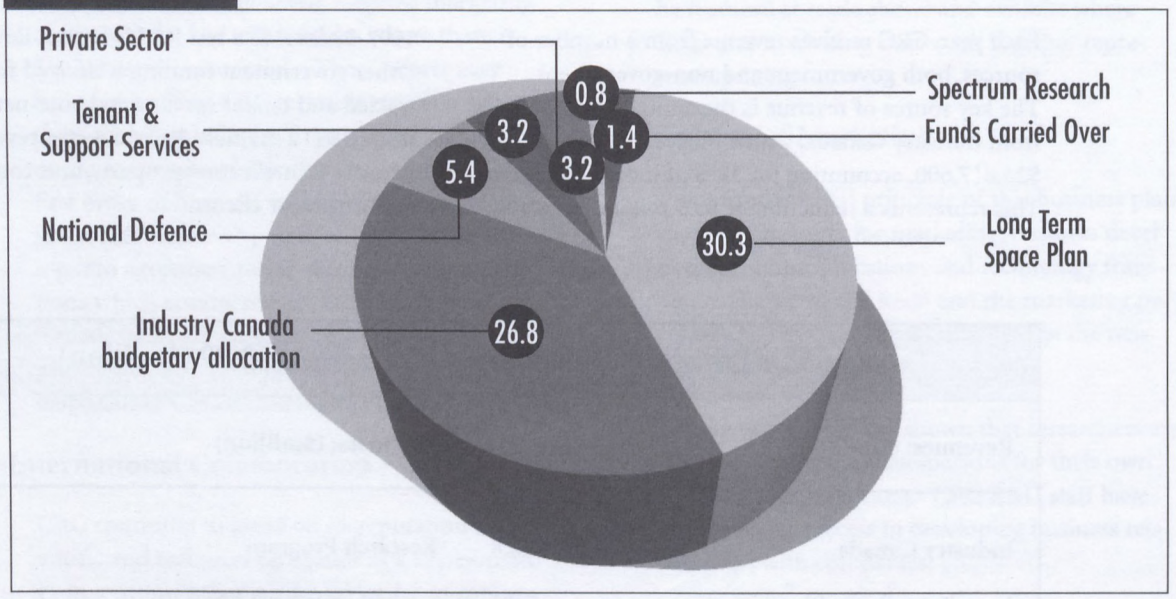
Revenues: ($million)	
Industry Canada	$26.8
Long Term Space Plan (note 1)	30.3
Department of National Defence	5.4
Private Sector	3.2
Spectrum Research (Industry Canada)	0.8
Tenant and Support Services	3.2
Funds carried over from 1997-98	1.4
Total:	**$71.1**

Expenses: ($million)	
Research Program	
CRC Research Program	14.5
Research Performed for National Defence	5.4
Long Term Space Plan (note 1)	
CRC Research	2.6
Contracts	27.7
Spectrum/Testbeds	0.8
Research Services (includes marketing)	5.8
Sub-total - Research Program	**56.8**
CRC Site Services	3.5
CRC Administration	3.7
Tenant & Support Services	2.2
Other & Extraordinary Items	4.9
Total Expenses	**$71.1**

Note 1: Includes $5.3 m reprofiled from 1997-98. The Canadian Space Agency (CSA) is responsible for the Long Term Space Plan. CRC has been delegated the advanced satellite communications portion. For the most part these funds flow through to satisfy contractual arrangements with outside parties.

Expected Revenues and Expenses 1998-1999 ($million)

Revenues



Expenses