Business Plan *1994*

Communications Research Centre
Centre de recherches sur les communications

R&D in the Government of Canada

"The departmental S&T establishments perform roles that are critical to the efficient functioning of modern societies and reflect their complexity and the heterogeneity of situations. A large proportion of these activities are undertaken to support policy advice, develop testing methodologies and support industry in process and product approval. Other intramural S&T activities produce unique, large and sophisticated data bases, our public knowledge infrastructure, that inform both government and business decisions. And, a few establishments operate in formal or informal partnerships with industry to provide strategic technological advances for medium and long term time horizons or operate major facilities required by both government and industry. Finally, some establishments are simply service organizations which provide engineering support to private sector firms or other government departments and agencies.

By expanding knowledge, science becomes a tool for fulfilling government responsibilities and achieving government objectives; it provides information for timely and effective policy and regulatory decisions and establishes the public knowledge infrastructure which is critical to many business and economic development activities. As the quality of science improves, so does the reliability of information and the probability that the choices made are the best ones. It is incorrect to postulate that government is simply a funder of S&T. It is an important user, and the significance and impact of its regulatory and decision-making roles as well as the public goods nature of a substantial portion of its output mean that government S&T must be as good as that anywhere else – in industry, in universities and in private organizations."

NABST: Revitalizing Science and Technology in the Government of Canada, November 1990. Pierre Lortie, Chairman

Table of Contents

Business Plan *1994*

Introduction

The Communications Research Centre has contributed and continues to contribute significantly to the communications infrastructure and industry in Canada. Like others involved in high growth and strategic areas of the economy, CRC is changing. In April 1992, as part of a five-year trial, the CRC became a "research institute" with increased authorities in line with recommendations in the Lortie Report of the National Advisory Board on Science and Technology (NABST). Since then, several significant changes have taken place. CRC received a President, created a new Board of Directors, developed its Strategic Plan "New Directions," and reorganized into two research branches.

This Business Plan builds on CRC's Strategic Plan, reports progress over the last year, and establishes goals for the next three years.

Technology Trends

The resulting convergence of computers and communications is leading to the electronic information highway ...

The internal report, "Technology Trends in Communications," was prepared as part of CRC's strategic planning process. Rapid changes, occurring in both business communications and entertainment services, will present new opportunities for Canadian industry. The market is moving quickly towards multimedia and all-digital communications. A market-place of unsophisticated users, needing user friendly interfaces and applications, interactive communications and access to a wide variety of information and entertainment services, is emerging. The growth in personal mobility in communications has created new challenges in wireless technologies: source signal processing, networking, transmission signal processing, and base technologies which affect or limit the efficient operation of a telecommunications system (for example computers, software, transmission channel studies, transmission signal processing, and electronics materials, devices and components).

These changes all require the expansion of networks, their interconnectivity, bandwidth on demand, and wireless access. There will be a need for high-speed wireless access to these services along with the conflicting requirement for narrower radio bandwidths to conserve spectrum. The resulting convergence of computers and communications is leading to the electronic information highway which will demand new requirements for voice and data security to provide both privacy and business confidentiality.

Mandate, Mission, and Vision

Industry Canada's mandate is to make Canada more competitive by fostering the development of Canadian business and by promoting a fair marketplace. Within Industry Canada, the Industry and Science Development Program promotes international competitiveness and excellence in industry, science and tehnology throughout Canada, and assists regional and aboriginal organizations to realize their economic potential. The Services to the Marketplace Program promotes the fair and efficient operation of the marketplace in Canada, supports consumer interests, and ensures that reliable and efficient radio spectrum services are provided to serve all Canadians at affordable costs. R&D activities undertaken to meet the mission requirements of government can in many cases be designed and delivered in such a way as to contribute significantly to the success of Canadian industry, both at home and abroad. CRC, through its R&D programs and diffusion of new technologies, helps to create a climate for more rapid rates of economic growth and international competitiveness.

CRC's mandate is:

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

Accordingly, CRC's mission is:

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

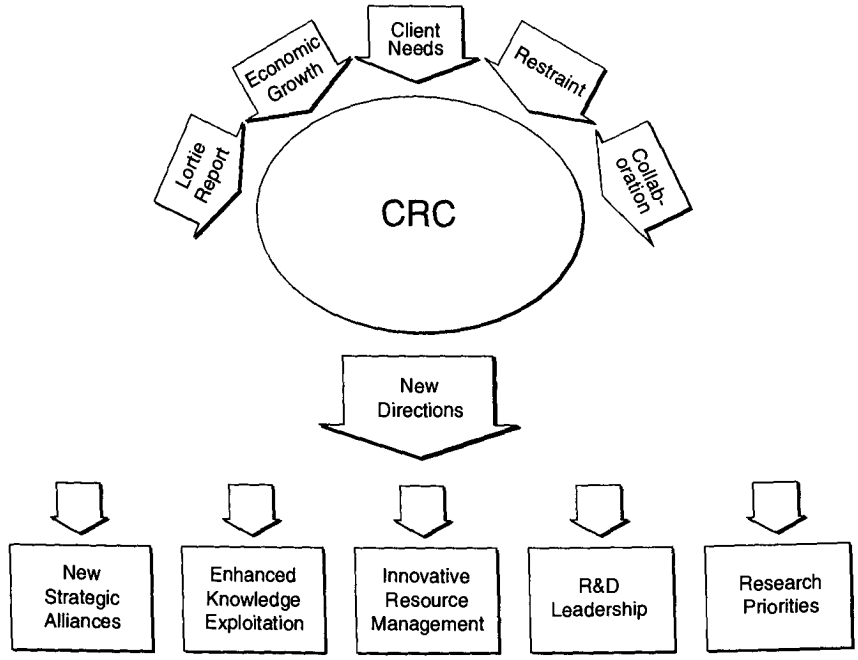
This leads to a corresponding vision, shared by all employees:

"Leadership and excellence in communications research."

Through its mandate, mission and vision, CRC strives to be an important government instrument to position Canada strategically by:

- developing and promoting the use of communications technologies, systems, and services;
- supporting the efficient use and management of the radio frequency spectrum;
- contributing to the development of national and international standards in communications technologies, systems, and services;
- transferring technology to Canadian industry for exploitation;
- providing strategic information and technical support to small and medium enterprises (SMEs);
- contributing technical expertise in support of policy development; and
- facilitating and participating in international research and development agreements.

Strategic Thrusts



CRC's Strategic Plan "New Directions" identifies five thrusts as being essential to shape CRC's future. These "New Directions", made possible by the authorities given by CRC's institute status, are:

- active participation in R&D leadership in Canada;
- the creation of strategic alliances;
- innovative use and management of CRC's physical, financial and human resources;
- enhanced exploitation of CRC's intellectual property and intellectual capital;
- the selection of appropriate research priorities.

The Strategic Plan sets out strategic directions for CRC. This Business Plan, the next step in the planning process, sets out specific goals for the next three years.

Thrust 1 - R&D Leadership

Effective leadership helps avoid duplicative effort and creates synergy

CRC has taken a leading role in many areas: by technical participation in the activities of the International Telecommunications Union and other international bodies, organizing key scientific and technical conferences, fostering international cooperative activities, and sponsoring and creating industry/government committees. CRC also participates actively with industry and others through memberships and project activities: OCRI, TRIO, CANARIE, CITR, TRLabs, NWCRF, CCMC. Some specific initiatives, directly related to CRC's research programs, which are discussed in this plan, include:

- an incubator facility to assist in the creation of new companies by providing office space, laboratory space and facilities, research services and business management consultation;
- an exchange program to bring private sector staff to work at CRC and to expose CRC staff to the private sector;
- the development of an R&D park to strengthen the transfer of technology between CRC and industry; and
- the creation of a broad band applications demonstration test bed both for research purposes and for showcasing Canadian products.

There are a large number of communications R&D activities in Canada. Effective leadership helps avoid duplication and creates synergy among the R&D programs of federal and provincial laboratories, centres of excellence, universities and industry. Industry Canada is responsible for ensuring the best possible science and technology policies. CRC, because of its R&D leadership, provides support to formulation of policy, and will continue working with others to coordinate research programs nationally.

Thrust 2 - Strategic Alliances

Alliances... are a useful means of augmenting core competencies and transferring technology

Alliances leverage resources, create synergy, minimize costs, and provide wider access to expertise. They provide a window into both CRC's activities and those of its partners, and are a useful means of augmenting core competencies and transferring technology between organizations. In some cases, such as the major agreement with National Defence for the research program in defence communications, not only are the specific needs of another department met, but there is also significant benefit to the civilian communications R&D program.

In the past year CRC has negotiated agreements with:

- Vistar, for a collaborative research program in satellite communications,;
- OCRInet, in which CRC will play a major role in the application and demonstration of ATM-switched high speed networks;

- the Canadian Space Agency, ensuring that CRC will remain responsible for delivery of the satellite communications segments of the Long Term Space Plan;
- the Government Telecommunications and Informatics Services for the implementation of MSAT services and for applications development.

In addition, the very successful research arrangement with the department's Spectrum Branches was continued, with about 40 research projects and an associated scientific seminar series being carried out.

Overall, these agreements are expected to provide $2.4 Million of "revenue" in fiscal year 94/95. At the same time CRC must contribute $1.2 Million to fulfill its obligations under the agreements.

Thrust 3 - Innovative Resource Management

In this period of restraint, the most effective use possible must be made of resources, both human and physical. CRC is initiating innovative human resource practices and is also investigating optimal ways of using the site and facilities at Shirleys Bay.

Employment practices for the scientific and technical staff will change significantly.

The strategic plan identifies four goals for human resource management: retraining, selective recruiting, succession planning and the creation of an exchange program. Last year, a personnel rejuvenation plan was prepared, based on a special $1 million fund from the department. Employment practices for the scientific and technical staff will change significantly. The permanent staff will be reduced by about fifteen percent through attrition, with term hiring used to provide management flexibility and to aid in selective recruiting. The fund will also provide for an exchange program for about thirty staff. Finally, through collaborative agreements and research projects, and contracted services, there will be an increased number of people from external organizations and contractors on site. Within five years the number of scientific and technical staff should increase from the current level of about 170 to about 300, with half of those being permanent employees.

...its Shirleys Bay location is very well-suited for the creation of a research park where companies could locate their R&D facilities.

The incubator program, which will expand the use of both CRC's intellectual capital and its site facilities is being implemented. In addition, since CRC is located among many Ottawa-Carleton high-tech companies, its Shirleys Bay location is very well-suited for the creation of a research park where companies could locate their R&D facilities. Experience elsewhere has shown that this could be an effective way to create synergy among diverse industries. This initiative would require the construction of new buildings on site with the attendant problem of financing such construction. A feasibility study of the concept is being carried out.

Thrust 4 - Knowledge Exploitation

Companies exploit knowledge transferred from CRC to generate new business and profits. Economic benefits are thereby generated for the company itself, other Canadian manufacturers and service providers, society at large, and government. CRC exploits its knowledge base and intellectual property in several ways. One of these ways is through collaborative research through strategic alliances (thrust 2) and other ad hoc arrangements. Other ways are described below.

Intellectual Property

CRC has the responsibility to manage its intellectual property, and recently received the authority to retain revenues derived from its use. Last year, CRC issued about 40 licences for the use of its intellectual property and patents, and generated about $200,000 from royalties and licence fees.

Technology Incubation

...CRC can be proactive in fostering the development of new companies...

In addition to offering its intellectual property, CRC can be proactive in fostering the development of new companies, through the use of its many specialized facilities. Plans are in place to offer incubator facilities both to existing staff who may wish to start their own companies and to small, emerging companies who would benefit from being located on CRC premises and from CRC's reputation. From time to time, well-established companies may also wish to take advantage of this program.

To date, three companies have expressed an interest in this program. The first company is expected to move on site in 1994.

Exchange Program

CRC will create an exchange program to help in the two-way transfer of knowledge between industry and CRC researchers. The program, included as part of CRC's Personnel Rejuvenation Plan, will be patterned after the one at the Centre for Information Technologies Innovation.

Training

CRC's skills are well suited to the provision of highly specialized training courses for internal use and on a fee basis to outside organizations.

In cooperation with the Natural Sciences and Engineering Research Council, a series of CRC scholarships and fellowships will be created to help support students and to create good employee prospects both at the undergraduate and graduate level. This initiative is included in the Personnel Rejuvenation Plan.

Contracted Services

Contracts for research services will be accepted ...where the laboratory will not be in competition with industry.

Contracts for research services will be accepted from outside organizations in cases where CRC possesses special expertise or facilities, and where the laboratory will not be in competition with industry. Policies, procedures and fee schedules have been developed for R&D collaboration and the provision of specialized services. The projected revenue for 1994/95 is $700,000, of which $350,000 might be considered as profit to support further development of the research program.

Thrust 5 - Program Management

This is a new thrust for this business plan. It recognizes that, as part of its responsibility to foster the development and implementation of new communications services, CRC supports major government initiatives through the management of major crown projects. One such example is the MSAT program, a major crown project which has received federal funding of over $200 million. MSAT will be launched in late 1994 to provide the world's most powerful mobile communications satellite. In addition to the overall management responsibilities, CRC is working closely with Government Telecommunications and Informatics Services (GTIS) to assist in the implementation of new MSAT services for government users.

Another example is the Advanced Satcom program which is currently under consideration by cabinet as part of the new long term space plan. If approved, this program will form the next major crown project in satellite communications.

Management of such programs has several major benefits in that it fosters close relations with industry, influences research priorities, enhances CRC facilities, increases CRC's influence in infrastructure development and uses CRC's core capabilities to advantage.

Research Program

CRC's business is R&D in wireless and broadcast communications, including proof-of-concept applications development and demonstration.

The Strategic Plan, "New Directions," puts forward a vision of CRC's place and role in the developing global communications network. This vision includes interactive multimedia communications, and a renewed importance of radio communications in providing the essential ingredient of mobility. Other network characteristics are bandwidth on demand, distributed network intelligence, improved user interfaces, and transparency of national boundaries while preserving network security and user privacy. Such developments are proceeding rapidly all over the world.

CRC's business is R&D in wireless and broadcast communications, including proof-of-concept applications development and demonstration. To conduct this R&D, CRC depends on its core competencies, which include:

- advanced television and radio, and broadcast technologies;
- computer and communications networks, and radio interconnects;
- modulation, coding and signal design;
- satellite communications system design;
- defence communications applications;
- audio and video compression and processing;
- radio propagation and the electromagnetic environment; and
- microwave integrated circuits and electrophotonic devices.

The strategic plan outlines the R&D activities in a three-tier structure. The first level activities directly support our business in wireless and broadcast communications R&D: Satellite Communications Systems, Broadcast Technologies, Network Systems and Technologies, and Radio Communications Technologies. The second level is more generic in nature. It provides enabling and supporting expertise to the first: Radio Science, and Microelectronic and Optical Technologies. The third level, including proof-of-concept demonstrations and testbeds, showcases R&D achievements and provides powerful tools for encouraging the transfer of new technologies and systems to industry for exploitation.

Tier 1 Research Activities

Satellite Communications Systems

...new business opportunities (are) being created by the rapid evolution in satellite communications technologies.

Satellite communications augments terrestrial systems to provide telecommunications and broadcasting services to all of Canada including remote areas. The Satellite Communications Systems research program focuses on the long term planning of new communications systems and services and the R&D required to meet Canada's long term needs, and to enhance Canada's international competitiveness. The program also supports Industry Canada in carrying out its statutory responsibilities to establish satcom policy, and to plan spectrum and orbit utilization to ensure that such services are provided in the most cost effective manner. Close liaison with industry and universities ensures that the research program complements the R&D performed by these sectors.

CRC has a strong competency in all major aspects of satellite communications R&D. Many new satellite communications systems and services are being planned and introduced, including the introduction of mobile satellite communications services and private business networks, and the early development and exploitation of the new 30/20 GHz frequency bands. Satellite communications need to be integrated into the emerging electronic highway to extend coverage to remote regions of Canada. The challenge is to respond to these developments during a time of fiscal restraint. Satellite communications R&D has a proven record of providing significant returns to the Canadian economy. The Satellite Communications Systems research program assists industry to take advantage of new business opportunities being created by the rapid evolution in satellite communications technologies.

The program is divided into four major areas.

Area 1: Exploitation of New Frequency Bands

Part of the Long Term Space Plan, this program will exploit the 30/20 GHz bands for the provision of advanced services, such as personal communications and advanced business communications, for which there is good export potential. R&D activity is underway in systems studies and earth terminal development.

Goal: *Develop critical technologies relevant to a new major crown project for an advanced demonstration satellite in 1998/99.*

Area 2: Satellite On-Board Signal Processing

On-board processing (OBP) increases the versatility of satellites by implementing the "switchboard in the sky" concept. It also improves the utilization of scarce satellite transmit power using time-division-multiplexed downlinks. Development of this type of technology is long-term R&D well suited to CRC, and will help Canadian industry remain competitive. The program in Area 1 will demonstrate Canadian capability in this new technology.

Goal: Develop, in conjunction with industry, an OBP demonstration package for the advanced demonstration satellite program.

Area 3: R&D Support for Mobile Satellite Communications

In addition to the MSAT program, there is a great deal of interest in low- or medium-orbit satellite systems to provide communications to hand-held terminals. System standards, spectrum policy and new technologies are required to ensure Canadian participation, rather than having Canadians act as re-sellers of foreign services. CRC provides R&D for MSAT, international mobile satellite communications and personal communications by satellite, in the areas of satellite terminal subsystems, such as antennas and RF conversion techniques, and special terminals for applications such as aeronautical, maritime and secure voice.

Goal: Influence the development of international standards for mobile satellite communications.

Goal: Develop a series of technologies which will assist industry in addressing markets for mobile satellite applications.

Area 4: Modulation, Coding, and Multiple Access Techniques

This area is longer term with application to both space and terrestrial communications. R&D priorities are: modulation and coding techniques which are robust in the mobile environment, yet spectrally efficient; the digital implementation of large portions of radios; and multiple access methods. This research will result in highly flexible, spectrum efficient communications methods with good potential for technology transfer.

Goal: Ensure that the needs of spectrum management are reflected in the development of new communications hardware and systems.

Broadcast Technologies

During this decade, there will be a dramatic increase in new television and radio broadcast services which will allow the consumer to select and interact with entertainment and information programs. Digital technologies will increase the performance of broadcast systems and reduce spectrum requirements. These new broadcast services will require new policies, spectrum allocation rules and

regulations which will provide new opportunities for industry while protecting consumer interests.

Many countries are expending significant resources and effort to develop the next generation of broadcast technologies. Proposed television improvements range from enhancement of present-day systems to fully digital, entirely new high definition television (HDTV) approaches. Development of digital radio broadcasting (DRB), with sound quality that of compact disks, has the potential to replace the current AM and FM radio services. Moreover, the convergence of broadcast with computer and communications technologies will provide the basis for new home entertainment and information services. In future, broadband fibre networks will play a major role in service delivery.

...Canada has a major stake in ensuring that future advanced broadcast services evolve to meet its needs, sustain its industrial infrastructure and support its national identity.

Thus, Canada has a major stake in ensuring that future advanced broadcast services evolve to meet its needs, sustain its industrial infrastructure and support its national identity. In broadcasting, Canadian priorities are to protect and promote the interest of the program producer, service provider and the consumer, while taking full advantage of technical advances. However, before new services can begin, spectrum has to be allocated, standards developed and approved, and regulations established. Research provides the technical information, analysis and advice needed by the department and industry to select, adopt and implement the best systems and services for Canada.

The Broadcast Technologies research program focuses on R&D into advanced broadcast and related technologies, systems and services to support Industry Canada in: defining and promulgating standards; regulating and managing the spectrum; developing broadcasting and telecommunications policies; fostering support for Canadian industry and its international competitiveness; and, serving the general public interest in broadcasting.

The program is divided into three main work components:

Area 1: Television Broadcast Technologies Research

Researchers in this area investigate television technologies, systems and services that range from enhancements to the present-day TV format (NTSC) to HDTV and beyond. Research is also conducted into viewer requirements for television systems. A specialized facility is available to conduct subjective assessment and evaluation of advanced television (ATV) and other video systems.

Goal: Influence the development of the North American delivery standard for the next generation of television.

Goal: Provide expertise necessary to protect Canada's interests in the establishment of a digital video compression standard for video and television systems for efficient delivery and storage of content.

Area 2: Radio Broadcast Technologies Research

Here, researchers investigate digital radio broadcast (DRB) technologies, systems and services as well as research to enable existing AM and FM radio

systems to carry new services. Research is also conducted into listener requirements and evaluation of audio quality of sound sub-systems for both radio and television.

Goal: Influence the establishment of a world-wide standard for digital radio broadcasting.

Goal: Establish the technical bases for the mixed satellite/terrestrial concept for delivery of digital radio broadcast services in Canada.

Area 3: New Broadcast Services Research

In this area, researchers investigate service concepts and service features for the broadcast delivery of integrated digital services. Research is also conducted into service access techniques and user interface requirements for consumer receiving equipment.

Goal: Provide expert advice and technology leading to the efficient and effective availability of integrated entertainment and information services to Canadian consumers.

Network Systems and Technologies

To compete effectively, a country ... is dependent on state-of-the-art communications infrastructure and services.

To compete effectively, a country must transfer and process information efficiently and hence, is dependent on state-of-the-art communications infrastructure and services. In Canada, we foresee a network consisting of fibre optic and satellite backbones. This future network could provide an enormous range of services, from sensor monitoring to electronic commerce, ultra-fast information transfer and new entertainment offerings.

Canada must ensure that its communications infrastructure and services evolve to meet its needs, that industry is competitive internationally, and that its systems can ensure the protection of information.

The Network Systems and Technologies research program responds to the government's civilian and military requirements, including: the definition and promulgation of standards; the development of a state-of-the-art communications infrastructure adapted to government needs; maintenance of expertise to protect Canada's interests in international negotiations; and the transfer of technology to stimulate industrial capability.

The program focuses on four main work components.

Area 1: High Speed Networking

High Speed Networking R&D seeks to extend ATM (Asynchronous Transfer Mode) technology to media such as radio or satellite, to evaluate interfaces between ATM and non-ATM networks, and to address DND-specific problems.

Goal: Establish a technical base for the extension of fibre-based ATM networks to radio and satellite-based networks.

Area 2: Network Services

In this area researchers carry out R&D into key network applications such as the use of directory services to support network operations, security and messaging systems, and the provision of real-time services in packet-switched networks. Emphasis is placed on the performance of these applications over radio networks. This work will lead to the successful and secure integration of emerging network services to meet civilian and military needs.

Goal: Establish a technical base for network services, both real-time and non-real-time, over different network types.

Goal: Influence the development of ISO and NATO standards.

Area 3: Network/Information Security

This research area focuses on issues related to the provision of security services in future network architectures (including multi-level security). These issues include management of encryption keys; the placement of the security functionality; the balance between application, network and physical security; the impact of security on network design, performance and management; the means of providing the required security services; and the means of achieving secure information transfer over unsecured networks. This work provides expert advice for governmental network services users, both military and civilian, to ensure the appropriate protection of their information.

Goal: Establish a technical base for the provision of efficient and effective security services in the developing integrated communications system environment.

Area 4: Network Systems

Network Systems R&D is concerned with network management; the analysis, modeling and simulation of networks and internetworks; and the support of real-time and network multicasting services over, in particular, packet-switched networks. A particular emphasis is placed on policy-based routing and associated issues. This component also includes subnetworks design, enhancement or evaluation. This research will help ensure that existing and planned networks can be integrated into a national communications system infrastructure as well as to ensure interoperability with other nations.

Goal: Develop a technology base for subnetworks and transport mechanisms to support emerging and anticipated network services, and for the characterization of their behaviour.

Radio Communications Technologies

Radio communications is a key part of the information infrastructure necessary to ensure Canada's prosperity and security. Although the demand for radio communications is expanding rapidly, so are a number of problems. The growth of cellular radio is limited by problems of congestion and security. Increased usage of mobile and portable radios has resulted in congestion in the mobile radio bands. Various means, including speech compression techniques and bandwidth efficient modulation schemes, are being explored to reduce the amount of spectrum required for radio communications, thus increasing the number of possible users.

Although the demand for radio communications is expanding rapidly, so are a number of problems.

Data security is the study of methods of protecting information from unauthorized disclosure and modification. Traditionally there were only military and government communications requirements, but with the explosion of information and computer networks the public now also has a need. Fraud, forgery and unauthorized access to information are costing millions of dollars. Networks must be able to provide information integrity, privacy, and authentication. Electronic data interchange needs methods to verify that the document was not tampered with and has the appropriate authorization.

Fraud, forgery and unauthorized access to information are costing millions of dollars.

The radio communications technologies program focuses on three main areas.

Area 1: Privacy and Security

Research staff analyze risks to and vulnerability of information, and research new technologies to protect information. Many diverse areas are investigated and combined to solve these problems. For example, image processing, cryptography, data transmission, and communications knowledge are utilized to make printed documents forge-proof.

Goal: Apply cryptographic techniques to practical problems in safeguarding voice, data and images from interception, tampering and forgery.

Area 2: Radiocommunications Techniques

Researchers in this field investigate and develop new techniques for mitigating the harmful effects of propagation and interference upon radio signals, and for handling specific user link-level requirements, such as high data rate, covertness, or reliability.

Goal: Develop techniques to mitigate adverse propagation and interference effects on radio systems.

Area 3: Communications Processing

R&D is carried out in narrowband speech compression (analog and digital) for both military and civilian applications. Digital speech compression allows for efficient speech transmission, storage and encryption.

In addition, studies, simulations and demonstrations of new bandwidth efficient techniques for the transmission of analog and digital information on narrowband RF channels are undertaken. Various modules of radio communications systems, such as the modulation, coding, adaptive equalization, combined source and channel coding are studied for optimized performance and implemented using digital signal processing techniques.

Goal: *Develop low rate vocoders and combined source and channel coding techniques to meet emerging standards from organizations such as NSA, COMSAT and INMARSAT.*

Tier 2 Research Activities

The second tier of research priorities comprises areas of knowledge and expertise which support and enable those in Tier 1.

Radio Science

Radio science is the study and quantification of physical limits to the reliability and performance of radio communications systems – propagation effects, radio noise and interference and electromagnetic compatibility. CRC is the only organization in Canada that conducts a comprehensive program to study these effects.

New services such as digital broadcasting and digital mobile communications demand radio propagation knowledge and channel modeling in more detail and in different forms than was the case for analog systems. The ubiquitous use of radio transceivers for personal communications will cause EMC problems due to increased EM radiation levels.

Industry Canada is responsible for ensuring that the use of the radio spectrum evolves to meet the needs of Canadians. The measurement of propagation data and the development of propagation models are required for the orderly planning and development of radio spectrum usage in Canada. The results of radio science research provide the technical information and advice needed by both government and industry to select, adopt and implement the best systems and services for Canada.

The program is focused on four main aspects.

Area 1: Microwave Propagation Research

This area collects, analyzes, and disseminates information relating to the propagation of radio waves in the SHF and EHF bands, to improve the design and management of terrestrial and satellite communications systems. It also provides expertise required under international obligations, such as those associated with the ITU, and a technical cooperation agreement between Canada and the ASEAN countries. The studies include the measurement of propagation data for frequency ranges and climatic regions where few data exist, fundamental experiments on poorly understood phenomena and the development of propagation models from experimental data and theory.

Goal: Develop improved interference and propagation prediction models for satellite and terrestrial communications systems.

Area 2: HF/UHF Propagation Research

Researchers investigate ways to improve and apply knowledge of radio communications in the HF, VHF and UHF bands. Computer programs are developed to predict propagation characteristics and system performance under given system and environmental conditions. Programs are available for the estimation of ionospheric conditions, HF circuit performance, and VHF and UHF propagation. Experiments are carried out to validate and improve the predictions. The results of this work supports Canadian interests in the ITU and in World Administrative Radio Conferences.

Goal: Provide a technical knowledge base of radio wave propagation in the MF through UHF bands, for band allocation, system planning and spectrum management.

Area 3: Electromagnetics and Compatibility Research

In this area, staff carry out theoretical and experimental studies in four areas of research: electromagnetics (antenna problems); electromagnetic environment (signals and noise); electromagnetic compatibility (immunity and near field effects for safety and standards); and high power fields. Research is carried out into the near field effects of transmitters, particularly for VHF/UHF portable transmitters in close proximity to the head and body. Technical support is provided for spectrum management to DND and the work of the ITU.

Goal: Develop a centre of expertise in electromagnetic modeling and radiating compatibility (EMC including simulation and measurement of near fields).

Area 4: Mobile/Indoor Radio Propagation Research

Although the mobile/portable radio industry worldwide is switching from analog to digital transmission techniques, radio channel impairments to digital transmission have not yet been adequately modeled. This group measures propagation characteristics on land mobile, portable, and indoor channels and derives models for channel behaviour and interference. Measurements are carried out to verify techniques for the prediction of digital system performance and channel models. The group collaborates with industry to support engineering and applications-oriented activities.

Goal: Acquire and disseminate knowledge of radio propagation and its statistical variations on indoor and land mobile radio channels,.

Microelectronic and Optical Technologies

The ability to meet these needs is closely tied to advances in microelectronics technologies.

Ubiquitous personal communications requires new techniques to miniaturize electronics and antennas for portable, low-power consumption and lightweight systems. Demand for wideband services requires systems operating at higher frequencies and very fast switching speeds. There are increased requirements for interconnectivity between diverse networks and transmission media, and the ability to meet these needs is closely tied to advances in microelectronics technologies.

Microelectronic technologies permit a high degree of integration of microwave, optical, digital and antenna functions within a small volume. They are enabling technologies which help provide for spectrum efficiency, as well as increased functionality.

CRC uses its unique facilities and expertise to stimulate an industrial capability in several key communications-related areas of microelectronics. The results of the research provide timely and strategic technical information, analysis and advice for use by the department in defining and establishing industrial policy and by Canadian industry for accessing and addressing new telecommunications and broadcast markets. R&D priority is on the miniaturization of circuits which impact the research areas of the first tier program. Examples include small integrated antennas operating at millimetre-wave frequencies for wideband satellite communications, chips which converge microwave, optical and digital signals for interface applications, and photonic components for processing information in the all-optical domain.

The research program focuses on two areas:

Area 1: Microelectronics Research

This area includes research into technologies to permit increased integration and miniaturization of higher levels of signal processing functionality with particular emphasis on techniques for wireless communications. Of particular interest are Microwave Monolithic Integrated Circuits (MMICs), Miniature Hybrid Microwave Integrated Circuits (MHMICs), digital implementation of radio, on-board (the satellite) processing technologies, antennas, and the associated analysis and design capabilities.

Goal: *Develop advanced technologies such as 20/30 GHz active phased array antennas and transfer them to industry under license or through collaborative R&D arrangements.*

Area 2: Optical Technologies Research

This area includes research into optoelectronic and optical fibre component technologies to permit high-speed switching, signal processing, and signal interconnections to be achieved in optical communications networks and systems. Emphasis is on performance requirements for operation and interconnection into wireless communications systems for broadband communications. The work addresses the integration of lasers, photodetection and other electrophotonic technologies to increase the utilization and application of fibre optics systems.

Goal: *Develop and demonstrate components to interface high-speed optical networks with radio and satellite communications systems.*

Goal: *Develop, in partnership with industry, a domestic source of strategic optical components using the incubator and other technology transfer programs.*

Tier 3 Research Activities

The third and final tier included in the research priorities contains two items.

Test Beds

A sophisticated means of testing ideas and verifying performance is often an essential part of the R&D process. The required test beds are often sufficiently complex and expensive that it is useful to make arrangements for collaboration and sharing with others. These may be computer simulations of particular processes, such as the behaviour of a network under various stresses, or they may involve extensive hardware installations with considerable maintenance requirements.

At CRC, important test beds are available or under development for high speed broadband network applications, network privacy and security, video compression techniques, and video and audio evaluations. A new CRC initiative is the Broadband Applications and Development Laboratory (BADLAB) which will permit the development of integrated communications networks comprising fibre-optics, satellite communications, and radio; and which will allow the testing of new broadband applications through communications networks which are being implemented across Canada as part of the electronic highway.

Goal: Ensure that BADLAB becomes a focal point for the demonstration of high speed networking technologies.

Goal: Establish a TDMA inter-LAN satcom test-bed at CRC in the next two years.

Proof-of-Concept Demonstrations

...it is usually not possible to interest a potential client in exploiting new technology or services without a proof-of-concept demonstration.

Ideas for new technologies, systems or service applications become meaningful and credible only when the idea becomes tangible, and it is usually not possible to interest a potential client in exploiting new technology or services without a proof-of-concept demonstration. Thus the development of prototypes and demonstrations become essential ingredients in successful technology transfer to stimulate markets, meet user needs and ensure commercial exploitation. These are found in all telecommunications R&D laboratories in both the public and private sectors.

As mentioned earlier, CRC has long supported the MSAT program, a major crown project, and will continue to assist industry in demonstrations and

applications development as well as the Government Telecommunications and Informatics Services branch in implementing new MSAT services in the federal government. Other important demonstrations include government applications for mobile satellite, satellite technologies and applications in the 20-30 GHz bands, hybrid microcircuits incorporating photonics and digital and analog circuits, new satellite system and service concepts for Canada; and new health and educational services/applications.

Goal: *Provide technical support to meet the 1994 MSAT launch requirements and the test, demonstration and implementation of services during 1995.*

Goal: *Provide demonstrations of ATM applications such as satellite-based wide area networks and satellite extension to networks for telemedicine and distance learning.*

Performance Indicators and Targets

To gauge the quality and effectiveness of the R&D carried out at CRC, a number of criteria are available. These are in part based on the performance indicators contained in the December 1992 Communications Canada Operational Planning Framework (OPF). Some of these do not lend themselves to a quantitative description. For the others, which can be usefully measured, targets are given.

- Achieving the goals of the Lortie pilot model: management practices better suited to the needs of R&D; a better focused mandate; and, less unproductive overhead.
  - *New and innovative practices in order to develop strategic alliances, enhance the exploitation of knowledge, introduce innovative resource management and provide leadership in telecommunications R&D.*
  - *Tighten the organizational structure at CRC on both the research and services sides to improve economy and efficiency.*
  - *Ensure that the results of the Lortie pilot study at CRC are effectively communicated in order to influence the overall management practices of federal laboratories.*
- Participation by CRC in collaborative partnerships that result in product, system and service exploitation.
  - *The initial steps toward creation of an incubator facility have been made. During 1994, a minimum of three clients will be attracted to the facility.*
  - *A feasibility study of the creation of a research park at CRC is underway. If the research park study is positive, the target will be to obtain federal, provincial and municipal approvals to create the park in fiscal year 1995/96.*
  - *BADLAB (broadband applications and demonstration laboratory) will be launched in collaboration with the Ottawa-Carleton Research Institute (OCRI) and OCRInet and industrial partners. The target is to position BADLAB as a major node in the Information Highway, to use it for R&D activities in support of policy development, and to make it available to small business and universities for product testing and application demonstration.*

- Client satisfaction.
  - *In 1992 and 1993, senior managers of twenty-seven client organizations were interviewed, using a standard set of questions relating to: trends, challenges and opportunities; the usefulness and significance of CRC's research projects; and the effectiveness of CRC's research both in terms of usefulness to the client and as part of the development of telecommunications in Canada.*
  - *A similar survey will be carried out in fiscal year 1994/95 in preparation for the evaluation of the success of the Lortie pilot trial at CRC and the assessments of achievements against this business plan.*
- Assessment by peer review of the quality and quantity of R&D compared to other similar R&D establishments.
  - *Peer group assessments have been carried out in the past with consistently favorable results. During 1994/95, it is planned to carry out peer assessments of the Mobile Satellite Communications and Television Broadcast Technologies Research Areas.*
- Amount of contracting-in and technology exploitation.
  - *In fiscal year 1993/94, approximately $0.77 million was received in direct payment for contracted work, loans and purchases.*
  - *Over the next three years, it is planned to increase this amount to $2.4, 2.8 and 3.6 million.*
- Assessment of the perceived benefits/costs of intramural R&D.
  - *With the assistance of the Corporate and Industrial Analysis Branch of Industry Canada, the target is to identify economic indicators that will lead to a useful cost/benefit measurement of R&D activities at CRC.*
- Number and quality of published papers, research reports, conference presentations, workshops, seminars and symposia.
  - *The pressure to publish is decreasing as the value of intellectual property becomes better recognized. However, as part of CRC's 1992 Strategic Plan, a comprehensive list of research publications and presentations was compiled. For the years 1990, 1991 and part of 1992, more than 200 research articles were tabulated. The list will be updated during 1994. A target of 75 research publications, including 20 publications in referreed journals, has been set for fiscal year 1994/95.*
- Total revenues, patents and licenses generated from intellectual property.
  - *In fiscal year 1993/94, the first year of the Lortie pilot trial, $0.22 million was generated from licensing. During the year, maintenance fees and new patents cost $0.11 million, or half of the total.*
  - *The target is to increase the income by $0.1 million per year to $0.3, 0.4 and 0.5 million for fiscal years 1994/95 through 1996/97.*

- Significant findings or applications from research efforts.
  - *These findings will be reported in the annual report. It is difficult to set a target for the creation of significant research outputs, but the cost/benefit indicators referred to earlier will help to establish useful measures.*
- Operation of the overall research program according to plan, and within agreed operating budgets.
  - *This indicator will be reported against annually in the annual report.*
- Achievements and impact against major initiatives and policy targets of government.
  - *CRC actively participates in the review of federal S&T policy.*
  - *CRC participates in the Information Highway initiatives, through BADLAB, OCRINet, CANARIE and contributes to policy formulation.*
  - *In cooperation with the Department of National Defence and the Canadian Space Agency, a study has been started to examine the potential benefits and cost savings of the provision of common research and site services to all the occupants at Shirleys Bay.*
- National and international recognition of the mandate, objectives and activities of the labs by relevant clients, industry and government, and of resulting Canadian expertise in communications research and development.
  - *This is primarily a qualitative indicator which will be evidenced through CRC's national and international reputation. Some measures will continue to result from peer reviews. Others will result from effective participation in national and international forums. The target for fiscal year 1994/95 is participation in ten such forums.*

Financial Plan

REVENUES ($ Million)	1993/94	1994/95	1995/96	1996/97
Parliamentary Appropriations				
- salary and wages	$17.9	$17.0	$17.0	$17.0
- operating costs	13.3	13.1	13.1	13.1
Intellectual Property	0.2	0.3	0.4	0.5
Industrial Partners	0.7	2.4	2.8	3.6
Other Govt. Depts. - Research	2.9	2.9	2.9	2.9
- Site Services	3.0	3.0	3.0	3.0
Industry Canada - Spectrum	1.9	1.5	1.5	1.5
Human Resource Rejuvenation	0.0	1.0	1.0	1.0
Contracted Services	0.2	1.1	1.8	3.5
Total	$40.1	$42.3	$43.5	$46.1

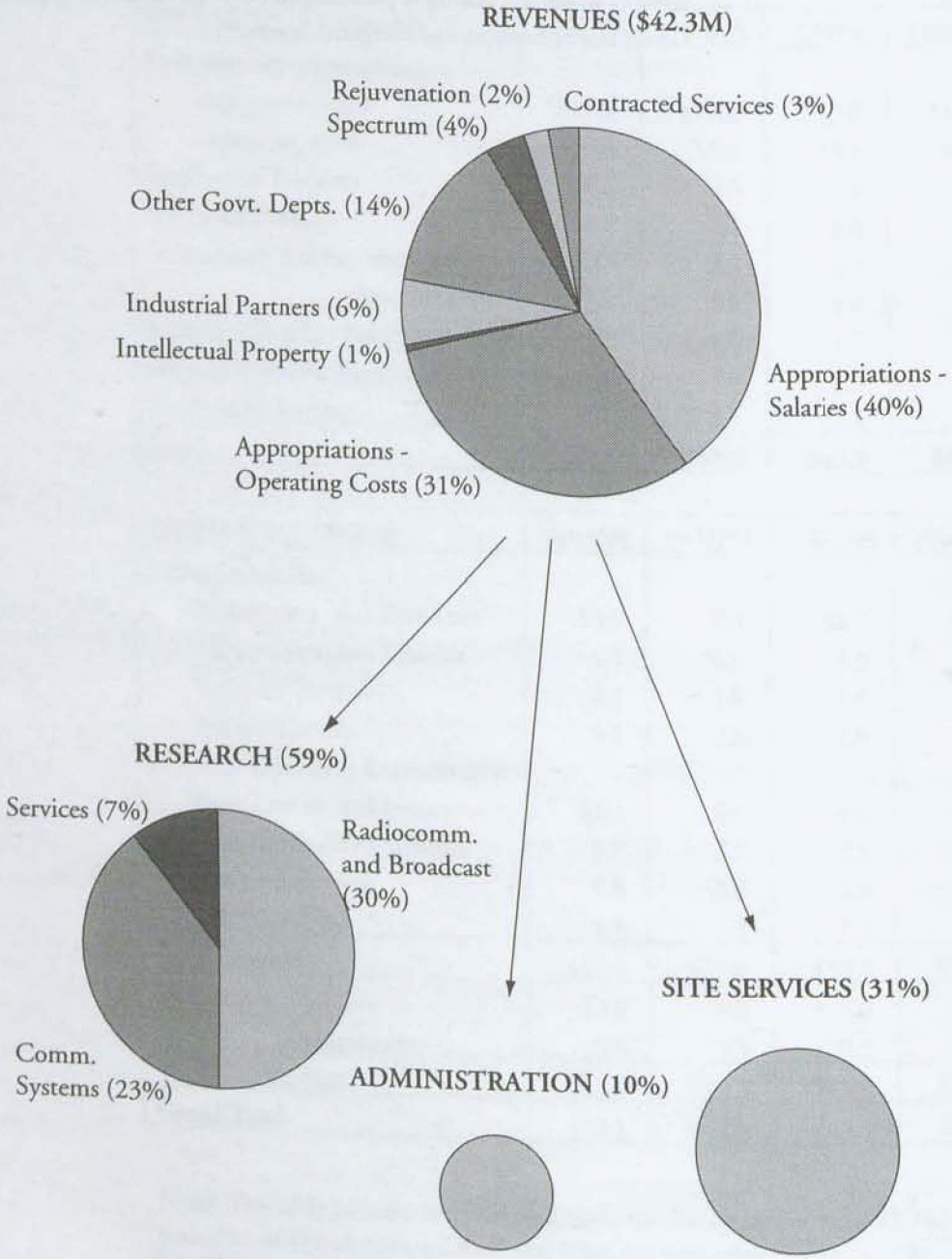
EXPENSES ($ Million)	1993/94	1994/95	1995/96	1996/97
Research Salaries:				
Radiocomm. and Broadcast	$6.6	$8.0	$8.5	$9.2
Communications Systems	5.4	6.6	7.1	7.8
Research Services	2.2	1.8	1.8	1.8
Administration	3.1	2.8	2.8	2.8
Research Operating Expenditures:				
Radiocomm. and Broadcast	$3.4	4.5	4.6	5.4
Communications Systems	3.7	3.2	3.3	3.7
Research Services	0.8	0.8	0.8	0.8
Administration	1.3	1.3	1.3	1.3
Total Research	$26.5	$29.0	$30.2	$32.8
Site Services - Salaries	$4.2	4.0	4.0	4.0
- Operations	9.4	9.3	9.3	9.3
Total Site Services	$13.6	$13.3	$13.3	$13.3
Grand Total	$40.1	$42.3	$43.5	$46.1

Note: The table includes revenues and expenses *directly* associated with the provision of site services to DND and CSA, the two other tenants at CRC. The table also includes the portion of *indirect* costs of common services supplied by

CRC "free of charge" to them, such as the cost of roads, snow removal, parking, library, security, etc.

Site services costs ($13.3 Million) represents 31.4% of the total CRC budget. These include security and fire protection, infrastructure maintenance, construction, all utilities, asset protection, cleaning, toxic waste removal, accommodation design and planning, telecommunications and site development, services which are normally provided to other government departments by Government Services and budgeted separately.

Revenues and Allocations, Fiscal Year 1994/95



Challenges

A major challenge facing CRC is the ongoing costs of operating the site at Shirleys Bay. Because historically the property belonged to the Department of National Defence, which has its own property management mechanisms, support is not provided by Government Services (formerly Public Works). Instead, CRC manages the budget for operating the site.

The funding allocated to operating the physical facilities at Shirleys Bay is about thirteen million dollars, plus costs for incremental services which are recovered from DND/DREO and the CSA. This amount is insufficient to keep the existing structures fully operational and in good repair. Many of the facilities date back to the 1950s and are quickly reaching the time for a mid-life refit. Security and fire protection services are badly in need of replacement.

While requests to Treasury Board for funding for maintenance and refits will continue, it is not realistic to expect massive relief. During the past year, operational methods have been examined to find ways to economize. An innovative energy conservation scheme involving private investors is being studied which could provide savings to CRC in five or six years. The amount of contracting out to trades is being examined, and significant savings may be possible through additional CRC staff. The creation of a research park would help share infrastructure costs such as maintenance of roads and services.

The cost of operating and maintaining the site will be a difficult problem for the foreseeable future.