Review of the Broadcast Technologies Research Branch Communications Research Centre

performance management network

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Final Report

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Prepared for:
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Communications Research Centre

October, 1999

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Executive Summary

This review of the Broadcast Technologies Research Branch is being undertaken in order to help CRC management determine the extent to which the programs and activities of the Branch are appropriate and effective in meeting government needs for technical support to broadcasting and, in addition, to identify opportunities to improve the performance of the Branch and its effectiveness.

The review has taken account of the recent policy paper on S&T activities within the federal government "Science and Technology for the New Century" and the response of the Industry Portfolio, outlining its main strategies for undertaking and managing S&T activities in the future.

CRC began a research program linked to broadcasting about ten years ago. Since that time, radio and television broadcasting research has continued under various organizational structures. The groups have been combined, split apart and rejoined several times, however the scientific and technical programs have continued essentially uninterrupted. The long life of the radio and television research programs, together with the recent changes made the Broadcast Technologies Research Branch a logical candidate for a major review at this time.

The Broadcast Technologies Research Branch has expenditures of about $3.5 million annually. These consist of salaries for 50 person years of effort provided by about 33 permanent and 17 temporary staff, and $1.3 million for operational and minor capital expenditures. Revenues and special funds provide about $650,000, or 17% of Branch expenditures.

The review addressed three major issues and a number of questions which addressed specific aspects of each issue. Detailed analysis and discussions on the various questions can be found in the main body of this report.

It is clear that, overall, the Branch is appropriately and effectively fulfilling the role of a government research laboratory in the field of broadcasting,. meeting the needs of both public and private sector clients and stakeholders. Based on the responses of clients and experts interviewed, the Branch is providing valuable and important services to clients, through the generation of results of a technical or strategic nature difficult or impossible to achieve without the contribution of the Branch. Clients rate the quality of research, services and equipment highly. However, there is concern that loss of qualified staff has left the Branch less able to meet client needs.

An overview of the evidence and conclusions for each issue, followed by recommendations for change is provided below. It should be noted that, while the purpose of the study was to review the Broadcast Technologies Research Branch, a number of the recommendations apply not just to the Branch, but to CRC as a whole.

Issue 1. To what extent are the programs and activities carried out within the Broadcast Technologies Research Branch relevant and effective in terms of the appropriate role of government laboratories?

It is clear that the Canadian government expects its scientific laboratories to fulfill a dual role in support of both the public interest and economic growth and wealth creation. This is reflected in the CRC mission statement. The Broadcasting Technologies Research Branch is effectively performing these dual roles in a complementary manner. Broadcasting is important both as an instrument of public policy and as a vehicle for economic growth and wealth creation. The social and cultural well being of the public needs to be supported through an efficient, effective, and accessible broadcast system and the private broadcasters need appropriate standards, regulations, and technical assistance to help them develop and provide a quality broadcast system. The role of government S&T is also to provide technical support to the development of national regulations and standards compatible with international systems. Neutral independent testing of systems is also recognized as an important role for government laboratories, free from commercial interests and influences. Evidence collected also shows that the Branch effectively undertakes these roles on behalf of the Canadian Broadcast community.

The need for Branch capabilities is particularly acute at the present time, as digital broadcasting is being implemented. There are many demands for new standards, regulations and testing as well as technical assistance to implement the new technology. The Canadian broadcast industry has lost much of its technical capability through downsizing and in many cases, the Broadcast Technologies Research Branch is the principal remaining source of expertise and knowledge about this technology in the country.

A review of Branch programs and projects, analysis of clients and collaborators, and feedback from the client survey, staff and expert interviews show that the Branch is effectively supporting both public and private interests within the Canadian and international broadcast community. In fact, the Branch has been credited with helping draw these two stakeholder groups into a closer, mutually beneficial relationship with respect to Broadcast technology, particularly digital radio and television. In addition to R&D and technical advice and support, the Branch is valued by its clients and partners for providing other types of important, relevant services, such as information, advice, and strategic intelligence.

While the Branch is seen by the community as working in a highly relevant, effective manner, additional needs were identified to which the Branch can make a contribution. For example, in addition to the testing, technical assistance and advice provided, clients and other sources suggested that the strategic intelligence which the Branch obtains from international broadcasting standards meetings and other sources is valued highly. It is an important asset which many feel

should be utilized more effectively. A number of members of the broadcast community interviewed would like the Branch to make a greater effort to make them aware of technical developments and other emerging issues on a regular basis.

Another emerging need in the broadcast community is for highly qualified personnel with experience in digital broadcasting technologies. A number of the skilled staff of the Branch have been hired away to fill these needs in other organizations. There was a suggestion that the Branch work with industry to develop a more formal role for the Branch in providing support for the training of personnel for industry while also providing additional staff for Branch research and development programs.

Relevance - Recommendations

Communications and Awareness

The Branch should move to address the need in the broadcast community for improved access to strategic intelligence on international technical developments and emerging issues. Communicating with the broader broadcast stakeholder community about Branch initiatives and perspective on emerging issues should become a higher priority, and the Branch should develop new methods to complement those already in use. It is likely that a combination of approaches will be more effective than a single one.

Training of Highly Qualified Personnel

In order to help meet the need for highly qualified personnel in the broadcast industry and to attract young researchers to work on broadcast research priorities, the Branch should work with the broadcast community to develop creative, new methods for bringing young people into the Branch to work on projects of relevance to both the Branch and industry.

Maintain Multiple Complementary Roles

It is clear that the Broadcast Technologies Research Branch is uniquely positioned to meet needs of both the public and private sectors within the Canadian Broadcast community and that insight into the needs of one group contributes to the Branch's ability to meet the needs of the other. The Broadcast Technologies Research Branch should continue to maintain a balance among its various roles, providing technical support and services to meet both public and private sector needs in a complementary manner.

Issue 2. Is the Broadcast Technologies Research Branch being managed effectively?

Management of research is in transition. Traditionally, in many government laboratories, there has been much delegation of responsibility to local managers and senior professional staff. More recently, during the 1980s and 1990s, there has been increased pressure for a more formal management approach, with senior management taking a greater role. Particularly following the release of the government strategy for federal S&T in 1996 entitled "Science and Technology for the New Century", there has been a new emphasis within the federal government to continue the change. This involves complementing the distributed operational management structure with a more formal, active senior management component which provides strategic management input and monitors overall performance based on agreed upon indicators and adjusts programs and resources to ensure that objectives are achieved. The new approach is also used to demonstrate effective use of government resources to Parliament and stakeholders and accountability for the use of public funds through performance reporting.

At the corporate level, CRC has recently identified strategic directions for the next 3-5 years, and Branch strategies, activities and projects are expected to reflect those goals through a reallocation of resources. While the Branch has performed well in the past, evidence suggests that the Broadcast Technologies Research Branch, like other CRC research branches, has not yet moved significantly to the new, more formal approach to strategic and operational management of research identified in the government S&T Strategy. It is also clear that the Branch has performed well under its present approach to management.

Formal performance reporting within the Branch primarily consists of the quarterly progress reports from each group, which are focused on activities and outputs. There is little or no feedback received from senior management on the information in the reports. The Branch is required by CRC to keep track of financial records of revenues and expenditures, and keeps track of publications and presentations to conferences and workshops as part of activity reporting and input to the staff promotion system.

While the President of CRC has recently introduced initiatives to encourage collaborations among Branches, evidence suggests that branches within CRC remain largely self-contained, with inter-branch collaboration primarily for a specific separately funded project, revenue producing contract or through informal staff contact. The result is that branches operate largely as separate entities. The Broadcast Technologies Research Branch has had mixed experiences with CRC collaborations; some have been successful, but others have not. Collaborations between the Branch and universities have been facilitated through adjunct professorships held by Branch scientific staff, and NSERC funded projects. There have been a number of successful collaborations with broadcasting laboratories in other countries focused on sharing technical information and developing new regulations and testing procedures.

Clients were generally pleased with the present mix of activities (research, application and development, contracts, testing, technical assistance, and advice) within the Branch. While the overall balance in the Branch was about right, evidence suggests that there may some need for rebalancing within individual groups. The Radio Broadcast Systems Group has been working on developing software to measure broadcast coverage patters from various transmitter configurations since the early 1990s, with heavy expenditures of resources and the reception of several hundreds of thousands of dollars in revenues. Licensing a commercially focused, up to date, user friendly version of this successful technology to a Canadian private sector firm would ease the workload in this area and allow the group to refocus its priorities on new emerging areas.

Some evidence suggests that the integration over the past year of the five groups which were brought together in April 1998 has moved slowly, and the Branch is still evolving. The Branch needs to move forward to develop and implement a unified strategy to respond to the pressures towards convergence in the broadcast and communications communities.

Management - Recommendations

Branch Management Strategy

As the needs of various stakeholder groups for broadcast and related technologies converge, the Broadcast Technologies Research Branch may need to develop a more integrated strategy to meet those needs. A Branch level, integrated approach to strategic and operational decision making should be developed to ensure that resources are appropriately allocated and that the Branch develops a supportive, coordinated approach.

To support this Branch level approach, minimize confusion and lack of awareness, regular meetings should be held with staff to discuss options, share information and discuss options.

Development of Performance Measurement, Management and Reporting Strategy

To support government requirements for improved performance management and reporting, CRC should develop a high level performance measurement approach based on Industry Portfolio preferred practices, and link it to their operational and strategic planning. Improved information on clients and partners, quality of service and the results of client interactions would support more informed decision making by Corporate and Branch level management, and help demonstrate the value and impact of CRC on the various communities it serves.

With the completion of this review, the Broadcast Technologies Research Branch is in a good position to develop and pilot test a new approach before widespread implementation.

Alignment of Corporate Goals and Reward Systems

CRC should ensure that the reward systems for staff are well aligned with the objectives and priorities of the organization. CRC has evolved from a research organization whose primary goal is to do research to one whose primary goal is to utilize CRC's scientific and technical capabilities to support public and private sector needs and to help improve social well being and create wealth.

Support for Inter-Branch Collaboration

CRC has recently introduced several mechanisms to encourage interBranch projects, including special funding for cooperative projects. However, the study suggests that Branches still have a tendency to act as individual organizations, without consideration of CRC level objectives or the needs of other Branches. CRC should continue to develop improved mechanisms to support inter-branch collaborations, where appropriate, as a means to better meet clients' needs through access to a more extensive pool of expertise

Focus on Application of Knowledge for Benefit of Clients

While the present overall mix of research, development, testing and contract work seem reasonable at the Branch level, the balance at the group levels needs to be monitored and adjusted as required. As a government agency providing scientific and technical support to public and private sector clients, the focus needs to be on utilizing existing knowledge to support achieving their objectives, while continuing to make resources available to perform research in order to build capability to meet emerging needs.

Licensing of CRC-COV

In order to support the transfer of technology to the Canadian private broadcast sector and free up resources for other priorities, the Branch should move to complete as quickly as possible a basic, user friendly, WINDOWS version of CRC-COV, suitable for use in the design of digital broadcast systems, and license it to a Canadian broadcast consulting firm. The Branch should continue to make available to the broadcast community specialized services using the general multicapability version of CRC-COV in those cases requiring the highest level of expertise.

Issue 3. To what extent does the quality of research and services provided by the Broadcast Technologies Research Branch meet the needs of clients and collaborators?

The issue of the appropriateness of quality of research and services was reviewed through a number of complementary methods. Based on the client survey results, expert and other interviewees, the large majority of clients and collaborators are generally highly satisfied with the quality of research and technical services provided by the Branch, and have confidence in the results obtained. Clients and experts also both agree that existing services are highly relevant to the needs of the broadcast community. When clients were asked to rate their satisfaction with the Branch's contribution to a specific project, the average rating was 9.0 out of 10. This is an extremely high rating, indicating a very positive relationship between the Branch and the clients surveyed. However, some clients thought that the quality of research is now lower than it has been due to the inability to retain qualified professional staff. There has been a significant loss in the past several years of highly qualified staff, leading to a loss of important research and testing capabilities in the Branch.

For those interviewees who had worked with other communications laboratories, the Branch also compared reasonably favourably. In many cases, these other organizations were large national laboratories such as NASA (USA), BBC R&D (UK) and CCETT (France), which are much better funded than the Branch, so in that respect clients noted that the comparison may not be fair. Clients rated the quality of Branch equipment and facilities somewhat poorer, quality of personnel slightly better and overall responsiveness to client needs much better than these comparable organizations. When asked to provide a summative overall perspective, clients rated the Branch somewhat better than comparable organizations (5.9 out of 10, where 5.0 is equal). It is clear that the Branch staff's responsiveness is largely responsible for the overall positive rating.

Quality – Recommendations

Hiring and Retention of Qualified Staff

CRC should treat the hiring and retention of qualified professional staff as a priority. The President, in cooperation with DND DREO, has recently made representations to Treasury Board to alleviate the situation. While these efforts were unsuccessful, other avenues to ameliorate the situation need to be explored with central agencies and other public sector stakeholders. For example, CRC could consult with other science based departments and agencies through various means such as the Science ADM committee to explore options. The practices of other government research agencies such as NRC should be reviewed to provide information on available options, including flexibilities which could be introduced into rules and regulations on staffing issues.

1.0 Introduction

1.1 Background

As outlined in the Treasury Board Review manual, Departments and Agencies must conduct reviews of major policies and programs to ensure that senior management receive objective information to provide assurance that programs are relevant and are operating and managed as intended, and to assist in improving program performance.

Government policy, with respect to the role of government research laboratories, has evolved considerably over the past ten years and Communications Research Centre (CRC) management is interested in whether the activities and objectives of the Branch remain appropriate and effective in meeting government needs. In making this assessment, it is important to determine who the beneficiaries of Branch activities are, and what benefits they receive.

Recently, government has asked all departments and agencies to take account of client feedback, particularly concerning the quality of services and interactions. CRC is no exception, and a review provides an opportunity to obtain client perspective on a number of aspects of the Branch, including the capabilities of Branch staff, quality of research and facilities, advice and test results, and client relations.

As well, following the 1996 review of federal S&T, management of the performance of S&T activities in general and research laboratories specifically has become a greater focus. This review will also examine a number of aspects of the effectiveness of the management of the Broadcast Technologies Research Branch.

This review of the Broadcast Technologies Research Branch has an additional objective. It is in some senses a pilot project, which will be used to assist CRC management in determining how best to go about examining other CRC research branches. Based on management's view of the appropriateness of the methodological approach, quality and usefulness of the study, a decision will be made whether to follow a similar approach to examine other CRC research branches.

Based on the input from CRC management and their requirements for information to demonstrate accountability and support decision making, the following three issues have been developed. Each issue has a number of questions to help define information and analytical requirements.

1.2 Study Issues

Issue 1. To what extent are the programs and activities carried out within the Broadcast Technologies Research Branch relevant and effective in terms of the appropriate role of government laboratories?

1.1 Is there a continuing need for the research and testing facilities provided within Broadcast Technologies Research Branch programs?

1.2 Who benefits from the Broadcast Technologies Research Branch programs? In what manner?

1.3 How effectively is the Broadcast Technologies Research Branch meeting Canadian public and private sector needs for information and advice about emerging television and radio broadcast technologies and systems?

1.4 In what manner does the Broadcast Technologies Research Branch contribute to the mission of CRC?

1.5 Is the Broadcast Technologies Research Branch within CRC filling an appropriate role for government?

Issue 2. Is the Broadcast Technologies Research Branch being managed effectively?

2.1 What mechanisms for strategic and operational decision making and resource allocation are being used within the Branch?

2.2 What approach does the Broadcast Technologies Research Branch use for monitoring and reporting on performance?

2.3 What is the nature and extent of collaborations by the Branch within CRC and with other organizations?

2.3 Does the Broadcast Technologies Research Branch have the proper mix of strategic and collaborative research, development, testing and applications? Are the resources being used in the most appropriate areas?

Issue 3. To what extent does the quality of research and services provided by the Broadcast Technologies Research Branch meet the needs of clients and collaborators?

3.1 Do clients and collaborators have confidence in the quality of research, testing and other services provided by Broadcast Technologies Research Branch?

3.2 Are Broadcast Technologies Research Branch services relevant to the needs of clients?

3.3 Are the capabilities of Broadcast Technology Research Branch staff and the quality of facilities appropriate to the needs of clients and collaborators?

1.3 Methodology

This section presents a summary of the methodological approach developed to gather appropriate evidence to reach credible conclusions on the study issues and questions. (A detailed description of the approach can be found in the **Planning Report for the Review of the Broadcast Technologies Research Branch** which was used as the basis for this study.) The methodological approach is based on the commonly accepted practice of using several complementary analytical methods to gather multiple lines of evidence to arrive at credible findings and conclusions. For each question, there is at least one major source of evidence, with additional supplementary ones as appropriate. Each of the methods used were adjusted to the specific information sources and requirements.

Based on the information provided in the preliminary document review, interviews and preparation of the Branch profile, the following sources were used to collect evidence for the study:

- CRC and branch document and file review and analysis;
- analysis of Branch publications for the past three years (1996 - 1998);
- interviews with 11 Branch managers and senior staff and six other present and former CRC managers and staff;
- survey of 30 partners, collaborators and clients of the Branch (face-to-face and telephone interviews using a standardized questionnaire) taken from a list provided by the Branch (**Annex A**);

- interviews with six broadcast sector experts;
- analysis of two similar organizations in other countries; and,
- in-depth case studies of five major Branch projects.

In addition, an integration and analysis phase reviewed pertinent evidence from different sources in order to provide more credible conclusions on the various questions and issues.

1.3.1 Study Limitations

Reviews of this nature are essentially applied social science. Each particular methodological approach has some strengths and some limitations, and careful combining of methods can minimize the limitations and provide more credible conclusions than available from a single source.

Table 1-1 summarizes the strengths and limitations of each of the methodological approaches.

Table 1-1: Strengths and Limitations of Methods

Method	Strength	Limitation
Document Review	Provides factual background information to support other sources.	Usually does not relate directly to review issues. Must be complemented with other methods.
Publication analysis	Provides factual information about scientific outputs of Branch, collaborators and intended audience.	Focuses on quality of scientific outputs (one of the issues).
CRC Staff Interviews	Staff input essential to provide background, context. Have detailed knowledge about internal issues.	Input is combination of fact and perception. Needs to be confirmed from other sources (i.e., for quality of service, compared to those of clients).
Client Survey	Important source of partner and client perspective on relevance, need, quality and benefits arising from working with Branch.	Clients chosen from list provided by Branch - may not be representative. Numbers too small to generalize. Perception is not fact - comments may not reflect reality, cannot be proven.
Expert Interviews	Experienced, well-informed individuals provide important strategic perspective unavailable elsewhere.	Not representative of stakeholder group, perspectives are personal, possibly biased.
Comparable programs	Provide valuable information about alternative approaches and practices.	Few situations are truly comparable, as political and policy environments vary. May not be appropriate for Branch.
Case studies	Provide in depth probing of roles, relationships and pathways to benefits.	Not representative or generalizeable, usually chosen from among best projects to demonstrate nature and extent of benefits which can occur.

2.0 *Broadcast Technologies Research Branch Description*

2.1 *Background*

CRC is the Canadian government's primary communications research organization. It was originally formed in 1969 as an agency of the Department of Communications, having evolved from previous military communications objectives to a new civilian role. In 1993, CRC was made part of Industry Canada, the federal government's major industrial and economic development agency. The corporate goals of CRC are:

- to be at the forefront of communications science and technology in order to offer insight to the government for the formulation of industrial strategies, regulations and policies in the public interest;
- to be recognized nationally and internationally as a leading centre of excellence in communications technology R&D addressing Canadian needs and as a primary source of independent technical and scientific advice;
- to be a catalyst and central player in a web of industrial and institutional partnerships to ensure Canada maintains its world leadership position in the development and application of communication technologies; and,
- to make sustained and measurable contributions to the growth of an entrepreneurial, innovative communications industry in Canada.

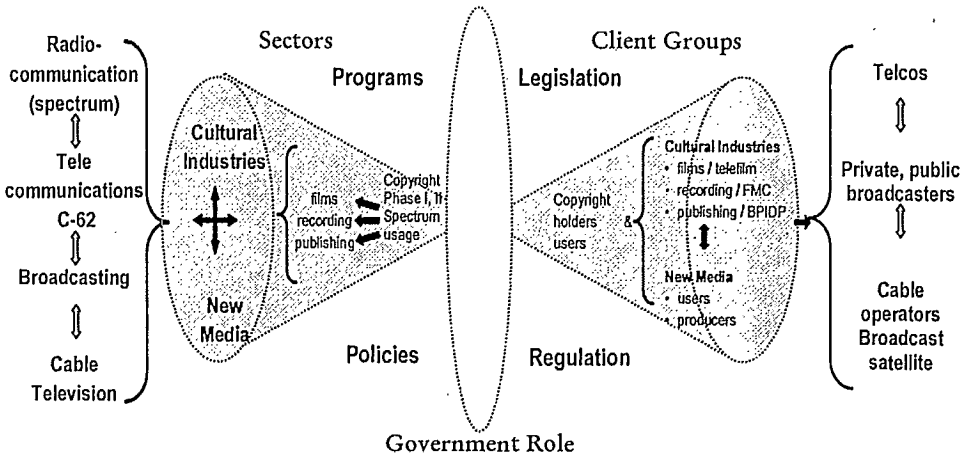
2.2 *Description of Branch*[1]

The Broadcast Technologies Research Branch provides technical support to the Canadian broadcast and communications community. The primary clients and partners are the Canadian government through Spectrum Engineering, radio and television broadcasters, broadcast and telecommunications equipment manufacturers, and service providers.

[1] For a more complete description of the Branch, please see the report **Profile of the Broadcast Technologies Research Branch**, which was developed in preparation for this review.

Exhibit 2-1 presents an overview of the environment in which the Branch operates. There is a move to greater and greater interdependence and convergence of the various communications industry sectors.

Exhibit 2-1: Audio and Video Sectors and the Public Interest



The Branch supports the technical needs of these stakeholders by undertaking research, development and testing of advanced audio, video and digital television (DTV), digital radio broadcasting (DRB) and datacasting services to be carried over terrestrial off-air channels, satellite, cable, multipoint distribution systems and local multipoint communications systems. Compatibility and operability between the various delivery systems and their integration with broadband communications are important objectives.

The Branch has four research programs related to DRB and DTV. The two programs related to DRB are Radio Broadcast Systems and Transmission and Advanced Audio Assessment and Coding, and the two related to DTV are Television Systems and Transmission and Advanced Video Assessment and Coding. These research programs are described in greater detail in the following sections.

2.2.1 Radio Broadcast Systems and Transmission

The objectives of this research program are:

- to determine the best implementation of DRB services in Canada to suit the needs of broadcasters, service providers, manufacturers and the Canadian public; and,
- to serve as a focal point for Industry Canada Spectrum Management, the CRTC, other radio associations and Canadian industry for the provision of scientific

expertise, development and testing of new concepts, products, and services for digital radio broadcasting.

Facilities include a DRB testbed to simulate the mobile reception environment, interference and characterize transmitters and receivers. The testbed is used in-house to support development and testing and by DRB manufacturers to evaluate prototype equipment. As well, a mobile test van is available for field testing. Software has been developed to calculate DRB and other broadcast reception coverage (CRC-COV) and has been licenced to a number of Canadian and international users. Improved versions are being developed for other applications including military use. Other related software to support design and analysis is also being developed. CRC is a member of Digital Radio Research Incorporated (DRRI), and operates the DRRI experimental DRB site in Ottawa. This system, in operation since 1995, is used for experimentation and demonstration of DRB to Canadian and foreign visitors. The group is also involved in studying interactive mobile datacasting and participates actively in Canadian, American, and international standards work.

2.2.2 Advanced Audio Assessment and Coding

The objectives of this program are to conduct R&D and provide technical support in the areas of advanced sound systems and digital audio technologies, focusing on sound and channel signal processing, human auditory perception and sound quality assessment. This work is carried out to support the management of the broadcast spectrum, development of the regulatory framework, the setting of national and international standards and the introduction of digital radio broadcast services. Current projects include developing modifications and improvements to the Eureka 147 DAB system, adopted as the standard technology to deliver DRB in Canada and a number of other countries. Other work focuses on human auditory perception and subjective sound quality assessment. CRC's Audio Perception Laboratory is operated by this group, and is used for both in-house and contracted subjective evaluation of audio and speech systems.

2.2.3 Television Systems and Transmission

The objective of the research program is to provide technical knowledge in advanced television systems and transmission technologies to support Industry Canada's broadcast spectrum management and development of regulatory frameworks, and transfer technology to the broadcast and telecommunications industry in support of implementing digital television services and developing equipment. Projects include collaborative work with Spectrum Engineering and industry on the introduction of digital television services. Other initiatives include investigation of interactive television, microwave distribution via local multipoint communication systems (LMCS) and data broadcasting. A Channel

Simulation Facility is being used to reproduce channel conditions in the laboratory to test various transmission systems. Other facilities include a mobile laboratory (test van) to carry out field measurements.

2.2.4 Advanced Video Assessment and Coding

This program focuses on digital video processing, video compression, human visual perception and video quality assessment in support of the CRC mandate for providing technical assistance to Industry Canada for spectrum management and development of regulations, transfer of technology to the broadcast industry in support of the implementation of advanced television systems and other industries involved in developing video-based products and services. Research includes subjective evaluations of video image quality, High Definition Television (HDTV), Stereoscopic (3D) Television and digital video transmission over broadband networks. Research is carried out in-house and in collaboration with Canadian university and industrial partners as well as international organizations. The group is also active in national and international standardization for a related to video source coding, digital TV and picture quality assessment. CRC's Advanced Television Evaluation Laboratory (ATEL) is used both in-house and by clients and collaborators to assess picture quality under critical test conditions.

2.3 Resources

In 1998-99, Broadcast Technologies Research Branch had expenditures of $3.5 million, which is approximately 12% of CRC resources devoted to programs other than space related contracts. These funds include salaries of $2.2 million to provide salaries for 50 full-time equivalent permanent and temporary staff positions and $1.3 million in operations and minor capital funding (O&M). **Table 2-1** contains the details of Branch funding in 1998-99 for the research groups and Branch management. Note that half of O&M funding ($664,000 of $1,313,000 total) came directly from government allocations (A-base). The remaining half came from other sources, including $220,000 from contracts and $205,000 from Industry Canada Spectrum Management Branch. Funds from other sources account for about 18% of total annual Branch expenditures, including salaries. This is close to the target of 20% set by the President for all of CRC. While no detailed examination of the trend in Branch funding was carried out, there are indications that resources have declined significantly in recent years as part of the general government reductions in program funding.

Table 2-1: Branch Resources 1998-99

	FTEs		O&M FUNDING ($000's)					
	A-Base	Other*	A-Base	Spectrum	IP	Cont. In	Other	Total
VP Office**	6		60				88	148
RTNT	7	1	127	58		125	25	336
RAVS	11	3	187	44		60	15	306
RBSC	7	6	170	78	80	10		338
RPSP	7	2	119	25	3	25	13	185
TOTAL	38	12	664	205	83	220	141	1,313

FTEs = full-time equivalent staff
* Includes project paid, Co-op, Contract Employees & Exchanges
** Includes Branch Management

2.4 *Broadcast Technologies Research Branch Performance Framework*

The Science and Technology Management Committee of the Industry Portfolio, of which CRC is a part, agreed in 1998 to use the performance framework approach for describing and reporting on S&T programs within the Portfolio. This approach describes the essential components of a program in terms of five broad categories. They are:

- activities (what program staff and management do);
- outputs (direct products of program activities);
- reach (individual organizations and groups directly and indirectly involved in or "reached" by program activities, includes co-delivery agents);
- direct outcomes (direct results of interaction between program and those reached, includes knowledge transfer, attitudinal and behavioural changes); and,
- ultimate impacts (follow direct outcomes, usually longer term, should link directly to program objectives).

These five categories can be further condensed into three groups, resources (activities, outputs), reach (reach) and results (direct outcomes, ultimate impacts), which answer the three basic performance questions of:

- HOW are we going to allocate resources to provide activities and outputs which achieve program objectives?

- WHO do we need to work with and influence to achieve program objectives? and,
- WHAT is the logical result of doing these things with these people and organizations?

In developing the Profile of the Broadcast Technologies Research Branch, a performance framework was developed for the Branch, shown on the following page as **Exhibit 2-2.** As can be seen, the Branch performance framework presents a strategic view of the main elements of the Branch operations, its target clients and partners as well as intended immediate and longer term results. This framework will be used in this review as the basis for comparing aspects of the actual performance of the Branch to the intended performance.

Exhibit 2-2: Performance Framework for the Broadcast Technologies Research Branch

Mission Statement: To investigate emerging digital radio and television broadcast technologies and systems, and their integration into a broadband communications operating environment, including operability among delivery media.
Resources: $5.5 million A-base funding for 50 FTEs and $600,000 O&M, plus additional $600,000 resources

HOW?	WHO?	WHAT do we want?	WHY?
Resources	**Reach**	**Results**	
Activities / outputs	**users / clients / co-deliverers / beneficiaries**	**direct outcomes**	**ultimate impacts**
Research Development and Testing • radio broadcast systems and transmission • advanced audio systems • television systems and transmission • advanced video systems Development and Operation of Test Facilities Publications / Test Results Advice / Assistance Management • contracts • projects • staff	**Public Sector:** Federal Government: • Spectrum Management • CRTC • Public Broadcaster-CBC • DND • Canadian Heritage International Regulatory Agencies Other National Government Agencies **Private Sector (Canadian and international):** Private Broadcasters Service Providers Broadcast Industry Associations Telecom Equipment Manufacturers Broadcast Equipment Consultants Universities International Firms, Organizations	**Public Sector:** Technically informed policy and regulatory decision making Improved use of technology Canadian influence in international standards development **Private Sector:** Awareness of international developments, use of Canadian capability, approach Increased awareness of DRT and DRB technology and applications, international developments by industry New and improved products, processes and systems Improved linkages between public and private sector stakeholders in broadcast sector	**Public Sector:** Best use of spectrum Technically effective, efficient public broadcast policy, regulations Canadian influence in international regulatory system Canadian policies and regulations aligned with international requirements **Private Sector:** Increased competitiveness of Canadian broadcasters, equipment manufacturers, and broadcast engineering consultants More informed, appropriate decisions by public and private sector broadcast stakeholders

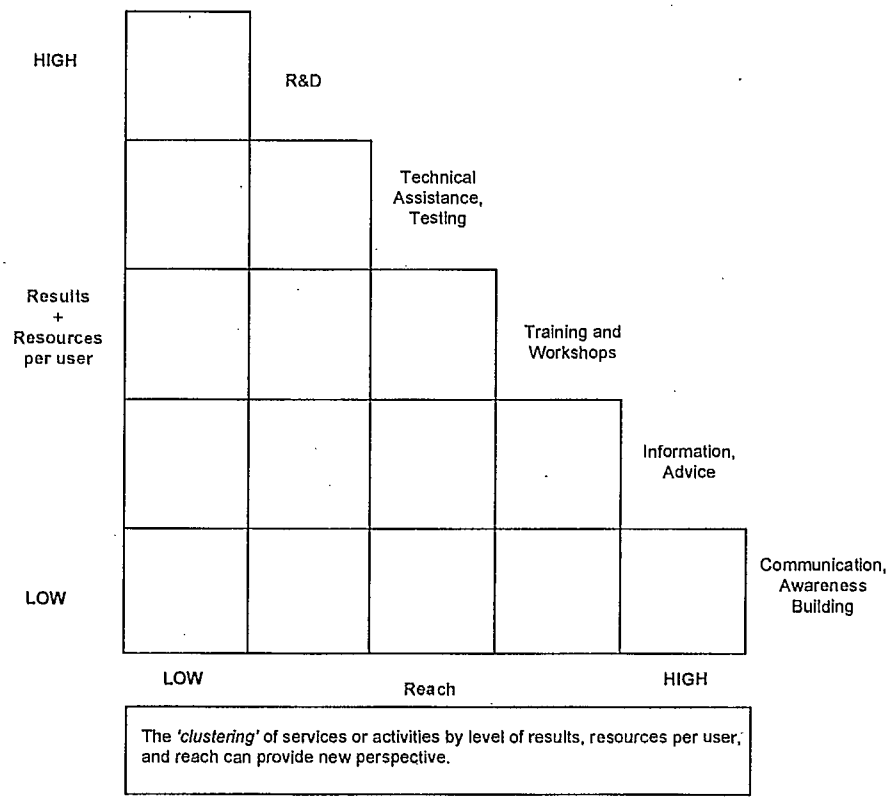
2.5 *Analysis of Services Offered by Broadcast Technologies Research Branch*

The discussion of the performance framework approach and its application to the Broadcast Technologies Research Branch can be extended to describe in more detail the types of services provided. In fact, the types of services which a research organization can provide to its clients and collaborators can be classified in terms of the level of effort or resources required for each "service" provided and the extent of "reach" or number of clients or recipients reached by each service. Exhibit 2-3 presents a summary of the main types of services and their characteristics. For example, an R&D project is typically very resource intensive and has only one or several participants. Using this classification, an R&D project has a high cost per client or user, and a small reach (one or a few clients). At the other extreme, awareness building and communication through newsletters or via a website have a relatively low cost per recipient and can reach a large part of the target client group. Between these extremes are:

- in-depth technical assistance and testing, such as provided in conducting a subjective evaluation test;
- training and workshops, such as provided for CRC-COV licences; and,
- short-term information and advice, such as provided at broadcast association meetings.

The results or impacts expected from these different types of services also varies, with the largest impact per client or recipient expected from those services which have the highest cost per user. This categorization of types of services in terms of expected impacts will be used in examining the issues.

Exhibit 2-3: Services Classified by Resources, Reach and Results



Source: Steve Montague, The Three Rs of Performance: Core concepts for planning, measurement, and management, Performance Management Network Inc., 1997, p 120.

3.0 Program Relevance

Issue 1: To what extent are the programs and activities carried out within the Broadcast Technologies Research Branch relevant and effective in terms of the appropriate role for government laboratories?

Five specific questions related to program relevance have been identified in order to examine various aspects of this issue. These include:

- continuing need for Branch research and testing facilities;
- nature and extent of benefits and beneficiaries;
- Branch effectiveness in providing information and advice on emerging trends;
- Branch contribution to CRC mission; and,
- appropriateness of Branch activities and programs for a government research agency.

Each question is studied in detail in the following sections, followed by a general summary and recommendations. Analysis of this issue will include reference to Section 2.5 and **Exhibit 2-3**, which identify the various types of services and their characteristics, from R&D to communication and awareness building.

3.1 Is there a continuing need for the research and testing facilities provided within the Broadcast Technologies Research Branch programs?

3.1.1 Context

The question of continuing need represents one of the basic questions which must be answered about all government programs. In this case, there are many dimensions to the question which must take account of the multiple roles which the Branch is expected to perform in support of both the public and private sectors. Need should be examined from at least three perspectives, that of the country, the broadcast community at large, and individual organizations.

This question was examined using evidence from three major sources. These include: expert interviews, the client survey, and staff interviews. Of particular importance was the input from the major public and private sector clients, namely Industry Canada Spectrum Engineering and representatives of the Canadian broadcast sector.

Further discussion related to continuing need will be addressed in several following sections. In particular Section 3.2 examines the beneficiaries of the Branch's activities and programs and the benefits which occur due to their interactions with the Branch, and Section 3.5 reviews the appropriate role for government research agencies.

3.1.2 Detailed Findings

Expert Interviews

It is clear from discussion with representatives from Spectrum Engineering and other experts that the Branch has played and continues to play a critical role in Canada's broadcasting and telecommunications infrastructure. This is particularly true today. The introduction of digital broadcasting services in the 1990s is changing the nature of broadcasting and requires new technical and business approaches. Policy decision making and implementation for use of spectrum and related matters needs high quality technical input, and evidence available shows that the Branch has successfully provided such input to the government broadcast regulatory and standards system through Spectrum Engineering. As an indication of relevance and need, Spectrum Engineering provides the Branch with over $100,000 annually in additional funds to undertake specific research projects to address Spectrum Engineering technical requirements. One respondent from Spectrum Engineering stated that ensuring an effective public broadcast system is the principal role of the Broadcast Technologies Research Branch, followed closely by its complementary role of providing technical support to the Canadian broadcast sector. As mentioned previously, with the introduction of digital services, this need is greater than it was previously. Broadcasters have downsized and cut back on engineering and technical capabilities during the long period of standardized analogue broadcasting services.. requiring few new technical developments[2]. With the low level of technical capability in the industry, the BTRB, together with the broadcast consulting and engineering community are needed to provide technical input to business decisions related to digital radio, television and other communications related services, to ensure that they are well aligned with public policy, standards and regulations in this emerging field.

As mentioned, the broadcast community is suffering from a lack of trained technical staff. This is a result of downsizing but also difficulty in finding people with the required expertise. To some extent the Branch is presently acting as an unofficial training ground, as staff from the Branch are hired away by members of the broadcast community. One expert suggested that the Branch could assist in meeting this need in a more formal and mutually beneficial way which would also assist the Branch by having more young

[2] See recent article by Steve Edwards in Broadcast Dialogue.

research and /or technical staff available. The suggestion was to work with the broadcast community to develop a program to train highly qualified personnel with expertise in the new digital technologies. Many different approaches could be used, some mentioned were:

- co-op students hired by firms and placed at the Branch;
- secondments from individual broadcast firms; or,
- Canadian Association of Broadcasters sponsorship of training program.

Client Survey

The issue of continuing need for the Branch's capabilities by individual organizations was addressed by several questions in the client survey. An additional indication of the continuing need for BTRB is the long-term relationships which the Branch has with many of these organizations. Of the 29 respondents who answered this question, 13 had worked with the Branch for ten years or more; ten for between five and ten years; and six for less than five years. While not asked directly if they would continue to work with the Branch, the enthusiastic and positive statements of the importance and value of their relationship with the Branch by the majority of respondents is a good indicator that the Branch continues to meet their needs.

To probe whether there were additional needs to which the BTRB could address, respondents were asked to identify new or improved capabilities which the Branch could add to better meet their needs. Most were unable to identify any, indicating that the present array of services being offered by BTRB met their needs. Nine of 30 respondents made specific suggestions, many of which related to the interaction between the Branch and their community as compared to additional technical capabilities. For example, several respondents surveyed wanted the Branch to improve its communication with the broadcasting community and interact more proactively. A periodic newsletter and possibly an internet site identifying the Branch capabilities and major projects were suggested by some. As will be discussed in more detail later, clients see the Branch as a valuable source of strategic intelligence and want better access to it.

Respondents were asked why they worked with the Branch. As the question was open ended, with no list of prepared options, there were a variety of responses. The most frequent related to the strong technical capabilities of the Branch, as reflected by the expertise and commitment of staff and the facilities and equipment. Other answers included reference to the need for access to the international standards expertise available through the Branch.

Evidence suggests that for many clients, the Branch provides unique services otherwise unavailable in Canada, and in some cases, in the world. Respondents were asked to consider, for specific projects identified by the Branch, what effect not having access to the Branch would have had. Of the 30 specific projects examined, there would have been major negative effects for 27 (90%) and minor effects for the other three (10%). Negative effects include the following:

- project could not be done without Branch participation;
- project would be less complete, less reliable;
- loss of credibility due to absence of Branch;
- major delays; and,
- increased costs.

It is important to note that the projects to be examined were selected by the Branch and may not be representative of Branch interactions with clients. However, corroborating evidence from interviews with individuals broadly aware of the Canadian and international environment support the information obtained from clients. These combined results from multiple sources indicate that the Branch is meeting important needs for its client community and the Canadian broadcast community which are not available elsewhere in Canada.

Survey respondents were asked to rate the relevance of BTRB to their organization on a scale of 1 to 10, with 1 being not at all relevant and 10 being extremely relevant. The average rating from the 26 who answered this question was 8.6, a very high rating. In some cases, respondents from organizations with a broad product mix or mandate, were responding only in terms of that part of their business to which BTRB capabilities were a good fit. Ratings from representatives of Spectrum Engineering and broadcast industry associations in particular were very high, in all cases either 9 or 10, indicative of the importance these organizations place on the Branch's contribution to their objectives.

Staff Interviews

Evidence from the staff interviews shows that Branch staff are very aware of the need for ensuring that programs and activities are relevant and linked to client needs. Group managers indicated that they are proactive in monitoring client needs closely and adjusting programs in response to those needs. They also are proactive in identifying emerging trends and developing capabilities in anticipation of clients requesting services. As a recent example, discussed in more detail in a case study (**Annex D**), the video systems group identified 3D as a natural progression which could be built on existing digital television infrastructure, and began working on it in 1994. Since then, IMAX, and more recently, Spectrum Engineering, have begun collaborating with the Branch in this area. This would

not have occurred unless the Branch had developed some capability before the need was expressed by clients.

3.1.3 Conclusions

Evidence collected in this review indicates strongly that the Canadian public and private sectors both have a clear and continuing need for the research capabilities and facilities of the Branch. Clients and experts have spoken of the importance they place in having access to the expertise at the Branch, particularly now that digital broadcasting is emerging as the next generation of broadcasting. This applies to both the federal government through Spectrum Engineering and private sector broadcasters. In terms of the relevance of the Branch to meeting their needs, clients surveyed rated the Branch 8.6 out of 10, a very high rating. While the research and testing services have been important in developing standards and regulations and developing knowledge of the new digital technologies, the focus of need will likely change as digital radio and television broadcast services are being introduced to the marketplace. The broadcast community will require access to the expertise and technical knowledge in the Branch as they introduce and implement these services.

In addition to the traditional research and testing services provided by the Branch, which are needed and appreciated, there is evidence from the interviews that clients would appreciate and benefit from additional services. These include:

- more formal and better communication about Branch research initiatives; and
- access to the strategic intelligence which the Branch gains about standards, regulations and technology through participation in international standards meetings.

In addition, the branch is ideally suited to provide increased support to the training of highly qualified personnel (HQP) in broadcast technologies to meet the growing need in this area.

3.2 Who benefits from the Broadcast Technologies Research Branch programs? In what manner?

3.2.1 Context

An analysis of the number and types of individuals and organizations benefitting from Branch activities and the nature of those benefits is central to the issue of program

relevance. The question will be analyzed in terms of direct and indirect beneficiaries and the nature and extent of program outcomes and benefits which result from Branch activities and interactions with other organizations.

The BTRB performance framework is a useful reference for this question as it provides a strategic perspective on the intended beneficiaries and impacts of the work of the Branch. As shown in **Exhibit 2-2**, the question has two parts related to Branch reach (beneficiaries) and results (direct outcomes and ultimate impacts). Note that both the public and private sectors are directly involved. In studying this question, most methodological approaches used provided information of value. Primary sources were Branch documentation, client interviews and case studies, while the publication analysis and staff interviews also provided support. In many cases, similar evidence was found in more than one source. In those cases, it will be presented once with mention of confirmation from additional sources.

3.2.2 Detailed Findings

Documentation

Documentation provided by the Branch included lists of clients and collaborators for the interviews and surveys. A list of all names and organizations provided is shown in **Annex B** categorized by type of organization. The list also identifies those individuals who were contacted for the survey and interviews. Assuming that a complete or representative list of clients and collaborators was provided, analysis shows that the types of clients and partners, which the Branch works with directly, closely parallel those identified in **Exhibit 2-2**. The following list identifies the types of organizations with which the Branch works and in what types of activities:

- Spectrum Engineering (Canadian government broadcast policy and regulation, spectrum allocation);
- Canadian Broadcasters and their associations (technical matters related to radio and television broadcasting);
- Canadian broadcast equipment manufacturers (development and testing of digital and related equipment);
- Canadian broadcast consulting and engineering firms (technical services related broadcast design and engineering, broadcast coverage);
- Canadian universities (broadcast related research);
- American broadcast equipment manufacturers and their associations (digital standards development, equipment design and testing);
- international public and private broadcast and telecommunications laboratories (broadcast research, standards development and testing); and,

- International broadcast communications standards bodies ITU-R and ITU-T (development of international standards)[3].

It is important to note that this list of clients and collaborators provides no information about the relative expenditure of Branch resources for each group. In some cases, work is performed on a cost recovery basis under contract, while in other cases, resources come from the internal Branch budget. In addition, the relative effort towards each group varies according to the specific projects and initiatives underway at any particular time.

The list of publications for the radio and television groups in the Branch can be analyzed to show some aspects of their activities and outputs and the target client groups. **Table 3-1** presents a summary of the number of various types of publications for the two groups for the period 1995 to 1998. (This analysis does not include the number of publications per staff member. At the present time the TV group has approximately 25% more staff than the radio group.)

Table 3-1: Branch Publications 1995 - 1998

Type of Publication	TV Group	Radio Group
Journal Article	24	17
Conference Proceedings and Presentations	63	18
ITU-R Reports	23	24

As can be seen, the television group is slightly more heavily involved in publishing and significantly more involved in making presentations at conferences. This suggests that its outputs are targeted more toward an academic and international audience. The radio group has also held a number of workshops to share knowledge and transfer technology to clients, particularly with respect to the use of CRC-COV. Possible explanations for this difference in outputs will be discussed in Section 4.5.

[3] Identified from third quarter 1998 Progress Report.

Client Survey

The client survey gathered information on the benefits and impacts resulting from interactions between the Branch and the clients surveyed. Respondents were asked to focus on a single project and identify whether specific results had or will occur as a result of the project. For those results which have or will occur, respondents were also asked to rate the involvement of the Branch in achieving the results on a scale of 1 to 10, with 1 representing not at all involved and 10 being the completely responsible for the result. Table 3-2 contains a summary of the survey data.

Table 3-2: Project Results Identified in Survey

Result *	Has Occurred (#)	Will Occur (#)	Importance of Branch Role
Solution to technical problem	17	4	8.5
New knowledge	24	3	8.0
Increased scientific / technical capability	22	3	8.1
Reduced development time	12	2	7.6
New / improved product	14	3	7.4
New / improved process	6	1	8.5
Cost savings / greater efficiency	7	2	7.4
Increased competitiveness	10	5	7.3
Increased sales	5	5	7.4
New / improved policies / regulations	12	8	8.0

*There were 29 individuals who responded to this question.

The respondents who said that the result will occur is made up of two groups. In some cases, projects have not been completed, in others the project has been completed and the result has not yet occurred, but is still likely to occur in the future.

This list of possible results reflects a progression from immediate to potential longer term results. It begins with the most immediate and likely results, being new knowledge and solutions to technical problems as well as increased scientific or technical capability being developed in or transferred to the client organization during the project. These results can be found for all types of projects with all types of clients. Increased organizational capability is a particularly desired result, as it leaves the organization in a better position to make its own technical decisions without continuing assistance. Of these three types of results, solution to a technical problem occurred least frequently in the survey population. This is likely due to the fact that some of the projects involved testing of broadcast components, an activity which is not associated with solving technical problems but rather

providing assurance that problems have already been solved and the system is reliable. In some cases, the Branch had also been involved in the earlier stage in developing the system to be tested.

The next group of results relating to products and processes occur further downstream from research and testing. While they can occur in public sector organizations, products in particular tend to be associated more with private sector organizations. The Branch is often associated with new and improved processes as a result of being involved in developing new testing methods and processes. The relatively lower rating for the Branch's role in product development reflects that the client organization typically take the lead in this type of project, with a concomitant reduction in the Branch's role.

The next three types of results (cost savings / greater efficiency, greater competitiveness, increased sales) are clearly related to private sector benefits, and are unlikely to be found in public sector related projects. This is partially responsible for the lower frequency. In addition, the length of time between R&D and the achievement of commercial results is probably responsible for the larger number of results which are expected to occur compared to have already occurred. Once again, the rating for the Branch's role is somewhat lower due to the continued involvement and leadership from the client organization for these downstream benefits to occur.

The final category of results reflects a different stream of results, namely public sector impacts. It is related to one of the main roles of the Branch, namely involvement in the development and testing of new and improved broadcast regulations and policies nationally and internationally. Many of the clients surveyed and projects identified relate in some way to this principal role of the Branch. The rating of the importance of the Branch's role is higher for this result due to the specific expertise and capability of the Branch in this type of project, and the reduced role for the client organization.

Respondents were also asked to identify any other results. Very few additional results were mentioned; the most frequent responses were directly related to Branch capability in testing and verification of new technology, a category not specifically included in the prepared list.

In addition to providing information about the results from a specific project, respondents were also asked to provide a more general sense of the value of the Branch to their organization. They were asked to rate the importance of the Branch to their organization's success on a scale of 1 to 10, with 1 being of no importance and 10 being of major importance. The average rating of the 19 respondents who answered the question was 7.3, with 5 giving a rating of 6 or below. This is not unexpected, as some clients and partners have several lines of business and broadcast related activities may be a relatively

small portion. In addition, while digital technology will be important for broadcast in the future, to date, it is not making a large contribution to current success. About one third of the respondents did not answer the question, in many cases due to the fact that their relationship with the Branch was personal, and related to standards development for the broadcast community and their organization was not directly involved in or benefitting from the project.

Case Studies

The case studies (**Annex D**) probed more deeply into the relationships among the participants and impacts of specific projects on the participants and the broader community. The individual case studies support the evidence from the client survey, identifying benefits at the partner organization level as well as the broadcast community level.

These case studies show the various ways research can influence policy and technological choices. In the case of the Ottawa field trial for single frequency multipoint broadcasting of digital radio, the case study demonstrates the pathway for research and testing of new technology to influence business decisions and be eventually accepted by the community.

Expert Interviews

These interviews confirmed that the evidence from the client interviews and case studies was representative of the types of benefits and beneficiaries associated with the Broadcast Technologies Research Branch programs and activities. Experts noted that the Branch had not been focused as much on helping equipment manufacturers, partially due to the fact that there are not many. With the advent of digital services, there may be more opportunities in this area. It was emphasized by several interviewees that the critical role played by the Branch in achieving these results was partially due to its reputation as a neutral, credible, reliable partner whose results can be taken as correct without question.

3.2.3 Conclusions

The beneficiaries of the Broadcast Technologies Research Branch fall into two major groups, public and private, reflective of the dual mission of CRC. They also include both Canadian and foreign organizations.

The first direct beneficiary is the Government of Canada, through the provision of technical support and advice to Spectrum Engineering and the CRTC for broadcast policies, standards and regulations. Spectrum Engineering relies on the Branch for these services, as there is no other Canadian source of equivalent capability. The indirect

beneficiaries are the Canadian public, through the provision of a technically effective, regulated public radio and television broadcast system.

The second beneficiary group is the Canadian broadcast community, made up of broadcasters, broadcast equipment manufacturers and service providers, who benefit from specific projects to solve technical problems as well as general advice and information.

Another group of public and private sector beneficiaries is the foreign and international broadcast community, made up of specific broadcast organizations and laboratories and the international broadcast standards and regulatory groups, principally ITU-R and ISO. Canadian public and private sector clients benefit from the Branch's activities with the international broadcast community.

Beginning with digital radio in the late 1980s, the Branch has been instrumental in the development and implementation of digital radio and digital television broadcasting technologies in Canada, benefiting both the public and private sectors. The majority of major technological changes in broadcasting have been introduced to Canada through the Branch. Branch clients and partners benefit through access to technical information, advice and assistance, test data provided by the Branch through collaborative and in-house R&D as well as participation in international broadcast standards and regulatory fora.

Clients receive important technical benefits from projects with the Branch. These include new knowledge, solution to technical problems, increased scientific and technical capability, new and improved products and processes, and reduced development time. These technical impacts often result in economic and organizational benefits, including cost savings, and in the case of private sector firms, increased competitiveness and sales. Public sector clients report new and improved policies and regulations arising from interactions with the Branch.

Exhibit 3-1 summarizes the various types of impacts and benefits which clients and the broader broadcast community receive, based on information from the case studies and client survey.

Exhibit 3-1: Impacts of Branch Programs

Project Incrementality (influence)	Direct User Impacts	Industry Sector / Supply Community Impacts	Economy / Societal Impacts
Involvement x helped in completing the project more quickly x helped in completing the project more thoroughly x helped do R&D that otherwise would not have been done x major role in project success s minor role in project success	Technical results x new or improved product x new or improved process x advancement of knowledge x increased technical capabilities s improved quality control s new skills internally 0 increased efficiency / improved productivity s technology transfer Policy / legislative results 0 policy behavioral changes 0 agreement / accord s legislative / regulation x acceptance of standards Commercial results s increased sales s increased market share s increased profitability s cost savings Organizational effects 0 increase in jobs 0 diversification 0 expansions s strategic alliances / partnerships 0 achievement awards / recognition	s production process efficiencies x increased science and technology information s increased sales 0 cost savings p changes to industry structure (e.g., concentration, competitiveness internationally) 0 spin-off companies x technology infrastructure (e.g., standard scientific and engineering data, industry standards, test protocols, and instrumentation) s training of technological problem-solvers whose talents can be applied in many areas x establishment of quality standards (audio/video subjective assessment)	0 reduced consumer costs 0 protection of environment 0 improved energy efficiency savings 0 improved public health and safety 0 education / awareness s public service efficiency gains s/p increased employment 0 reduction in subsidies

x = occurs often
s = occurs sometimes
p = potential (future)
0 = does not occur

3.3 *How effectively is the Broadcast Technologies Research Branch meeting Canadian public and private sector needs for information and advice about emerging television and radio broadcast technologies and systems?*

3.3.1 Context

Digital broadcast radio and television services have been, and will remain, emerging technologies for the next few years, and the Branch is focusing on various aspects of that technology. For that reason, much of the discussion in Section 3.1 on the continuing need for the broadcast research and testing facilities is relevant to this question in a general sense, and will not be repeated. Examination of this question will focus specifically on Branch effectiveness in meeting needs for information and advice. The discussion in Section 2.5 and Figure 2-3 are again relevant to this question. Provision of information and advice falls in one of the defined categories of services which can be provided to the client community. Incremental costs are relatively low and the number of recipients of the information can be quite large, including some outside the range of the more focused services. Access to strategic intelligence is highly valued in all organizations, and of particular importance in high technology sectors such as broadcasting. The advent of digital radio and television in this decade has placed particular importance on keeping up with new developments. As stated previously, with the significant downsizing and lack of in-depth technical expertise in Broadcast Engineering and most broadcasters, the role of the Branch in providing information and advice on emerging international trends in both standards and technology has become even more critical. The rapid changes and convergence of the many forms of telecommunications, in particular entertainment point to multipoint distribution, place additional pressures on the broadcast sector and the Branch.

The primary source of information used to examine this question is the client survey which provides the perspective of representatives of the Canadian public and private sectors. Additional information is taken from the expert interviews.

3.3.2 Detailed Findings

Client Survey

The client survey provided information directly related to answering this question. Respondents were asked whether the Branch helped make their organization aware of emerging trends. The majority (19) said yes and 8 said no. One respondent who said no, volunteered that he wished that the Branch would provide that service to his organization. The respondents who said that the Branch did keep them informed were next asked to rate both the importance of that help and how well the Branch does at keeping them aware.

As usual, a scale of 1 to 10 was used in both cases, with 1 being very low and 10 being extremely important or extremely well respectively. In the case of the importance, the average rating was 7.3, with 5 of the 19 respondents giving a rating below 7. The range of ratings is indicative of whether the organizations have alternative sources of intelligence. In some cases, they are partners with the Branch in international standards work or large organizations with their own mechanisms for remaining up to date. For some of these, the Branch provides an additional source for confirmation of their own information. In other cases, such as Spectrum Engineering, the various Canadian broadcast associations and many Canadian broadcasters, the Branch is needed as a source. These organizations rated importance highly. In terms of rating how well the Branch does at providing help, the average rating was 7.9, with 6 of the 19 respondents giving a rating below 7. While the number of respondents is low and the evidence is far from conclusive, a detailed examination of the responses suggests that clients working with the digital radio sector are more satisfied than those working with the television sector.

The survey also collected information on this question from other sources. In discussing weaknesses and making suggestions for additional services, several respondents identified the need for better communications with industry. There were suggestions for an annual Branch newsletter identifying major Branch activities and providing strategic intelligence on some aspects of emerging issues in digital radio, television and other related telecommunications. An improved use of the CRC web-site was also suggested.

Staff Interviews

Staff reported that the Branch considers sharing information on emerging issues part of its responsibilities. Groups have a number of methods of sharing information. For example, they share technical information with Spectrum Engineering directly and with the Canadian broadcast community through various committees and associations such as DRRI, CDTV and JTCAB. Conference presentations, technical and scientific papers, and workshops are also used.

Information from other CRC staff, discussed in Section 4.3 which follows, suggests that other CRC Branches would value knowing more about Branch projects and initiatives, and strategic intelligence received from international standards meetings and other sources.

Expert Interviews

A number of experts spoke about the importance of the role of sharing strategic intelligence with stakeholders. The general sense is that BTRB seems to be doing a good job with major clients and partners with whom it has established relationships. Members

of the broadcast community who are less directly connected to the Branch do not seem as well informed.

Peter Shelswell, from the BBC Research and Development Laboratory, spoke about the importance of communicating with stakeholders about general capabilities as well as current priorities and projects of his laboratory. As an example of proactive communication and marketing, his laboratory has recently held what it called "open days" where it opened the laboratory to visits from their major stakeholder groups. One day was for other BBC colleagues, another for university and other non-industrial laboratories, and a third day for industry. Each day, the laboratory had a program of presentations about current and just completed projects in-house and with partners as well as tours of facilities and demonstrations of tests. Over 100 people visited the laboratory over the three days. Including preparation, this initiative was very time consuming, but Mr. Shelswell considered it to be a great success.

3.3.3 Conclusions

Evidence shows that the Broadcast Technologies Research Branch is working effectively to keep major clients and organizations with which it has a continuing relationship aware of emerging issues in broadcast technologies and systems. The Branch works closely with Spectrum Engineering and major digital radio and television stakeholders to ensure they have up-to-date information. However, it is clear that the broadcast community values strategic intelligence highly, and some interviewees suggested that the Branch make additional efforts to provide strategic intelligence to the broader broadcast community which is not as well connected to the Branch. Suggestions included a periodic newsletter with information about Branch projects and priorities, a more informative web-site, workshops and periodic open houses for the broadcast community and other interested groups including other CRC staff.

3.4 In what manner does the Broadcast Technologies Research Branch contribute to the mission of CRC?

3.4.1 Context

The mission of the CRC is:

- to be the federal government's Centre of Excellence for communications R&D ensuring an independent source of advice for public policy; and,

- to help identify and close the innovation gaps in Canada's communications sector by engaging in industrial partnerships, building technical intelligence and supporting small and medium technology enterprises.

The work of the Broadcast Technologies Research Branch will be examined in terms of its relationship to both aspects of the CRC mission statement. The analysis will not include new evidence, but will draw to a large extent on evidence and discussion from the other sections related to the issue of relevance.

3.4.2 Detailed Findings

Evidence presented in Section 3.2 on benefits and beneficiaries is pertinent to this question. The role of the Branch in providing Spectrum Engineering with technical information and advice to support public broadcasting policy and regulations, and spectrum allocation is directly aligned with the first part of the CRC mission statement. Comments from the client survey identify the Branch's major role in the development and testing of international standards and its strong technical capability as important strengths which make it a desirable partner for private sector firms. The Branch's participation in international standards organizations work is also an important factor in keeping the Canadian government aware of emerging technical and political issues relating to broadcasting, and helping ensure that government policies and regulations are consistent with international standards.

In terms of its role as a Centre of Excellence, many clients say that the Branch is a unique source within Canada with the technical expertise, equipment and facilities, credibility and reputation required for a number of the projects. Loss of access to the Branch's services would have caused major negative impacts for many of the projects, ranging from time delays and greater costs to inability to proceed. One international expert stated that the Branch was considered internationally to be one of a small number of centres of excellence in specific aspects of broadcast research and standards development.

Section 3.3 focused on the role of the Branch in providing strategic intelligence on emerging technologies. Those discussions will not be repeated here. However, the Branch's participation in digital radio and television broadcasting sector associations (DRRI and CDTV) is an example of how the Branch's technical expertise in digital communication is made available to Canadian industry, how that the broadcast industry is kept aware of international development, and conversely that the government is aware of broadcast industry initiatives. This role is directly linked to CRC's mission to build and share technical intelligence.

Detailed discussion in later chapters on the issue of the quality of Branch research and services (Ch 5.0) shows clearly that clients and collaborators rate the quality of Branch capabilities and services highly, both in terms of development of new knowledge and application of existing knowledge. In fact, information from staff and expert interviews shows that the Branch was a major factor in developing the recent successful partnership between the government and broadcast industry in cooperating on the technical aspects of the introduction of digital radio and television.

Evidence also shows that the Branch supports small and medium broadcasters through the broadcast industry associations, small and medium sized broadcast equipment manufacturers, and broadcast engineering and consulting firms in a number of ways.

3.4.3 Conclusions

It is clear that the strategies and priorities of the Broadcast Technologies Research Branch are closely aligned to the mission statement of the Communications Centre, and that the Branch is helping achieve the CRC mission. All major projects and initiatives can be shown to provide either public policy advice or support to the Canadian broadcast industry. In fact, many Branch projects have contributed to both aspects of the mission statement through working with the public and private sectors collaboratively to achieve technical objectives. These interactions have helped forge a link between public and private sector groups within the broadcast community, leading to a more cooperative, effective working relationship.

3.5 Is the Broadcast Technologies Research Branch within CRC filling an appropriate role for government?

3.5.1 Context

This question is, to a large extent, a comparison between the present strategic positioning of the Branch and government policies on the role of government research agencies. To address the question, this study will examine a number of policy documents and studies, and review Section 3.2 on beneficiaries and benefits as well as relevant information from expert interviews.

3.5.2 Detailed Findings

Document Review

In its 1996 review of government S&T entitled "Science and Technology for the New Century", the government identified three interrelated goals as the focus of future federal S&T activities. They are:

- the application and commercialization of S&T to create jobs and economic growth;
- using S&T to improve the quality of life and social well being of Canadians; and,
- achieving and maintaining excellence in the advancement of knowledge.

These three objectives can be restated in terms of using S&T to support industrial development and economic growth, including support for individual private firms, using S&T for public good through improved policies and services to the public, and continued creation and development of knowledge, particularly to support the achievement of the first two goals.

As well as these three goals, the government also identified a number of operating principles in its 1996 review. One of specific interest to CRC and the BTRB is: positioning Canada competitively within emerging international regulatory, standards and intellectual property regimes.

Another document relevant to this question is the recent study by the RAND Critical Technologies Institute in the U.S. entitled "New Forces at Work: Industry Views Critical to Technology". This study collected the views of major U.S. industrial firms, who identified the government role in supporting S&T as:

- funding higher education and basic research;
- supporting basic research in high risk research;
- supporting pre-competitive R&D in targeted areas; and,
- ensuring an economic, legal and regulatory environment conducive to innovative activity.

This role is similar to that proposed by Dr. Gregory Tassey of the National Institute for Science and Technology (NIST) in the United States. As part of his work, Dr. Tassey has developed a descriptive model (shown in **Exhibit 3-2**), which describes the role played by S&T activities in a modern innovative economy. The model shows the relationship

between knowledge creation, development of that knowledge into generic pre-competitive technologies, through to firm specific proprietary applications processes and products. As well, there is a parallel stream, with new knowledge developing into standardized test procedures and measurement methods (infratechnologies) used as common standards and protocols to provide assurance that technical systems operate as intended and agreed upon. This second stream is the means by which government standards designed to protect the public interests are utilized.

3.5.3 Conclusions

Based on an examination of the federal government objectives for S&T and a review of other countries' science policy, the objectives and activities of the Broadcast Technologies Research Branch are well positioned to support a number of roles appropriate for a government research agency. These include research and development, technical support, testing and advice:

- to the Canadian and international broadcast standards and regulatory community, in support of the public interest and social well-being of Canadians; and,

- to the national and international private broadcast sector, including broadcasters, telecommunications equipment manufacturers, and consultants, in support of a viable broadcast industry, wealth creation and economic growth.

In particular, the Branch is recognized as a neutral, credible source of scientific data and analysis on broadcast issues and can be relied on to present a technically accurate, unbiased perspective. The Branch is strongly supported in undertaking these multiple roles, by both public and private sector stakeholders, who recognize their common interests in this area.

While the primary role is in support of the various public and private dimensions of the Canadian broadcast sector, working with American, European and other national organizations enables the Branch to influence the development of the North American and international broadcast sector and provide strategic intelligence to the Canadian broadcast sector about emerging issues in other jurisdictions.

The Broadcast Technologies Research Branch performs a number of complementary roles in support of both public and private sectors. First and foremost, the Branch provides support to the Canadian broadcast policy and regulatory system through its relationship with Spectrum Engineering. This is linked to the "quality of life and social well-being" goal of the government. The Branch's support to Spectrum Engineering and its role in developing national and international standards and regulations are also directly linked to

the RAND objective of "ensuring an economic, legal and regulator environment conducive to innovative activity". Lastly, the Branch's role is consistent with current international thinking on the role of government in the modern innovation system. Like the U.S. National Institute for Standards and Technology, the Branch is involved in developing infratechnologies, standards and test methods to ensure that new technology meets accepted standards and that all parts of the system are compatible and will operate as intended. This issue of compatibility is very important in a complex innovative society. The Branch performs that role on behalf of the government for the benefit of both public and private sectors.

3.6 Relevance - Summary

It is clear that the Canadian government expects its scientific laboratories to fulfill a dual role, in support of both the public interest and economic growth and wealth creation. This is reflected in the CRC mission statement. These two roles can be complementary, particularly in the case of standards and regulations. In the case of broadcasting, the social and cultural well being of the public needs to be supported through an efficient, effective, and accessible broadcast system and the private broadcasters need appropriate standards, regulations, and technical assistance which help them develop and provide a quality broadcast system. Policy studies support the role of government S&T as providing technical support to the development of national regulations and standards compatible with international systems. Neutral independent testing of systems is also recognized as an important role for government laboratories, free from commercial interests and influences. The Branch fulfills this role for the Canadian Broadcast community.

The need for Branch capabilities is particularly acute at the present time. As digital broadcasting is being implemented, there are many demands for new standards, regulations and testing as well as technical assistance to implement the new technology. The Canadian broadcast industry has lost much of its technical capability through downsizing and in many cases, the Broadcast Technologies Research Branch is the principal remaining source of expertise and knowledge about this technology in the country.

A review of Branch programs and projects, analysis of clients and collaborators, and feedback from the client survey, staff and expert interviews show that the Branch is effectively fulfilling these complementary roles, supporting both public and private interests within the Canadian and international broadcast community. In fact, the Branch has been credited with helping draw these two stakeholder groups into a closer, mutually beneficial relationship with respect to Broadcast technology, particularly digital radio and television. In addition to R&D and technical advice and support, the Branch is valued by

its clients and partners for providing other types of services, such as information, advice, and strategic intelligence.

Evidence points to the effectiveness of the Branch in providing relevant technical support to the broadcasting community, particularly Spectrum Engineering and broadcasters. Testing services and technical advice are particularly appreciated.

While the Branch is seen by the community as working in a highly relevant, effective manner, additional needs were identified to which the Branch can make a contribution. For example, in addition to the testing, technical assistance and advice provided, clients and other sources suggested that the strategic intelligence which the Branch obtains from international broadcasting standards meetings and other sources is valued highly. It is an important asset which many feel should be utilized more effectively. A number of members of the broadcast community interviewed would like the Branch to make a greater effort to make them aware of technical developments and other emerging issues on a regular basis.

As discussed previously, another emerging need in the broadcast community is for highly qualified personnel with experience in digital broadcasting technologies. A number of the skilled staff of the Branch have been hired away to fill these needs in other organizations. There was a suggestion that the Branch work with industry to develop a more formal role for the Branch in providing support for the training of personnel for industry while also providing additional staff for Branch research and development programs.

3.7 Relevance - Recommendations

3.7.1 Communications and Awareness

The Branch should move to address the need in the broadcast community for improved access to strategic intelligence on technical developments and emerging issues. Communicating with the broader broadcast stakeholder community about Branch initiatives and perspective on emerging issues should become a higher priority, and the Branch should develop new methods to complement those already in use. A number of opportunities exist, including:

- regular open houses and workshops, possibly aligned to the specific needs of various stakeholder groups (broadcasters, broadcast equipment manufacturers, service providers, university and other broadcast researchers);

- periodic (annual or semi-annual) newsletter, with information about Branch projects, strategic intelligence from international meetings; and,

- improved, up to date web page, with basic information about the Branch priorities, as well as similar information as in the newsletter described above.

It is likely that a combination of approaches will be more effective than a single one.

3.7.2 Training of Highly Qualified Personnel

In order to help meet the need for highly qualified personnel in the broadcast industry and to attract young researchers to work on broadcast research priorities, the Branch should work with the broadcast community to develop creative, new methods for bringing young people into the Branch to work on projects of interest to both the Branch and industry. Possible methods include:

- co-op students hired by firms working in Branch laboratories on projects of mutual interest;

- broadcast association funding of post graduate research;

- collaborative projects with the NCIT' of interest to broadcasters (i.e. broadcast and multimedia technologies;

- secondments of broadcast industry technical staff to Branch; and,

- making use of the NSERC Research Partnerships Agreement program to identify and fund relevant, high quality research projects involving partnerships between CRC and private sector partners.

The Branch should develop a proactive approach to addressing this issue, linking with other stakeholders in the research and broadcast communities, such as NSERC and the Canadian Association of Broadcasters.

3.7.3 Maintain Multiple Complementary Roles

It is clear that the Broadcast Technologies Research Branch is uniquely positioned to meet needs of both the public and private sectors within the Canadian Broadcast community and that insight into the needs of one group contributes to the Branch's ability to meet the needs of the other. The Broadcast Technologies Research Branch should continue to maintain a balance among its various roles, providing technical support and services to meet both public and private sector needs in a complementary manner. The provision of high quality technical support for Canadian broadcast policies, standards and regulations in the public interest also helps provide the private broadcast community with an efficient effective regulatory infrastructure within which to work. Similarly, the Branch's support to meeting the technical needs of the Canadian broadcast community, including broadcasters, equipment manufacturers and service providers, helps the government remain aware of and focus on the needs of the private sector as well as the public in developing broadcast standards and systems.

4.0 *Management*

Issue 2: Is the Broadcast Technologies Research Branch being managed effectively?

The Broadcast Technologies Research Branch was formed in April 1998 from an amalgamation of the existing radio and TV groups, during a reorganization of CRC. In addition, the management structure was flattened, with one level of management (directors of the radio and television groups) being removed, leaving one overall Vice President and managers for each of the four Branch groups. One of the former directors is the new Branch Vice President in an acting capacity. This is important background to the examination of this issue.

As for the other review issues, Branch management was addressed by examining a number of specific questions. In gathering evidence to respond to these questions, additional information not directly related to these questions but pertinent to the main issue has emerged. In order to address these additional points, a fifth question has been added under this issue:

- What other factors are involved in the effective management of the Branch?

Much of the discussion under this issue is focused on management internal to the Branch, however, some information and discussion relates to the broader CRC level management situation.

Most evidence to address the questions under this issue comes from staff interviews and Branch internal documentation. Additional input to address Section 4.4 on the proper mix of activities within the Branch comes from the client and collaborator survey and expert interviews. Some information from the client survey is also relevant to Section 4.5.

4.1 What mechanisms for strategic and operational decision making and resource allocation are being used within the Branch?

4.1.1 Context

Management of S&T programs has recently emerged as a new focus within the government of Canada. The 1996 government review of S&T review identified the need for new approaches to governance and improved consultation with stakeholders. As well, the Industry Portfolio has made a commitment to providing greater attention to the management of S&T, including development of results-based management and ongoing monitoring and review of performance.

These government and portfolio level policy statements imply more proactive program performance measurement, management, and reporting at the organizational and program levels. This includes a more integrated approach, with resource allocation and project selection decisions being tied more directly to planned outputs and outcomes, with a balance between bottom-up and top-down decision making and management. The Branch's current approach will be examined in light of this new environment.

4.1.2 Detailed Findings

Staff Interviews

Branch manager and staff interviews suggest that there is an informal, distributed system of resource allocation in the Branch, largely based on the levels of the previous year. However, with the joining last year of the radio and TV groups which had been under two different directors previously, there was some realignment in the allocation procedures. After the groups were integrated last year, A-base operational resources for 1998-99 were distributed on the basis of the number of permanent staff in each group, with little or no modification to support priority initiatives or special circumstances.

At least one group, Digital Radio Broadcast Systems, which had previously received additional funds to support the efforts of a relatively large number of contract and other nonpermanent staff, had its resource level reduced significantly. Some adjustments were made after representations. The Branch does not seem to have a reserve fund or an ability to reallocate funds between groups during the year to take quick advantage of opportunities or changing priorities, other than reallocation within each group by the group manager.

In terms of operational and strategic decision making, information gathered in staff interviews suggests that most responsibility is distributed to the four group managers and

their senior scientific and engineering staff, who have significant freedom to operate within their own domain, in keeping with the broad guidelines established over the years. There is little evidence of an integrated Branch level strategy tied to resourcing levels. In fact, the four groups seem to be operating fairly independently at the present time.

As an example of different interpretation of general guidelines, interviews with managers and staff in each group indicated that each group has a different strategy regarding revenue generation and cost recovery. One group said that it focused on large contracts with non-Canadian organizations to generate revenue, and charged Canadian firms less or nothing; another said that it treated all potential contracts alike, with no differential pricing.

Some staff, particularly those below the manager level, commented that while they understand their specific role within the group, they feel isolated and uncertain about their role and that of their group within the Branch. Between the time the Branch was formed in April 1998 by the joining of the radio and TV groups, and the time of the interviews in April 1999, interviewees reported that there had been no Branch meetings. (A meeting was held in mid June 1999.) A number of interviewees were puzzled why no Branch meeting had been called, as they felt that one or more meetings would help the groups to grow together into a Branch level team.

At the CRC level, the President has recently created a President's fund of about $400,000 annually, with resources provided from a percentage of all O&M funds within CRC. A few strategically selected new initiatives are funded. In the first year, a new Wireless Test Bed and Networking Initiatives were the main choices. The Branch did receive funding for one proposal from the Advanced Video Systems Group. Most Branch staff who commented on this point were unhappy that their funds had been taxed for this initiative and seemed unconvinced that the projects selected were good choices. They were also unclear as to what selection criteria had been used to make the selection.

4.1.3 Conclusions

Evidence available from staff interviews suggests that the management style within the Broadcast Technologies Research Branch is largely informal, in keeping with the general approach in CRC. With notable exceptions, resource allocation and most decisions seem to be made at the group level, based on past practice and confirmed at the Branch level. Groups seem to operate largely independently, with differing approaches, cooperating where operationally useful. It was suggested that the clients and projects of the four groups are largely independent of one another, limiting the need for collaboration and interaction. The Branch has been together for only one year, and there did not seem to be any evidence of the development of an integrated Branch level strategy.

4.2 *What approach does the BTRB use for monitoring and reporting on performance?*

4.2.1 Context

In response to pressures from Parliament to know more about the performance of government programs, a new Parliamentary Estimates and Reporting system was introduced several years ago. Departmental Estimates are provided to Parliament yearly in March in a Report on Planning and Priorities (RPP). These requests for funding for the upcoming fiscal year are now required to identify and specify more clearly the intended outcomes of programs. In addition, each Department and Agency is required to produce a Fall Performance Report six months after the end of the fiscal year, which is intended to report on progress achieved, based on objectives identified in the RPP of the previous year. The Fall Performance Report is intended to provide a picture of the overall performance of the organization, linking strategies, activities, outputs, with information about the beneficiaries and the results and impacts achieved. In most organizations, an overall performance report is developed from performance reports provided by the various lower level organizational units. The performance framework, shown in **Exhibit 2-2**, is based on the approach developed for the Industry Portfolio S&T Management Committee, and accepted as the basis for S&T performance reporting within the Portfolio. Current practices will be compared to this approach.

4.2.2 Detailed Findings

Document Review

The 3rd quarter 1998 VP Broadcast Technology Report was examined from the point of view of performance reporting. It was found to be a typical research progress report of the old school, focused primarily on activities (i.e., new projects started, progress made, organization visited) and outputs (i.e., journal papers, conference proceedings, contract reports). There was no mention of Branch objectives, or the rationale for specific projects in relation to group, Branch or CRC objectives or strategies, or of the rationale for working with specific clients or the results of specific projects.

A review of the CRC Third Quarter 1998 Summary Report suggested that other Research Branches and groups within CRC also report primarily on activities and outputs. The sections by some of the Corporate Groups, including the Marketing, Operations and Office of the Comptroller present a somewhat more balanced picture of performance as they provide some references to the objectives of particular activities.

Staff Interviews

When asked about the mechanisms used for monitoring and reporting on performance, most Branch staff made reference to the quarterly reporting system which is standard within CRC. Each Group manager writes a quarterly report, which is integrated into a Branch level report, complete with Executive Summary, provided by the VP as Branch input to the CRC Summary Report. When asked, no interviewees could identify any use being made of the reports, as to their knowledge, no feedback was being provided to the groups or Branch. Some staff questioned the purpose and value of the reports, as they did not seem to serve any management function other than to provide evidence that quarterly reports were written. No other mechanisms for monitoring and reporting on performance were mentioned, except for informal interactions between managers and staff.

Interviews with other CRC staff indicated that following the tradition of most government research laboratories, CRC focuses largely on research quality, with less attention to examining the utilization of the research capability and results which occur at the individual client and partner level due to interactions. It was noted that the transition from a management approach focussed on resource utilization, activities and output based management approach to a more balanced performance based one which includes attention to the reach and impacts of activities is a difficult one for research organizations to make. While there is powerful anecdotal evidence of the impacts of the Broadcast Technologies Research Branch and other branches of CRC, the organization has not moved to develop a more formal system of measuring impacts and results systematically.

One person commented that the most complete reports on organizational performance are often contained in the personal performance reports of group managers and VPs, as they are responsible for groups under them. These reports are part of the human resources management procedures and are not public. The study was unable to confirm this observation as there was no access to these reports.

Another member of Branch staff stated that the CRC approach to monitoring performance is closely linked to research quality, a key factor in staff reward systems. This is particularly true for staff in the Research Scientist classification (RES), which focuses on the individual's ability to produce high quality research. While this is an important factor, there are many other dimensions to performance as mentioned previously, including utilization of research and service to clients.

4.2.3 Conclusions

Based on information available, monitoring and reporting on performance within the Branch seems largely informal. The Branch does use quarterly activity reports as its primary formal mechanism for reporting to senior management on performance, however, there is little or no feedback provided, and no indication that they are used. Other methods are linked to performance of individuals rather than groups or the Branch.

This minimalist approach, while traditional, is contrary to the commitment of the Industry Portfolio and its member organizations to a more proactive management approach. It does not respond to increased pressures from central agencies and the government S&T priorities for an effective demonstrated capability for measuring, managing and reporting on performance.

4.3 What is the nature and extent of collaborations by the Branch within CRC and with other organizations?

4.3.1 Context

CRC was reorganized last year into five branches, each with a Vice President. The branches are:

- Broadcast Technology Research;
- Broadband Network Technologies;
- Radio Science;
- Satellite Communications; and,
- Terrestrial Wireless Systems.

The nature of collaborations between the Broadcast Technology Research Branch and other branches and corporate groups will be examined. Also, collaborations between the Branch and organizations external to CRC, including universities, other government laboratories, and private sector laboratories will be reviewed. Primary sources of information for the analysis include document review and staff interviews.

4.3.2 Detailed Findings

Document Review

Analysis of the 3rd Quarter 1998 Activity Reports for BTRB and other Branches of CRC identified a small number of collaborations with other Branches of CRC and other organizations, which are listed below.

Internal to CRC

- adaptive directional DRB receive antenna; and,
- CRC Wireless TestBed - TV Systems and Transmission Group provided advice to the Broadband Wireless Branch on purchasing equipment for the new terrestrial wireless testbed, and collaborated with the Branch on a contract for Newbridge to conduct CMS measurements at 2.5GHz.

External

- with the Australian government on collection of data on use of CRC-DATAQ; and,
- with INRS and IMAX on NSERC Strategic Grant for research in 3 D video imaging.

A review of the client and project list discussed in Section 3.2 (**Annex B**), reveals a number of projects with external colleagues which have at least some dimensions of collaborations. These include the work with Dr. Chris Herdman, now mostly completed, on psycho-physical aspects of viewing videos. Several of the projects with international broadcast research laboratories in Europe involved collaborations related to the development and improvement of digital radio broadcast systems and related standards.

A review of joint authorships of Branch publications over the past few years also revealed a number of collaborations between Branch staff and staff from other branches of CRC as well as those external to the organization. These included several with other branches of CRC, one with the University of Western Ontario, several with the National Research Council of Canada and several with other Branch partners and clients already noted in **Annex B**.

Staff Interviews

Evidence from staff interviews suggests that most collaborations between the Branch and other CRC branches are informal and occur between staff members as required to exchange information. In fact, revenue generation pressures discourage collaborations, unless in the form of a subcontract or directly linked to Branch objectives, as helping another branch can mean using A-base resources to help achieve the objectives of the other branch. Many of the collaborations identified through document review were also mentioned during the staff interviews. Collaborations with the CRC antenna group are quite common, although not continuous. One example of a successful collaboration with another CRC branch (through a subcontract) can be found in the case study on the 1997 satellite DAR test. In this case, the Propagation Group in the Radio Sciences Branch worked effectively with the Branch radio groups to complete an important project in a short time. However, in another circumstance, attempts to have the same group collaborate in the development of CRC-COV were unsuccessful. It was noted in both branch and other CRC staff interviews that collaborations between applied and science-based branches are a particular problem, as their overall objectives do not match well.

Non-branch CRC staff interviews confirmed that most branches are relatively independent and work primarily with external clients and partners, not together. It was pointed out that this leads to the well known 'stovepipe approach', where individual groups within an organization are effectively separate mini-organizations, each with its own separate objectives and strategies. One person commented that it is difficult to identify an overall CRC strategy, other than the sum of the separate parts. Most staff are generally unaware of work in other branches. One suggested way to counteract this trend would be for each branch to have a 'show and tell' day or workshop, to present and discuss the main aspects of its programs to other branches. CRC had such an initiative, but it was cancelled two years ago. It was also pointed out that branches wishing to establish long term collaborations with others in areas of mutual or complementary interest should give as much notice as possible to potential partners, in order to allow them to adjust their research schedules.

Branch staff interviews and the document review identified the NSERC Strategic Project of the Advanced Video Systems Group as an important collaboration involving the Université du Québec Institut national de recherche scientifique and IMAX. Further information on this collaboration is available in the case study on 3D. Dr. Lew Stelmach of the Advanced Video Systems Group and Dr. Yiyan Wu of the Advanced TV Systems and Transmission Group are both adjunct professors at Carleton University. Through their linkage to Carleton, the Branch has access to graduate and post-graduate students who participate in research related to Branch interests. Dr. Herdman of Carleton University has collaborated with the Advanced Video Systems Group for a number of

years and provided test subjects for subjective viewing tests. The Digital Radio Broadcast Systems Group has no long term collaborations with universities. It attempted to develop a collaboration with Laval University several years ago which was not successful and is presently trying to build a relationship with Carleton University.

4.3.3 Conclusions

The Branch has a significant level of collaboration with other public and private broadcast and telecommunications laboratories, usually in the areas of development of new standards and testing procedures related to new developments in digital broadcasting signal processing, transmission, and subjective testing.

However, there is less evidence of collaborations with other CRC Branches. Most collaborations are informal, and at the level of individual staff members, or through subcontracts which provide funding. While the President has recently instituted an initiative to encourage interbranch collaborations through additional funding of specific projects, this initiative has not yet had significant impact on the Branch.

The Branch has some formal collaborations with groups within other branches of CRC, and others with local and other universities. The adjunct professorships of Branch staff are instrumental in the local university-based collaborations, and help provide access to basic research knowledge.

4.4 Does the Broadcast Technologies Research Branch have the proper mix of strategic and collaborative research, development, testing and applications? Are the resources being used in the most appropriate areas?

4.4.1 Context

Depending on the approach and resources available, this question could be examined at a macro or micro level. For this review, the analysis of this question will be at an overview level, as the resources and evidence available do not support an in-depth study of the specific activities and projects of the Branch. Little specific information on the various activities and projects was available for the review. Primary sources of information are the expert interviews, client survey, and staff interviews. Of these, staff are most aware of the details of the group operations and have the most informed perspective.

CRC has set a target of 20% for revenues as a percentage of A base funding. This is considered by CRC corporate management to be an appropriate level of revenue producing testing and contract work. Review of Branch financial data shows that revenues

and special funds accounted for 17% of Branch resources in 1998-99, which is close to the 20% target set by the President.

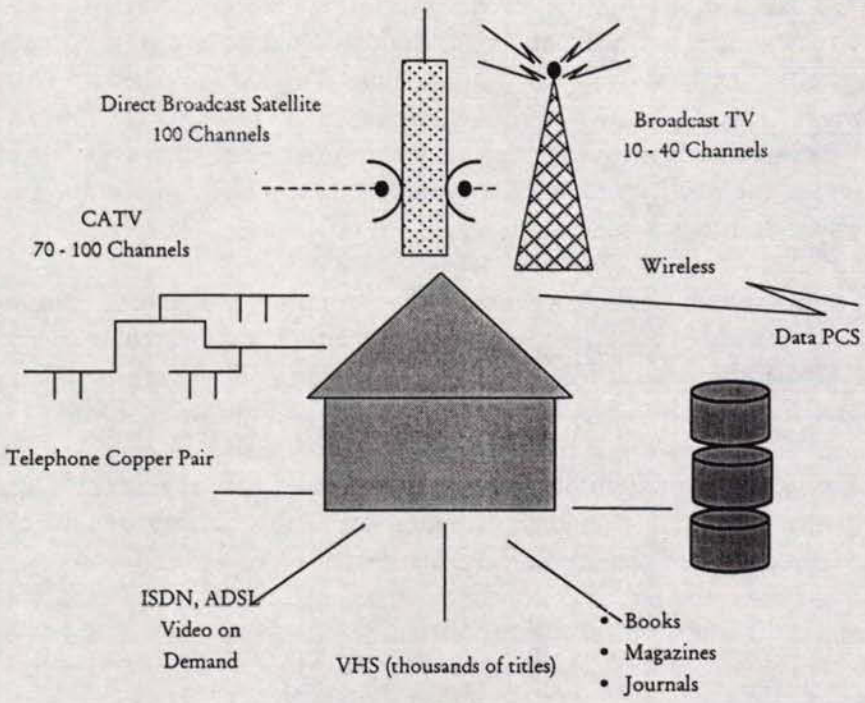
4.4.2 Detailed Findings

Expert Interviews

Broadly speaking, experts interviewed were not aware of the detailed workings of the Branch and could only judge the question from their limited perspective. Most felt that the groups in the Branch were generally current with the state of knowledge in their respective subject areas, fields and in fact were at the leading edge in some specific subjects. As well, they were aware that the Branch is working closely with Spectrum Engineering and the international standards groups as well as providing technical support and testing for the Canadian broadcasting community.

In terms of addressing the question of in what areas the Branch should be focusing its resources, several experts spoke of the integration of telecommunications systems and approaches, and the need for the Branch and the rest of CRC to work collectively to support emerging demands. Jacques Lyrette referred to several presentations he had made when he was President of CRC on analysis of future trends and developments. **Exhibit 4-1** is an example of this material, which describes the current environment in broadcasting and the broader telecommunications world. The Branch needs to study the general situation and likely emerging needs of the Canadian broadcasting sector and the greater telecommunications sector carefully in order to make some important decisions on what directions to pursue in order to decide on new projects and allocation of its strategic research funds.

Exhibit 4-1*
An Increasing Variety of Multimedia Data Sources



No Single Channel Will Dominate

* Provided by Jacques Lyrette (former President, Communications Research Centre)

Comparable Programs

In examining the BBC Research and Development Department and its role within the United Kingdom, there was some interesting information about standards bodies with which it works. It seems as though from its perspective, ITU is becoming less and less useful for some types of standards development. In its opinion, ITU is losing its dominant position and ISO is becoming more important as a broadcast standards body. This is partly due to the fact that ITU accepts multiple standards for the same situation, in some measure defeating the purpose of standards. ITU standards development also takes a very long time. The Branch has been aware of this situation and is working to make the ITU-R more effective through discussion on several initiatives. These include minimizing the number of acceptable standards and bringing additional aspects of broadcasting (i.e. cable TV) under the ITU-R. The ITU-R allows Canada to have significant influence in the development standards and use of spectrum by its role as "honest broker" between Japan,

the U.S. and Europe. Depending on the outcome of these discussions, the Branch may have to adjust its strategy related to international standards development and its role in ITU-R.

Client Survey

As the survey was designed to address the review issues and questions, the individuals surveyed were asked directly whether the mix of activities was appropriate. Like the experts, their awareness of the details of Branch operation was minimal. This was reflected in the fact that one third of respondents (9 of 27) said that they did not know enough to answer that question. Of the remaining 19, 18 said that the branch does have a good mix. The one dissenting person said that the Branch did have a good mix previously but no longer, as the quality of staff has diminished recently, and the ability to sustain a high-level research effort has been reduced.

A number of respondents also offered further comments. Several cautioned against moving too far towards research, saying that fundamental research is the role of other organizations, with the Branch focusing on applying and developing that knowledge, and sharing it with the public and private sector broadcast communities. One person observed that the Branch does not have many links with universities to access basic knowledge for use and application. Finally, another respondent noted that the Branch is able to take advantage of situations like the Ottawa digital radio test facility and combine applied research, development, and testing on the same system.

Staff Interviews

Branch staff were also asked to comment on the strategic mix of research in their groups. The radio groups, in particular the Digital Radio Systems Group, identified a need to move their balance towards more research, with a little less short term contract and other client services. As mentioned previously, the group is making efforts to increase its linkages with university-based researchers.

Other CRC interviewees suggested that the TV groups should increase their efforts towards working with clients directly to utilize existing knowledge, with a little less effort to building new knowledge. This would include increased efforts at making the community aware of their capabilities through increased attention to marketing opportunities.

These two perspectives demonstrate the difficulty in deciding on the best mix. The outside world is extremely positive about the relevance, quality and quantity of the work of the Digital Radio Systems Group and its value to the broadcast community, whereas

interviewees from the group stated that they perceive that they are not investing enough in renewal through research. Conversely, based on interviews, the TV groups are relatively content with their present mix, but some other CRC staff feel that they should reallocate some of their research effort to the utilization of their present capabilities, marketing themselves and working on short-term client-focused projects. Clearly the best mix of development and utilization of capability and expertise is difficult to determine. It should also be noted that digital radio and digital television are at different stages in their development. Digital radio is much closer to the marketplace, while digital television is still in the early stages of development and testing. These factors influence the mix of research and testing services appropriate to the circumstances.

There is another factor involved in staff perspective on the best mix. This involves staff classification categories in the federal public service. Individuals in the RES category are expected to focus on research, and the promotion and reward structures are oriented towards research quality and output. Alternatively, those in the engineering classification (ENG) are more focused on applications and utilization of knowledge to meet clients' needs. While this study did not examine in detail the relative balance among staff between these two categories in all Branch groups, it appears that the TV groups have relatively more RES staff and the Digital Radio groups have more ENG category staff. This is possibly a factor in the relative mix of activities between the TV and radio groups. However, this factor is likely to be a bigger consideration if the main management approach is laissez faire and bottom up. Branch management should be able to adjust the mix based on an informed strategic perspective on the appropriate balance, and hire the appropriate staff for the requirements.

In examining the strategic mix of activities, there was considerable discussion about the effect of CRC-COV on the Radio Broadcast Systems Group. As shown previously in **Table 2-1**, this group receives about $200,000 annually in contract revenue, most of it associated with CRC-COV, a software package designed to determine the signal coverage pattern for broadcast transmitters. CRC-COV has been a very successful source of revenue for the group. At the present time, a relatively old DOS version is complete, and a new improved WINDOWS version is under development. The WINDOWS version will have many options covering a wide variety of situations. A European firm is working with a beta version of the WINDOWS version and is sharing the results with the group as it continues to modify the package. There has been considerable interest, led by the technology transfer group within Corporate Marketing, in licensing CRC-COV to a Canadian consulting firm with business in this area. However, the Radio Broadcast Systems Group has continued to improve and develop the software, incorporating new developments. Development of CRC-COV and doing the contracts associated with it takes a considerable amount of the available time of the group. It was suggested that the group should move quickly to finalize a basic WINDOWS version of CRC-COV for use

in the conventional digital radio and TV systems coming on stream and licence it to a Canadian firm with expertise in this area. After helping the firm learn to use the software efficiently, the group would then be freed up to work on other things, including developing CRC-COV for other specialized situations, and continue its work on other related software applications, as well as the other aspects of its business.

4.4.3 Conclusions

Clients surveyed were generally satisfied with the Branch mix of research, applied projects, contract and testing, based on their generally positive opinion of Branch capabilities and services. The Branch has made good progress towards reaching the CRC goal of 20% for revenue generation, indicating a significant level of contract and project work which clients and partners consider highly valuable and applicable to their immediate needs. Interviews with Branch and other CRC staff suggest that the Digital Radio Systems Group should move the balance towards more research and a bit less contract and client service work, while the TV groups should consider moving the balance towards more client specific activities. With the recent formation of Canadian Digital Television Incorporated, there may be more requests for specific client services from the TV groups.

It was suggested by some interviewees that the Branch license a user friendly WINDOWS version of CRC-COV as soon as possible, thereby transferring this successful technology and helping a Canadian firm create new business opportunities, while receiving royalty payments and freeing up resources for other priorities. The Branch should continue to make available to the broadcast community specialized services using the general multicapability version of CRC-COV in those cases requiring the highest level of expertise.

4.5 What other factors are involved in the effective management of the Branch?

4.5.1 Context

In addition to the four specific questions addressed under this issue, there are a number of other factors related to effective management of the Branch which arose during the review. These relate to the unsettled state of the management of the Branch and issues related to the inability to retain staff. These will be discussed below. As evidence on this question arises from a number of sources, the discussion will not be separated into specific sources, but rather provided under a general heading.

4.5.2 Detailed Findings

Management Stability

As noted in the introduction to this issue, the Broadcast Technology Research Branch has been in a period of transition for the past year. In fact, the two groups have undergone a number of organizational changes over the past ten years, fortunately retaining most of their essential capabilities throughout. In April 1998, the radio and TV groups were joined once again, with a new Vice President. There is some evidence that the frequent changes have affected management of the Branch. The Branch would benefit by identifying an integrated strategy to deal with emerging trends and identify initiatives to meet new priorities.

Government Staffing Requirements

There has also been considerable input from staff about government staffing requirements. The freeze on permanent positions and relatively low salaries have been identified as major negative factors in the Branch's ability to attract and retain well-qualified staff to accomplish Branch objectives. It was noted that the Branch has difficulty attracting senior co-op students as the students migrate to opportunities which have a greater possibility of a permanent job after graduation. This is a CRC wide problem which needs to be addressed at that level. Both staff and clients have identified the loss of qualified staff, particularly young people, as a problem which affects the Branch's capabilities and reputation.

Section 3.1 identified a number of options for bringing young people into the Branch, albeit on a temporary basis. This approach would provide some additional research assistance to the Branch, while training individuals in digital broadcasting techniques to meet the needs of broadcasters in this area. While not dealing directly with the retention problem, it would alleviate it. One industry expert suggested that the Branch develop a strategy for training young researchers in digital broadcast techniques and pursue this suggestion with the Canadian Association of Broadcasters as a potential cofunding organization.

It was also noted that CRC might wish to take advantage of other opportunities for funding support and finding research collaborators. For example, NSERC administers a program entitled the Research Partnerships Agreement on behalf of government departments and agencies to select and fund research projects involving industrial partners of interest to both an industrial partner and the government department. Project funding is shared between the government department, NSERC and the industrial firm, with NSERC supplying the administrative support for selecting projects. CRC and the Branch

may wish to join this program as a means to build research partnerships with industrial partners in selected areas.

4.5.3 Conclusions

While the Branch research groups are working effectively in meeting the present needs of their clients, the Branch needs to move forward to develop an integrated broadcast communications laboratory, positioned to meet the future needs of its public and private sector broadcast community.

Government restrictions on hiring and the difficulties in retaining young experienced staff after training one is a serious problem, affecting the ability of the Branch and CRC in general to provide a qualified high quality work force to address program objectives. Steps should be taken to overcome or minimize these difficulties

4.6 Management - Summary

Management of research is in transition. Traditionally, in many government laboratories, there bottom-up approach, with much delegation of responsibility to local managers and senior professional staff. More recently, during the 1980s and 1990s, there has been increased pressure for a more formal management approach, with higher levels of management taking a greater role. Particularly following the release of the government strategy for federal S&T in 1996 entitled "Science and Technology for the New Century", there has been a new emphasis within the federal government to continue the change. This involves complementing the distributed operational management structure with a more formal, active senior management component which provides strategic management input and monitors overall performance based on agreed upon indicators and adjusts programs and resources to ensure that objectives are achieved. The new approach is also used to demonstrate effective use of government resources to Parliament and stakeholders and accountability for the use of public funds through performance reporting.

At the corporate level, CRC has identified strategic directions for the next 3-5 years, and Branch strategies, activities and projects are expected to reflect those goals through a reallocation of resources. Based on evidence provided, the Broadcast Technologies Research Branch, like other CRC research branches, has not moved significantly to the new, more formal approach to strategic and operational management of research identified in the government S&T Strategy. It appears that management remains largely distributed and informal. Much decision making is delegated to the four group leaders, and there is little evidence of a coordinated Branch approach.

Formal performance reporting within the Branch primarily consists of the quarterly progress reports from each group, which are focused on activities and outputs. There is little incentive to do even this much, as little or no feedback is received from senior management on the information in the report. The Branch is required by CRC to keep track of financial records of revenues and expenditures, and keeps track of publications and presentations to conferences and workshops as part of activity reporting and input to the staff rewards system.

While the President of CRC has recently introduced initiatives to encourage collaborations among Branches, evidence suggests that branches within CRC remain largely self-contained, with little inter-branch collaboration unless for a specific separately funded project, revenue producing contract or through informal staff contact.

The result is that branches operate largely as separate entities. The Broadcast Technologies Research Branch has had mixed experiences with CRC collaborations; some have been successful, but others have not. Collaborations between the Branch and universities have been facilitated through adjunct professorships held by Branch scientific staff, and NSERC funded projects. There have been a number of successful collaborations with broadcasting laboratories in other countries focused on sharing technical information and developing new regulations and testing procedures.

Clients were generally pleased with the present mix of activities (research, application and development, contracts, testing, technical assistance, and advice) within the Branch, although in most cases, their level of awareness of the details was low. While the overall balance in the Branch was about right, evidence suggests that there may need to be some rebalancing within individual groups. The Radio Broadcast Systems Group has been working on developing software to measure broadcast coverage patters from various transmitter configurations since the early 1990s, with heavy expenditures of resources and the reception of several hundreds of thousands of dollars in revenues. Licensing a commercially focused, up to date, user friendly version of this successful technology to a Canadian private sector firm would ease the workload in this area and allow the group to refocus its priorities on new emerging areas.

Some evidence suggests that the integration over the past year of the five groups which were brought together in April 1998 has moved slowly, and the Branch is still evolving. Some interviewees felt that there has been some confusion and slow progress towards integration and development of an integrated Branch strategy. The Branch needs to move forward to develop and implement a unified strategy to respond to the pressures towards convergence in the broadcast and communications communities.

4.7 Recommendations

4.7.1 Branch Management Strategy

As the needs of various stakeholder groups for broadcast and related technologies converge, the Broadcast Technologies Research Branch needs to develop a more integrated strategy to meet those needs. A Branch level, integrated approach to strategic and operational decision making should be developed to ensure that resources are appropriately allocated and that the Branch develops a supportive, coordinated approach to meet emerging needs.

To support this Branch level approach, minimize confusion and lack of awareness, regular meetings should be held with staff to discuss strategy, share information and discuss options.

4.7.2 Development of Performance Measurement, Management and Reporting Strategy

To support government requirements for improved performance management and reporting, CRC should develop a high level performance measurement approach based on Industry Portfolio preferred practices, and link it to their operational and strategic planning. Improved information on clients and partners, quality of service and the results of client interactions would support more informed decision making by Corporate and Branch level management, and help demonstrate the value and impact of CRC on the various communities it serves.

With the completion of this review, the Broadcast Technologies Research Branch is in a good position to develop and pilot test a new approach before widespread implementation.

4.7.3 Alignment of Corporate Goals and Reward Systems

CRC should ensure that the reward systems for staff are well aligned with the objectives and priorities of the organization. CRC has evolved from a research organization whose primary goal is to do research to one whose primary goal is to utilize CRC's scientific and technical capabilities to support public and private sector needs and to help improve social well being and create wealth.

4.7.4 Support for Inter-Branch Collaboration

CRC has recently introduced several mechanisms to encourage interBranch projects, including special funding for cooperative projects. However, the study suggests that Branches still have a tendency to act as individual organizations, without consideration of

CRC level objectives or the needs of other Branches. CRC should continue to develop improved mechanisms to support inter-branch collaborations, where appropriate, as a means to better meet clients' needs through access to a more extensive pool of expertise. A number of approaches are suggested. They include:

- continued, visible senior management support, including development and communication of a Corporate policy to support appropriate inter-branch collaborations;
- holding regular 'Show and Tell' sessions to share information about Branch projects and strategies with managers and staff from other Branches; and,
- having a small budget allocation within each branch designated for support to priority projects from other Branches, or inter-branch projects.

4.7.5 Focus on Application of Knowledge for Benefit of Clients

While the present overall mix of research, development, testing and contract work seem reasonable at the Branch level, the balance at the group levels needs to be monitored and adjusted as required. As a government agency providing scientific and technical support to public and private sector clients, the focus needs to be on utilizing existing knowledge to support achieving their objectives, while continuing to use some resources to perform research in order to build capability to meet emerging needs.

4.7.6 Licensing of CRC-COV

In order to support the transfer of technology to the Canadian private broadcast sector and free up resources for other priorities, the Branch should move to complete as quickly as possible a basic, user friendly, WINDOWS version of CRC-COV, suitable for use in the design of digital broadcast systems. This version of CRC-COV should be licenced to a Canadian broadcast consulting firm, with appropriate fees related not only to the purchase but also the use of the software. The Branch should continue to make available to the broadcast community specialized services using the general multicapability version of CRC-COV in those cases requiring the highest level of expertise.

5.0 *Quality*

Issue 3: To what extent does the quality of research and services provided by the Broadcast Technologies Research Branch meet the needs of clients and collaborators?

The wording of this issue is intentional as it applies to the Broadcast Technologies Research Branch. While it is not always recognized among researchers nor in the management and reward systems governing public sector R&D organizations, research quality is not an end in itself, but rather the means to an end. In the case of CRC, the mandate is to perform relevant research to meet the technical needs of public and private sector stakeholders and clients. This issue is related to the question in Section 4.4 which discusses the strategic mix of activities. These include on one hand, research in-house and with collaborators to build and maintain scientific and technical capability and, on the other, contract research, testing, product and process development, and advice which utilize existing knowledge. As noted, resource utilization needs to be carefully balanced between building and utilizing capability. This concept is clearly included in the government goals for S&T, discussed in Section 3.5, which include both building new knowledge and also utilizing current capability for economic growth and social well-being. The quality of research should be sufficiently high to meet the needs of the identified client group, but utilization of capability to achieve results is the real objective, as shown in the Branch performance framework in **Exhibit 2-2**. It should be noted that there is a range of requirements for research quality, with those of scientific collaborators being in most cases the highest.

In the case of services, the concept of quality is expanded beyond staff expertise and capabilities to include elements of 'client friendliness' such as responsiveness, ability to meet deadlines, and quality of facilities and equipment. This issue will be examined from this broader perspective of the relationship between quality of research and services and the needs of clients and collaborators.

As clients are mentioned in all three specific questions under this issue, the primary sources of evidence to address these questions will be the client survey, with some information taken from expert and staff interviews.

5.1 Do clients and collaborators have confidence in the quality of research, testing and other services provided by the Broadcast Technologies Research Branch?

5.1.1 Context

This is a basic question to be addressed during all reviews of research organizations. While the narrow interpretation of the question relates only to client confidence in the quality of Branch research and services, it will be examined from a number of related perspectives, including information on the quality of Branch staff, publications, and reports.

This question focuses on the perspective of existing clients and collaborators. As most of the clients and collaborators interviewed have relatively long-term, established relationships with the Branch, which are continuing, the answer seems on the surface obvious, without the need for further discussion. However, there is considerable additional evidence from the client survey and other sources which will be used to address the question in more detail.

5.1.2 Detailed Findings

Client Survey

A number of questions in the client survey relate to client perspective on the quality of Branch research and services and on the quality of Branch staff.

While respondents were not asked directly their opinion about the quality of Branch research, they were asked to identify the strengths of the Branch. The single most frequent response was the research and testing capabilities of the Branch, embodied in the technical competence and expertise of staff and the quality of equipment and facilities (to a slightly lesser extent). Respondents were also asked why they worked with the Branch. Again, the most frequent response was related to the scientific and technical capabilities of the Branch staff and availability of high quality testing equipment and facilities. In many cases, the Branch is the primary source of technical assistance for clients in the area of digital broadcasting, a further indication of the confidence they place in Branch capabilities and services.

In probing the quality of services, respondents were asked to focus on a specific project and rate specific features of the Branch in terms of importance and satisfaction. The rating was on a scale of 1 to 10, with 1 being extremely low, and 10 being extremely high (either in importance or satisfaction, depending on the question). Table 5-1 which follows, presents a summary of the results.

Table 5-1: Client Ratings of Branch Features Related to Service*

Branch Feature	Importance to Respondent	Satisfaction with Feature
Branch's understanding of your needs	9.0	8.7
Quality of equipment and facilities	9.3	8.9
Availability of facilities	8.2	8.0
Importance of Branch / satisfaction with Branch's contribution to project	9.0	9.0

* 29 Respondents

These data need to be interpreted carefully. Firstly, as mentioned previously, the sample of respondents chosen are almost all long term clients, with established relationships with the Branch. As such, they are predisposed to be positive and supportive. In spite of this caution, the average ratings are all very high, and indicate a high degree of satisfaction and confidence with these features of the Branch from this sample of clients.

While the survey data gives a high overall rating for equipment and facilities, several comments suggested that in some cases, specific pieces of existing equipment are not up to date and need to be upgraded. No details were collected about which particular equipment was considered deficient.

The relatively low ratings for both the importance of the availability of facilities and the clients' satisfaction are related and reflect the fact that many projects are not extremely rush jobs with very short time frames. One person suggested that the facilities are not heavily used and are therefore usually available for client projects.

The high ratings for the importance of the Branch to the project and the respondent's satisfaction with the Branch's contribution reflect the central role played by the Branch in supporting these clients needs through these specific projects chosen for consideration.

An additional set of questions related to the quality of various Branch features asked respondents to identify other research organizations which they found comparable in some way to the Branch. Most could not (19 of 29). Those who could identify another research organization were asked to identify it and compare the Broadcast Technologies Research Branch to the other organization on a number of features. The other organizations identified are:

- Advanced TV Test Centre (reorganized and renamed as Advanced TV Technology Centre) (two respondents);
- NASA (U.S.) (two respondents);

- NIST U.S.;
- CCETT (France);
- BBC R&D Department (U.K.);
- DND DCIEM Toronto;
- TR Labs; and,
- University Electrical Engineering Department.

Table 5-2 below contains the average ratings for the ten respondents who compared the Branch to another organization. The scale used was 1 to 10, with 1 being the Branch is much poorer and 10 being the Branch is much better than the comparable organization. A rating of 5 was used for equal. It is important to note that care must be taken in interpreting the average ratings due to the small number of respondents.

Table 5-2: Comparison of Branch to Other Organizations

Feature	Average rating
Quality of personnel	5.2
Quality of facilities and equipment	4.5
Responsiveness	7.3
Overall	5.9

While the average rating for quality of personnel was 5.2, there were two of the 10 who rated the Branch below 5, poorer than the comparable organization. They indicated that these other organizations were much larger and had much better funding and that the comparison was, in this respect, unfair. The rating for quality of equipment and facilities was the lowest of the four categories at 4.5, with four of the ten respondents rating it below 5. Once again, respondents noted that several of the organizations used for comparison were larger, well-financed national laboratories. The Branch was well perceived in terms of responsiveness with a rating of 7.3, the highest of the four categories. No one rated the Branch worse than the comparable organization in terms of responsiveness. One American respondent who gave the Branch a very high rating said that he wished that NIST would take a lesson from the Branch in client relations. Respondents also gave the Branch a higher rating overall, with one of the ten rating the Branch poorer than the comparable organization.

While these ratings may seem low, they are probably realistic. The Branch is being compared with some very large, high quality research organizations with significantly more resources than the Branch. In the area where the Branch could make a difference without spending a lot of money that it does not have, namely responsiveness and client friendliness, it scored well. The other features are to some extent out of its control, as they are related to resource levels.

The quality and capabilities of staff are critical to the quality of research and testing. This is discussed in more detail in Section 5.3. There is some concern that the overall quality of staff has dropped recently due to the Branch's inability to retain qualified staff. While it seems as though this problem has not yet been reflected in the quality of research and services, it may become a problem if it continues.

Expert Interviews

Several experts noted that the central role played by the Branch in working with key clients such as Broadcast Engineering, Digital Radio Research Inc., and Canadian Digital TV, which represent the major public and private sector participants, is an indicator of the confidence which the Canadian broadcast community places in the Branch. As another person noted, the fact that the U.S. has invited the Branch to participate in the testing of U.S. equipment and providing research results to inform its spectrum allocation decisions is a strong indicator of the credibility of the Branch internationally and the confidence which broadcast organizations have in its work.

Case Studies

In the case study on the subjective evaluation of HDTV performed for the U.S. Consumer Electronic Manufacturers Association, the ultimate test of quality was that the test results provided by the Branch were never challenged in any way, in spite of the various commercial interests involved. This was an acid test for demonstrating confidence in the Branch's capabilities and the quality of its work.

5.1.3 Conclusions

Evidence collected from all sources clearly shows that major clients, partners, and collaborators have a high degree of confidence in the quality of research, testing, and other services provided by the Branch. The central role played by the Branch in international standards work and interactions between the Branch and major U.S. and other broadcast organizations points to the international reputation of the Branch, and the confidence of clients and partners in the quality of Branch research and testing capabilities. When compared to other world class broadcast laboratories, the quality of equipment and facilities in the Branch was found to be somewhat lower overall, while the responsiveness of Branch staff was significantly higher. To a large extent, the relatively low rating of equipment and facilities was considered to be due to comparatively poorer funding and lack of resources. There was also concern among some interviewees about recent loss of qualified staff, leading to reduced technical capability and quality of work.

5.2 Are Broadcast Technologies Research Branch services relevant to the needs of clients?

5.2.1 Context

This question is to some extent a restatement of the first question under the issue of Branch relevance (Section 3.1). As well the second question (Section 3.2) addresses this question from a slightly different perspective. The detailed discussions and analysis associated with these questions will not be repeated here.

Once again, the fact that important public and private sector client groups have long term relationships with the Branch and express high degrees of satisfaction with the technical expertise, facilities and equipment, and testing services available from the Branch provides a generally positive sense of the relevance of the Branch to the needs of the clients. The client survey included two specific questions directly related to relevancy, and those results are presented here.

5.2.2 Detailed Findings

Client Survey

Clients surveyed were asked to rate the relevance of the capabilities of the Branch to the needs of their organization, once again using a rating scale of 1 to 10, with 1 being completely irrelevant and 10 being extremely relevant. The average rating for the 26 respondents who answered the question was 8.6. Although the small number of respondents in each category made comparisons difficult, the ratings were fairly consistent among the various groups (Canadian government, Canadian broadcasters, Canadian equipment manufacturers, international organizations). In some cases, respondents' organizations have many types of activities, only some of which relate to digital broadcasting. In several of those cases, many respondents based their ratings on the relevance of the Branch to the broadcasting part of their organization. As an example, one person said that relative to the project being discussed, Branch relevance was 9, but in terms of the overall company needs which extend far beyond broadcast communications, the rating was 3.

As another indicator of the relevance of current Branch services, the vast majority of clients were unable to identify additional services or capabilities to better meet their needs. As discussed in Section 3.1, the most frequently mentioned need was for better communication and awareness of Branch initiatives and new developments in the digital broadcasting field.

Expert Opinion

Experts interviewed were generally positive about the relevancy of Branch services to the needs of clients. However, there were two points mentioned by individual interviewees which bear on this question. It was pointed out that to date the focus has been on supporting Spectrum Engineering and the broadcast community, with relatively less effort going to the broadcast equipment manufacturers and other SMEs. In terms of the resources available and the opportunities, this has probably been a good choice, but the Branch needs to be aware of opportunities to work more with equipment manufacturers and other related firms as digital equipment opportunities open up. Likewise, more attention to meeting the needs of the Canadian broadcasting consulting and engineering community could become a higher priority.

One person mentioned that the Branch has to make a choice whether to develop technology and licence it to firms, or work with firms to help them develop technology and new equipment. To date the focus seems to have been on the former, perhaps due to the rewards which come to Branch staff from licensing royalties. Some firms would appreciate more support in helping them develop technology. Unfortunately, they probably cannot afford to pay for the support.

5.2.3 Conclusions

Clients and experts both agree that existing services are highly relevant to the needs of the major stakeholders in the Canadian broadcast community. Some members of the broadcast community identified additional services which build on the present strengths of the Branch. There were several suggestions made, including the following:

- improved, more formal communication with the wider broadcast community;
- greater focus on supporting broadcast equipment and other related firms through problem solving and testing (as resources permit); and,
- assistance with training highly qualified personnel in advanced digital technology.

5.3 *Are the capabilities of Broadcast Technologies Research Branch staff and the quality of facilities appropriate to the needs of clients and collaborators?*

5.3.1 Context

Once again, the generally positive response of Branch clients and experts to many of the other questions under issue 1 and in Section 5.1 and 5.2 immediately preceding are relevant to answering this question in the affirmative. In addition, however, the client survey directly addressed this question, and those results will be presented and discussed here, together with some input from the expert interviews.

5.3.2 Detailed Findings

Client Survey

One way to examine the relationship between Branch capabilities and client needs is to ask the clients. Survey respondents were asked to rate their satisfaction with several specific features of staff related to their capabilities. Once again, a scale of 1 to 10 was used, with 1 being not at all satisfied and 10 being very satisfied. Those results are shown in Table 5-3.

Table 5-3: Client Survey Perspective on Branch Staff

Staff Feature	Average Rating
Scientific / technical competence	8.0
Responsiveness	8.6
Ability to meet deadlines	7.6
Overall quality	8.0

These results are broadly indicative of a satisfied client group, with confidence in the technical capabilities and supportiveness of Branch staff. However, there is additional information in some of the comments which accompanied these responses. In terms of staff competence, three of the respondents gave a rating below 8, in all cases 7. Two observed that overall staff competence had dropped recently compared to the past, due to the loss of trained staff. Staff responsiveness was generally rated very highly, with many ratings of 10, with two respondents giving a rating below 8. One person commented that CRC administration was far less responsive and client friendly than Branch staff, giving it a rating of 3.

The question of deadlines is always a difficult one for research laboratories to deal with and client surveys often provide relatively low ratings in this area. On one hand, research

is by nature uncertain, and cannot be held to production type schedules. However, when dealing with clients and partners, it is important that they understand and are made aware of any problems meeting planned schedules. It is also true that missing deadlines may not be the fault of staff, but may be due to the project management system in place (or not). Ability to meet deadlines received the lowest of the ratings collected in this category. While most respondents gave a rating of 8 or higher (18 of 27), one third gave a rating of 7 or lower, with one person giving a rating of 3. While this single low score had a significant effect on the final rating, removal of that one outlying score would still leave an average rating below 8. While this rating is comparable to other public sector organizations, the Branch may wish to review its current practices for project management to determine whether improvements in the identification and meeting of project target completion dates and communications with clients can contribute to better client services in this area.

In terms of overall quality, results were similar to those for the first feature, staff competence, with the same two persons noting that overall quality had dropped recently compared to the past.

Another aspect of the capabilities of staff involves their ability to understand the needs of clients. **Table 5-1** in Section 5.1 presents clients' rating of importance of and satisfaction with the Branch's ability to understand their needs. The average ratings are 9.0 and 8.7 respectively out of 10, which reflect a generally high level of importance and satisfaction. While the question asked about the Branch, it is clear that it is the staff of the Branch who are responsible for understanding client needs. Although the rating was high, there were several comments suggesting that the Branch needed to improve its awareness of industry needs and work more closely with industry.

With respect to facilities, the same **Table 5-1** presents clients' rating of the importance of and satisfaction with the quality of Branch equipment and facilities. The average ratings of 9.3 and 8.9 respectively indicate a high degree of satisfaction by most clients and collaborators. As mentioned previously, there were one or two comments about the need to replace obsolescent equipment and to keep equipment up to date.

While these data do not directly address the question of appropriateness, the satisfaction of clients with capabilities of staff and quality of facilities can be considered a reasonable proxy.

Expert Interviews

As discussed previously, experts spoke favourably about the appropriateness of Branch capabilities in meeting the needs of clients and collaborators. Collaborators also agreed

with this perspective. There were no negative or cautionary comments on this question, other than the concern about inability to retain young professional staff.

5.3.3 Conclusions

Based on the information available, the large majority of clients and experts feel that the scientific and technical capabilities and responsiveness of staff, and the quality of equipment and facilities are of high quality and relevant to their needs. facilities. There were concerns by some about the timeliness of Branch services and the ability to meet deadlines, and to a lesser extent, obsolescent equipment. As previously mentioned, the loss of young qualified professional staff was also identified as a concern by some as it affects the present and future capabilities of the Branch.

5.4 Quality - Summary

The issue of the appropriateness of quality of research and services was reviewed through a number of complementary methods. Based on the client survey results, expert and other interviewees, the large majority of clients and collaborators are generally highly satisfied with the quality of research and technical services provided by the Branch, and have confidence in the results obtained. Clients and experts also both agree that existing services are highly relevant to the needs of the broadcast community. When clients were asked to rate their satisfaction with the Branch's contribution to a specific project, the average rating was 9.0 out of 10. This is an extremely high rating, indicating a very positive relationship between the Branch and the clients surveyed. However, some clients thought that the quality of research is now lower than it has been due to the inability to retain qualified professional staff. There has been a significant loss in the past several years of highly qualified staff, leading to a loss of important research and testing capabilities in the Branch.

For those interviewees who had worked with other communications laboratories, the Branch also compared reasonably favourably. In many cases, these other organizations were large national laboratories much better funded than the Branch, so in that respect clients noted that the comparison may not be fair. Clients rated the quality of Branch equipment and facilities somewhat poorer, quality of personnel slightly better and overall responsiveness to client needs much better than these comparable organizations. When asked to provide a summative overall perspective, clients rated the Branch somewhat better than comparable organizations (5.9 out of 10, where 5.0 is equal). It is clear that the Branch staff's responsiveness is largely responsible for the overall positive rating.

5.5 Recommendations

5.5.1 Hiring and Retention of Qualified Staff

CRC should treat the hiring and retention of qualified professional staff as a priority. The President, in cooperation with DND DREO, has recently made representations to Treasury Board to alleviate the situation. While these efforts were unsuccessful, other avenues to ameliorate the situation need to be explored with central agencies and other public sector stakeholders. For example, CRC could consult with other science based departments and agencies through various means such as the Science ADM committee to explore options. The practices of other government research agencies such as NRC should be reviewed to provide information on available options, including flexibilities which could be introduced into rules and regulations on staffing issues. For example, NRC has a separate single classification and salary system for all researchers, avoiding the problems associated with multiple classification for research staff (RES and ENG).

Annex A - Client / Partner Interview Guide

CRC Broadcast Technologies Research Branch
Client / Partner Interview Guide

Contact name: _____

Organization: _____

Telephone #: _____

Introduce yourself and the study.

1. How many people does your organization employ on a regular full-time basis at this location?

   _____ EMPLOYEES

2. For how many years have you been dealing with the Broadcast Technologies Research Branch (BTRB) / CRC?

   _____ YEARS Branch

   _____ YEARS CRC

3. During those years, how many research projects have you had with the Branch?

   _____ RESEARCH PROJECTS

4. Which group(s) in the Branch have you worked with?

   _____

   _____

   _____

   _____

5. Why do you work with the BTRB? *Probe:* Any other reasons?

_____

_____

_____

_____

The letter you received from CRC identified a specific project *(read project information from list).* I would like to ask you several questions about that specific project.

6. *If project is completed, read:* Overall, how successful was this project? Please use a scale of 1 for not at all to 10 for very successful.

1 2 3 4 5 6 7 8 9 10 DK

If project not completed, read: Overall, how successful do you anticipate this project will be? Please use a scale of 1 for not at all to 10 for very successful.

1 2 3 4 5 6 7 8 9 10 DK

7. Why do you say that? *Probe:* Any other reasons?

_____

_____

_____

_____

8. Using a scale of 1 to 10, 1 being not at all important and 10 being very important, how important are each of the following, as it relates to this project?

9. Also using a scale of 1 to 10, 1 being not at all satisfied and 10 being very satisfied, how satisfied are you with the BTRB on this for this project?

Feature	Q.7 - Importance		Q.8 - Satisfaction	
	Rating	DK / NA	Rating	DK / NA
Branch's understanding of your needs		X		X
Quality of Branch equipment and facilities		X		X
Availability of CRC facilities for your project		X		X
CRC's link to IRAP		X		X
Branch's link to other parts of CRC		X		X
Branch's link to other organizations		X		X
Overall, how important was the Branch to this project? / Overall, how satisfied are you with the Branch's contribution on this project?		X		X

10. If the Broadcast BTRB had not been available, would there have been a major, minor or no effect at all on this project?

MAJOR 1

MINOR 2

NO EFFECT ..... 3 → *Skip to Q.12*

DON'T KNOW / TOO EARLY TO TELL ..... X → *Skip to Q.13*

11. What would have happened? *Probe:* Anything else?

_____

_____

_____

_____

Skip to Q.13

12. Why do you say that? *Probe:* Any other reasons?

13. Did the following occur as a result of this project?

14. *If not:* Do you anticipate that this will occur in the future as a result of this project?

15. *If yes to Q.13 or Q.14, ask:* To what extent is due or will this be due to the involvement of BTRB on the project? Please use a scale of 1 to 10, 1 being not at all and 10 being to a great extent.

Result	Q.14 - Occurred		Q.15 - Will occur		Q.15 - Due to BTRB
	Yes	No	Yes	No	
Solution to technical problem	1	2	1	2	
New knowledge	1	2	1	2	
Increased scientific or technical expertise / capability	1	2	1	2	
Reduced development time	1	2	1	2	
New or improved products	1	2	1	2	
New or improved process	1	2	1	2	
Cost savings / more efficient operation	1	2	1	2	
Increased competitiveness	1	2	1	2	
Increased sales	1	2	1	2	
Others *(Please specify)* _____	1	2	1	2	
New or improved policies / regulations	1	2	1	2	

16. On a scale of 1 to 10 with 1 being not at all relevant and 10 being very relevant, please rate the relevancy of the BTRB capabilities to the needs of your organization.

1 2 3 4 5 6 7 8 9 10 DK

17. Overall, how satisfied are you with Branch staff on each of the following? Please use a scale of 1 to 10, 1 being not at all satisfied and 10 being very satisfied.

Feature	Not at all									Very
Scientific or technical competence	1	2	3	4	5	6	7	8	9	10
Responsiveness of Branch researchers	1	2	3	4	5	6	7	8	9	10
Ability to meet deadlines	1	2	3	4	5	6	7	8	9	10
Overall quality of Branch staff	1	2	3	4	5	6	7	8	9	10

18. Does the BTRB help keep your organization aware of emerging trends in broadcast technologies and systems?

YES 1

NO ..... 2 → *Skip to Q.21*

19. How important is it to your organization that the Branch keep you aware of emerging trends? Again, please use a scale of 1 to 10, with 1 being not at all important; and 10 being extremely important.

1 2 3 4 5 6 7 8 9 10

20. How well does the BTRB keep your organization aware of emerging trends? Please use a scale of 1 to 10, with 1 being not well and 10 being extremely well.

1 2 3 4 5 6 7 8 9 10

21. What are the strengths of the CRC BTRB? *Probe:* Any others?

22. What are its weaknesses? *Probe:* Any others?

23. From your perspective, does the BTRB have a good mix of strategic in house research, collaborative research and development with partners, contract work and testing?

YES 1

NO ..... 2 → *Skip to Q.25*

24. What changes would you suggest?

25. Have you worked with organizations which are similar to the Branch?

YES 1

NO ..... 2 → Skip to Q.28

26. Can you identify some examples?

Name of organization: _____

Name of organization: _____

27. How does the Branch compare to this organization for each of the following? Please use a scale of 1 to 10, with 1 being the Branch is much poorer and 10 being the Branch is much better?

Feature	Much poorer									Much better
Quality of personnel	1	2	3	4	5	6	7	8	9	10
Quality of facilities and equipment	1	2	3	4	5	6	7	8	9	10
Responsiveness	1	2	3	4	5	6	7	8	9	10
Value for money	1	2	3	4	5	6	7	8	9	10
Overall	1	2	3	4	5	6	7	8	9	10

28. How important is the Communications Technologies Research Branch to your organization's success? Please use a scale of 1 to 10.

1 2 3 4 5 6 7 8 9 10 DK

29. Why do you say that? *Probe:* Any other reasons?

_____

_____

_____

_____

30. What additional service or capabilities could the Branch provide that would better meet the needs of your organization? *Probe:* Any others?

31. Do you have any other suggestions for improvement or changes at the Communications Technologies Research Branch? *Probe:* Any others?

Thank and Terminate

Annex B - List of Clients and Collaborators

Clients and Collaborators of the BTRB[4]

Type of Organization	Relationship	Client or Expert Interviewed
Canadian Government		
Mr. Ralph Zeitoun Spectrum Engineering Industry Canada	DRB technical, regulatory and planning DTV regulatory, spectrum planning	yes
Mr. Royce Trenholm Spectrum Engineering Industry Canada	DRB technical, regulatory and planning DTV regulatory, spectrum planning	yes
Canadian Broadcasters		
Mr. David Garforth Digital Radio Research Inc.	DRB Association, DRB services, committee work	yes
Mr. Duff Roman CHUM Ltd.	DRB Association, committee work	
Mr.Michel Fortin CBC	DRB, international standards development	yes
Mr. John Lee CBC	DTV	yes
Mr. Steve Edwards Rogers Broadcasting Ltd.	DRB transmission and coverage	yes
Mr. Don Weese Telesat Canada	DRB over satellite broadcasting	yes
Ms. Carol Darling Womens TV Network	DTV standards development	yes
Broadcast Equipment Manufacturers and Systems Producers		
Mr. John Tremblay LARCAN	DRB transmission equipment DTV transmitters	yes
Mr. Denis Marchand C-MAC Industries	DRB receiver discussions	
Mr. Richard Beaton Q Design Corporation	Audio coding development, international standards committee work	yes
Mr. Larry Zurowsky Magnum Dynalab	DRB receiver development, market studies	yes
Mr. Douglas Cavil IMT Communications System	Local Multipoint Communications System study	yes
Mr. Christian Tremblay Miranda Technologies	Video processing, very low bit rate video	yes
Mr. Mickey Marshall WIC-Connexus	Local Multipoint Communications system Study and field trial	yes

[4] List of names, affiliations and projects as provided by the Branch to choose survey sample and expert interviews for the Review

Type of Organization	Relationship	Client or Expert Interviewed
Mr. Dennis Ma Wavesat Inc.	Video signal modulation and systems development	
Canadian Consulting and Professional Services		
Mr. Gord Henke D.E.M. Allen & Associates	DRB coverage Design	yes
Mr. Brian Sawyer Advanced Transmission Solutions (supporting Canadian Association of Broadcasters)	DRB transmission and planning DTV spectrum allocation, filed trial planning	yes
Mr.Wayne Stacey Stacey, Lawson Associates	DRB transmission and planning, work	yes
Mr. Gary Carter International Datacasting	DRB Datacasting	
Canadian Universities		
Dr. Eric Dubois Ottawa University	3D-TV collaboration, video processing	yes
Dr. Chris Herdman Carleton University	Video subjective evaluation	yes
Dr. Janusz Konrad Institute national de recherche scientifique University du Québec	3-D TV, video processing	yes
American Broadcast Equipment Manufacturers		
Mr. Randall Brunts Delco Electronics	DRB System Testing	yes
Mr. Ralph Justus Consumer Electronics Manufacturers Association	DRB Systems standardization, satellite digital audio radio study	yes
Mr. Mihir Ravel Tektronix Measurement Division, Tektronix	Video subjective evaluation	yes
Dr. Robert Graves Advanced TV Systems Committee	Digital TV systems comparison	yes
Dr. John Henderson Hitachi America Ltd.	Digital TV testing	yes
Mr. Peter Fannon Matsushita Electric Corporation of America	HDTV subjective testing	yes
American Broadcast Consultants		
Mr. Robert Culver Lohnes and Culver	DRB Systems Tests, transmission coverage	yes
Mr. Mel Engel Mel Engel Consulants	Datacasting System evaluation	yes

Type of Organization	Relationship	Client or Expert Interviewed
International Broadcast Research, Testing Labs		
Dr. Robert Rast Dolby Laboratories U.S.A.	HDTV subjective evaluation, testing	yes
Mr. Alexander Schertz Institut fuer Rundfunktechnik Germany	Video quality assessment	
Dr. Karl Brandenberg Fraunhofer Institute for Integrated Circuits	Subjective testing of audio codes	
Mr. Jim Hollanswort NASA Lewis Research Centre U.S.A.	DRB Systems Testing	yes
Dr. Yves François Dehery CCETT France	DRB collaboration, audio coding	
Mr. Bertrand Sueur, Mr. Bernard LeFloch CCETT	video coding for DTV	
Dr. Jae-Hong Park Electronics and Telecommunications Research Institute, Korea	DTV studies	
Mr.FrancKozamernik European Broadcasting Union Switzerland	DRB collaboration	
Mr.Egon Meier-Englen EUREKA-147 Project Office Germany	DRB collaboration	
Mr.Peter Shelswell BBC Research and Development Department United Kingdom	DRB collaboration, standards development	yes
Dr. Ennio Ravanello Communications LAB Australia		
Mr. Jack Chang Telecommunications Lab Chunghwa Telecom co. Ltd. Taiwan	DTV study, lab tests, field trials	yes

Annex C - CRC Staff Interview List

CRC Staff Interviews

Broadcast Technologies Research Branch

Dr. Metin Akgun	Vice President (acting), Broadcast Technologies Research Branch
Mr. Gérald Chouinard	Advisor to the CRC President and former Director Digital Radio
Mr. Bernard Caron	Manager, TV Systems and Transmission
Dr. Yiyan Wu	Senior Scientist, TV Systems and Transmission
Mr. André Vincent	Manager, Advanced Video Systems
Dr. Lew Stelmach	Senior Scientist, Advanced Video Systems
Mr. René Voyer	Manager, Digital Radio Broadcast Systems and Transmission
Mr. Bernard Breton	Research Engineer, Digital Radio Broadcast Systems and Transmission
Mr. Barry McLarnon	Research Engineer, Digital Radio Broadcast Systems and Transmission
Mr. Louis Thibault	Manager, Advanced Sound Systems
Mr. Gilbert Soulodre	Senior Research Engineer, Advanced Sound Systems

Other CRC Staff (present and past)

Dr. Bill Sawchuck	Vice President Radio Science Branch (former Vice President responsible for broadcasting
Mr. Graham Taylor	Director of Corporate Marketing
Mr. Joe LeBlanc	Manager, Technology Transfer (just retired)
Dr. M. Cuhaci	Manager, Advanced Antenna Design
Dr. René Douville	former Director
Mr. Jacques Lyrette	former President CRC, now at the National Research Council

Annex D
Case Studies and Comparable Programs

- Ottawa Digital Audio Broadcasting Multiple Transmitter Test Site
- 3D TV
- HDTV Subjective Testing
- DAR Satellite
- CRC-COV
- Comparison with Other Countries and their Broadcast Research Organizations

Case Study - Ottawa Digital Audio Broadcasting Multiple Transmitter Test Site

DAB Ottawa Test Centre and Field Trials for low power multi-site transmission system for digital audio broadcasting

Project Overview

The radio group has had a long history in working with digital audio broadcasting, beginning with the formation of the group in the late 1980s. The Eureka-147 system for digital broadcasting was developed in Europe based on OFDM with the first prototype developed by CCETT in France in 1988, and demonstrated in Canada in 1990. The new technology makes use of encoding and modulation technologies which permits the use of complementary low power multi-site transmitters for coverage of larger service areas. CRC led the effort to adapt the Eureka system for use in North America. Field trials of the new technology were held in Toronto, Montréal and Vancouver beginning in 1990 and pursued through the following summers. CRC participated extensively in those tests, in partnership with the CBC and private broadcasters.

The Ottawa test site was set up in 1995 with equipment purchased from $500K seed funding from Rogers Broadcasting, provided as a benefit attached to a CRTC application. Under the leadership of Digital Radio Research Inc. (DRRI), an organization established to carry out research into digital radio technologies, it was decided to build a test site in Ottawa for research, development and testing of an operational multi-site network in an operational situation. The resources from Rogers were used to purchase equipment for the test site, and the CRC was asked to become custodian and technical operator of the site, with responsibility for operation and maintenance of the equipment.

The test centre has been used to gather detailed transmission and reception data across the coverage region and test the operational viability of the approach. Results have demonstrated that this multi-site transmitter approach is a viable alternative to high power, single transmitter operation, particularly when large area coverage is required. Based on the research and test results from the Ottawa test site, the Broadcast Regulatory Branch of Industry Canada has developed a Canada-wide allocation plan based on this multi-site concept and broadcasters have decided to progressively introduce the multi-site approach. The first commercially operating multi-site system will be going into operation in Vancouver this year (1999).

Profile of the Partners

Digital Radio Research Inc. (DRRI), manager of the Ottawa test site on behalf of the digital radio broadcast sector, is the main partner on this project. DRRI is an industry-led organization,

formed in 1992, whose objective to undertake and support digital radio broadcasting research of interest to its members. As such it is the main mechanism for the Broadcast Technologies Research Branch to interact with the broader digital radio community. DRRI is supported by its members with additional funding from Industry Canada.

Project Profile

In 1994, Rogers bought part of the radio broadcasting business of McLean Hunter. As part of the decision to allow that acquisition, the CRTC accepted the proposal by Rogers to put $500K into development of new technology for digital radio broadcasting. It was decided to set up a multi-site operational test centre in the Ottawa region to gain operational experience with the Eureka-147 based technology. The digital radio broadcast group at CRC was involved in identifying the requirements for the equipment and installing it. After the test site was operational, the CRC group was asked by Rogers to become custodian and technical operator of the site, with responsibility for operation and maintenance of the equipment.

The Ottawa test site, set up in 1995, was designed to test the use of multiple transmitters for digital radio broadcasting, as well as acquiring data to improve the RF propagation prediction models for designing DRB coverage at 1.5 GHz. The system had three repeater sites: at Carleton; Place du Portage in Hull; and one in the east end on Montréal Road. The Broadcast Technologies Research Branch gathered detailed data on signal strength and characteristics at various sites in the coverage pattern. The test site did not remain static, but continued to evolve. A fourth transmitter is to be installed at CRC to test additional multi-site options.

The test centre has been used to test the viability of this novel approach to broadcast transmission. Specifically, it was used to make detailed measurements on signal strengths throughout the region and to test-specific aspects of the system, including loss of signal due to location (inside buildings) and the doppler effect of reception in moving vehicles.

Information from the test site was provided to Industry Canada's Spectrum Engineering Branch and the broadcast community through the Joint Technical Committee on Advanced Broadcasting (JTCAB), and was shared internationally through ITU-R meetings and publications.

DRRI has a budget to cover costs of the site leasing, and the Branch uses A-base funds and special funding from Spectrum Engineering to conduct research and testing. Continued funding for the project is uncertain. DRRI has agreed to fund the site lease until the end of 1999. The Branch and some broadcasters wish to continue using the site as a test centre. The original plan was to turn it over to community radio at some time. Carleton University wants to take it over and use it as a university radio station.

Roles and Relationships

Rogers/DRRI are responsible for overall management of the Ottawa test site on behalf of the industry. The Broadcast Technologies Research Branch acts as custodian and is responsible for the technical operation of the test site. Resources for work of the Branch is provided through A-base funding and about $60K/yr support from Spectrum Engineering Branch. Because of its role, the Branch is able to use and develop the Ottawa site for further testing. Test results are shared with the digital radio broadcast industry through DRRI, the Spectrum Engineering Branch of Industry Canada and the larger international community through ITU-R.

Impacts

The data collection and testing work undertaken at the Ottawa test site have provided valuable information on this alternative approach to digital radio broadcast transmission which has been used by both Spectrum Engineering and public and private broadcasters. The characteristics of the Eureka-147 digital radio broadcasting system permit a new approach to broadcast transmission, namely from networks of multiple low power transmitters. Rather than being restricted to the coverage allowed from a single high power transmitter, (even from the CN Tower, coverage is restricted by the RF horizon to about 40km) this technology permits use of additional transmitters to extend the coverage at a reduced cost over conventional alternatives, as well as the use of small gap filler transmitters to resolve coverage problems within the nominal coverage area.

The Ottawa test site has tested the technical feasibility and commercial viability of the low power multiple transmitter approach by collecting improved technical data in a real broadcast environment and covering an entire realistic service area, namely the Ottawa metropolitan area. Examples of specific issues being studied are the effects of the reception of multiple active echos caused by multiple on-channel transmitters, indoor reception capacity, and doppler effects due to moving receivers (in automobiles).

The test site continues to provide technical data on this approach which helps improve long-term decision-making on options for digital radio transmission design. The main beneficiaries of the information from the test site are those larger communications organizations with sufficient technical capability to understand and incorporate the test results into their internal design and development systems. These include, Rogers, Shaw, CBC and Spectrum Engineering in Industry Canada. Communications consultants also incorporate the results of these tests into their design benefit from having improved design capability to assist smaller broadcasters.

While much of the impacts are to come, there is evidence that the test site data has already influenced the introduction of digital radio broadcasting in Canada. At the government level, Spectrum Engineering has used the field data to support decisions on digital radio broadcasting

allocations, and as supporting documentation in negotiations with the U.S. on use of spectrum. Canadian broadcasters have also benefitted. Digital radio broadcasting has been introduced in three locations: Toronto; Montreal; and Vancouver. In two of these cases, due to the local conditions and the availability of a high point in Toronto (CN Tower) and Montreal (Mount Royal), single transmitters are being used, at least for now. However, due to the geographical conditions and coverage requirements in Vancouver, the new approach of multi-site low power transmission will be used. The system is being installed and will be in use by fall 1999. This option would not have been available without the confidence and improved information provided by the detailed test data from the Ottawa test site.

Potential

Based on the experience with the first installation in Vancouver, the data from the Ottawa test site and previous tests, broadcasters and digital radio system designers will have increased information about the options available when designing future transmission systems for digital radio broadcasting. They will be able to provide an improved, customized approach based on local conditions and the need for specific coverage patterns.

Individuals Interviewed

Gérald Chouinard	Advisor to President CRC, former Director of Radio Group at CRC
Mr. Steve Edwards	VP, Consulting Engineering and Technology, Rogers Broadcasting
Mr. David Garforth	Executive Director, Digital Radio Research Inc.
Mr. Royce Trenholm	Spectrum Engineering, Industry Canada

Case Study - Ottawa Test Site - Digital Radio Broadcasting Multi-site Transmitter

Project Incrementality (influence)	Direct User Impacts	Industry Sector / Supply Community Impacts	Economy / Societal Impacts
Involvement x project would not have been undertaken without Branch involvement x responsible for technical management of project x helped do some useful R&D that otherwise would not have been done	Technical results x new or improved product x new or improved process x advancement of knowledge x increased technical capabilities [] improved quality control [] new skills internally [] increased efficiency / improved productivity x technology transfer Policy / legislative results x policy behavioral changes x agreement / accord p legislative / regulation p acceptance of standards Commercial results [] increased sales [] increased market share [] increased profitability p cost savings Organizational effects [] increase in jobs p diversification x expansions x strategic alliances / partnerships [] achievement awards / recognition	[] production process efficiencies x increased science and technology information [] increased sales p cost savings p changes to industry structure (e.g., concentration, competitiveness internationally) [] spin-off companies x technology infrastructure (e.g., standard scientific and engineering data, industry standards, test protocols, and instrumentation) [] training of technological problem-solvers whose talents can be applied in many areas [] establishment of quality standards	[] reduced consumer costs [] protection of environment [] improved energy efficiency savings [] improved public health and safety x education / communication/ awareness x public service efficiency gains [] increased employment [] reduction in subsidies

[] has not occurred
x has occurred
p potential in future

Case Study - 3D TV

Note: this "case study" covers multiple aspects of BTRB work on 3D video imaging. As a consequence, there are, in fact several, mini-studies relating to different aspects of BTRB's 3D work within this overall case study.

Project Overview

The Advanced Video Systems Group initiated work on 3D TV in 1994, building on earlier work developing expertise in digital techniques for television and HDTV. The group identified 3D TV as the likely next major step in the evolution of television, following HDTV. The infrastructure which is being put in place for digital TV and HDTV including the development of the MPEG -2 video compression standard also permits the transmission of stereoscopic images and the creation of 3D from regular digital TV signals. The group's expertise in coding, video compression and psychophysical subjective testing were well suited for development of 3D video. In addition to Canada, Japan, the European Union counties and the U.S. are interested in 3D development at this time.

After a period of internal development and project work with IMAX on the use of MPEG compression techniques, BTRB joined with INRS (Professor Janusz Konrad, Principal Investigator and IMAX, industrial partner) and successfully applied for a 3-year NSERC Strategic Grant in Information Technology for the development of digital processing and compression techniques for 3D TV and related services covering the period Fall 1996 to Spring 2000. The three groups have complementary capabilities. INRS, which has extensive expertise in video processing, focuses on 2D to 3D conversion, intermediate view reconstruction and disparity estimation. BTRB is responsible for psychophysics, subjective assessment and MPEG-compatible stereo coding. IMAX contributes 3D material for use in testing and helps identify applications.

The NSERC grant has funded research at INRS and BTRB including additional staff (Post Doctoral Fellows at INRS and BTRB). BTRB has a continuing relationship with IMAX, beginning in 1995 with a contract with IMAX for research into the use of MPEG compression techniques.

The 3D work now involves most of the Advanced Television Systems Group in various aspects of the project (coding, subjective testing, recording, simulations, 3-D transmission system). While focusing primarily on 3D television broadcasting, the group is also addressing other application areas such as telemedicine, tele-education and multimedia.

While A-base funding is used, there are additional sources in addition to NSERC. The progress in developing 3D TV has also raised the interest of Spectrum Engineering, which is providing

funding in 1999-2000 for an initial study into defining the characteristics of an operational 3D Broadcasting System. The group is also collaborating with NHK (Japan) and Dr. Shimono of Tokyo University. The Advanced Television Group's Dr. Tam has received a $ 26K grant from the Japanese Broadcast Industry Association to conduct research on depth perception related to viewing distance and display size. Last year, in a CRC internal competition, the group received $60K from the President's Reserve Fund to acquire equipment to capture and display stereo images in real time.

The group is also involved in international testing of the MPEG-2 video compression and related effects on 3D images.

Profile of the Partners

IMAX is a major Canadian producer of high quality films, large format cinematographic equipment and is the owner of specialized theaters to view them. As such, the organization is critically dependent on remaining aware of the latest technology and making technically informed business decisions. As an indicator of their commitment to technical excellence, IMAX funds its own advanced imaging research laboratory, and collaborates on research into advanced 3D methods.

Spectrum Engineering Branch is the Industry Canada group responsible for allocation and use of radio and television communications spectrum in Canada. They work closely with the Branch in order to remain aware of emerging trends in broadcast technology.

Project Profile

Broadly speaking, the group is working on three aspects of 3D research. They are:

- the psychophysics of stereo vision, including subjective assessment of depth perception, response to asymmetric image quality, coding impairments, and reduced resolution;
- coding of stereo images, including characterization and comparison of MPEG-2 multi-view profile and MPEG-2 independent coding; and,
- development of stereoscopic video transmission test bed including the transmission of MPEG-2 compressed video over digital TV broadcast channels.

Specific sub-projects related to individual partners are described below.

NSERC-INRS/IMAX

The NSERC collaborative project with INRS and IMAX for the period November 1996 to April 2000 involves the following objectives:

- testing of MPEG-2 standard compression techniques using subjective assessment methodology;
- psychovisual research into stereo vision;
- development of digital algorithms to improve current stereoscopic acquisition and display system shortcomings; and
- exploration of processing and compression techniques for next generation stereoscopic viewing systems.

The NSERC funds are being used primarily to fund graduate students and Post Doctoral Fellows at INRS and Carleton/CRC.

The team at the Advanced Television Systems Group of the Branch have primary responsibility for conducting research into the response of the human visual system to conventionally-compressed stereoscopic video. This work is of immediate interest to IMAX. The team will also perform subjective assessment of various enhancement algorithms and next generation processing and compression techniques being developed.

Spectrum Engineering

Based upon the significant progress made in 3D video by the Advanced Television Systems Group, Spectrum Engineering has agreed to co-fund a project to study, define and characterize a 3D TV broadcasting system compatible with the current North American digital TV standard (ATSC DTV). The project will focus on the tradeoffs between quality, complexity and bit rate and the optimum means of transmitting 3D, compatible with DTV standards. The total project expenditures for 1999-2000 are estimated to be $48K in operating funds plus the work of the staff members. Spectrum Engineering will be supplying $14K, with CRC 's A-base resources making up the difference.

NHK (Japan) and IRT (Germany)

The Branch has conducted subjective evaluation of the MPEG-2 Multiview Profile as part of an international collaboration on behalf of the ITU.

Type of Technology

At the moment, the project is almost entirely involved in developing improved processes for coding 3D images and transforming 2D video codes to provide 3D images. Developing new and improved equipment is also a goal.

Roles and Relationships

There are several sets of formal relationships. They include:

- NSERC Grant involving INRS, IMAX and BTRB;
- BTRB with Industry Canada and Spectrum Engineering;
- BTRB with other national broadcast research organizations (Japan and Germany);
- BTRB with international standards development community; and,
- BTRB direct with IMAX.

The Branch also has less formal relationships with other Canadian private firms.

In terms of the NSERC Research Grant, Professor Konrad is the principal investigator, and responsible for coding and video compression studies. Dr. Lew Stelmach of BTRB, is also an adjunct professor at Carleton University and is responsible for the psychophysics and subjective testing aspects, while IMAX provides video material, consulting support and industrial perspective.

Spectrum Engineering has agreed this year (1999-2000) to fund an initial project to characterize a 3D broadcasting system to be compatible with the ATSC DTV. BTRB will provide the results to Spectrum Engineering and international standards groups.

In terms of support to international standards setting, BTRB is also conducting subjective testing of 3D images with various techniques related to the MPEG-2 standards and is making a contribution to development of a standardized methodology for subjective testing of 3D images.

BTRB also worked previously directly with IMAX under contract for MPEG compression tests in 1994-95.

Incrementality / Attribution

While Professor Konrad of INRS is the Principal Investigator for the NSERC project, Lew Stelmach of the Television Systems and Transmission Group of BTRB is identified as a collaborator on the project. The BTRB's expertise in subjective testing is an important component of the overall project and benefits which IMAX will receive.

In terms of the 3D project for Spectrum Engineering, as the group carrying out the work, the Television Systems and Transmission Group is completely responsible for any and all progress achieved.

For the international standardization work, as the Canadian organization involved in testing and development, BTRB is again a major participant in development of new standards related to 3D imaging and jointly responsible for advances in this area.

The expertise and knowledge of BTRB supported IMAX's internal analysis of the limits of increased video compression without noticeable image degradation.

Impacts

Impacts fall into several categories; namely technical and broader impacts at the organizational, sectoral or international. Impacts of the 3D work occur at all these levels. Because of the early nature of the work, many impacts are preliminary at this point and include transfer of knowledge to other broadcast researchers through scientific publications and presentations, as well as workshops and tutorials. Training of highly qualified personnel through the NSERC funding and co-op placements has also resulted.

Because the 3D work is ongoing, most of the eventual impacts are yet to be determined. However, there are a number of immediate impacts which can be identified and others which can be anticipated. These impacts will be discussed in terms of the four areas of 3D work identified previously.

NSERC Grant

IMAX has identified a number of benefits from the project. In terms of the contribution of BTRB, subjective testing of various coding options has led to a better understanding of the tradeoffs involved in 3D compression in terms of picture quality (perceived depth, sharpness and comfort), and a reduction in the anticipated bandwidth requirements for 3D viewing. More generally, IMAX has benefitted from general discussion, gaining knowledge about psycho-physical aspects of digital imaging, and information about new 3D equipment and standards. IMAX is confident that the project will help their firm remain competitive in the area of stereoscopic

imagery and 3D video systems. Longer term, more efficient compression techniques for 3D video coding will reduce the cost of installing and running 3D digital video entertainment theatres.

Any 3D technology developed will also have application in other entertainment applications, such as television and multimedia. Distance training, remote guidance and telemedicine will also be affected.

Spectrum Engineering

The project has just begun at the start of the current fiscal year, but anticipated impacts include definition of key elements of a 3D TV broadcasting system compatible with the current ATSC DTV standard, and continuation of Canadian leadership in international 3D video standards development through contribution to ITU-R WG-11B meeting in 2000.

International 3D Standards Community

The 3D subjective testing undertaken by the video systems group has led to a contribution to international standards such as ITU-R, including the methodology to do subjective testing for 3D video image quality. Further impacts are likely to occur based on continued progress in this area.

1995 IMAX Contract

The BTRB contract for MPEG image compression tests permitted IMAX to do the compression testing more rapidly and successfully than they could on their own. As stated by Mr. Gordon Harris, the BTRB contract on MPEG compression testing "was instrumental in proving the feasibility of using compression rations above our target goal . . . without significant image degradation on video projectors. . . the project has laid the groundwork for ongoing work here at IMAX."

Potential

BTRB work on 3D video imaging is ongoing. While good progress has been made, the work is in the early stages and continues to have great potential for the future. The main objective is to develop the best signal format and transmitting procedures for 3D TV broadcasting using standard digital TV broadcasting infrastructure. Another objective is to create 3 D images from 2D video signals. The Branch is involved in discussions with a Canadian firm about possible development of equipment for the 3D video market.

As can be seen from the case study, the Advanced Video Systems group is working on a number of complementary initiatives with Spectrum Engineering, Canadian universities, research institutes and private firms, as well as international research organizations and standards writing bodies. With this integrated approach, there is every reason to believe that their research, development and testing will have impacts in both the private and public sectors, both within Canada and internationally.

Individuals Interviewed

André Vincent	Manager Advanced Video Systems Group, BTR Branch
Dr. Lew Stelmach	Senior Research Scientist, Advanced Video Systems Group, BTR Branch
Professor Janusz Konrad	Institute national de la recherche scientifique, Université de Québec – Telecommunications
Mr. Gord Harris	Director Film Technology and Presentation Quality, IMAX Corporation

Case Study - 3D Television

Project Incrementality (influence)	Direct User Impacts	Industry Sector / Supply Community Impacts	Economy / Societal Impacts
Involvement [] project would not have been undertaken without Branch involvement x responsible for subjective assessment aspect of collaborative project management of project x helped do some useful R&D that otherwise would not have been done	Technical results p new or improved product p new or improved process x advancement of knowledge x increased technical capabilities [] improved quality control [] new skills internally p increased efficiency / improved productivity x technology transfer Policy/legislative results [] policy behavioral changes [] agreement / accord [] legislative / regulation [] acceptance of standards Commercial results p increased sales [] increased market share p increased profitability [] cost savings Organizational effects [] increase in jobs p diversification [] expansions x strategic alliances / partnerships [] achievement awards / recognition	p production process efficiencies x increased science and technology information [] increased sales p cost savings [] changes to industry structure (e.g., concentration, competitiveness internationally) [] spin-off companies x technology infrastructure (e.g., standard scientific and engineering data, industry standards, test protocols, and instrumentation) [] training of technological problem-solvers whose talents can be applied in many areas p establishment of quality standards	[] reduced consumer costs [] protection of environment [] improved energy efficiency savings [] improved public health and safety [] education / awareness [] public service efficiency gains p increased employment [] reduction in subsidies

[] has not occurred
x has occurred
p potential in future

Case Study - HDTV Subjective Testing

Project Overview

Beginning in the early 1980s, high definition television (HDTV) was identified as an important new technology to the U.S. In 1987, the Federal Communication Commission formed the Advisory Committee on Advanced Television Service (ACATS) to oversee the process for developing an HDTV standard. By the late 1980s, the U.S. was faced with the necessity to decide what system would become the industry standard. In 1988, the American broadcast community, principally broadcasters, set up a not for profit laboratory, known as the Advanced Television Test Centre (ATTC), to conduct fair and equitable testing on all HDTV prototype systems presented. ACATS and the FCC agreed to allow the private sector to test all proposed systems in collaboration with Canada. Through earlier discussions and attendance at international meetings, the U.S. was already aware that CRC had unique capability in the field of subjective testing. For evaluating prospective HDTV systems, it was agreed that ATTC would do the technical measurements and the new Advanced Television Evaluation Laboratory (ATEL) at CRC the subjective testing (psychovisual testing using "non-expert viewers").

In the first phase, six advanced TV prototype systems, one "enhanced NTSC" and five HDTV's were presented for testing. In 1990, all but one HDTV systems were either analogue or hybrid analogue-digital systems; but by early 1991, all HDTV systems except one were "all digital". In 1991-92, tests were done at both ATTC and ATEL on all six systems, and a full report was filed on each HDTV system. The "enhanced NTSC " system was withdrawn by its proponents before the report was published. ACATS committees did a comprehensive analysis of the strengths and weaknesses of each HDTV system, which was available to all participants. No single system was the clear winner, as various systems had superior characteristics in different areas. The one "analogue HDTV system" was withdrawn when ACATS and the FCC indicated that an all-digital system was preferred. After considerable discussion, the seven organizations supporting the four remaining all-digital systems agreed in 1993 to create the Grand Alliance, with the best elements of all four competing technologies integrated into a single system.

The next step was to test the HDTV system proposed by the Grand Alliance. It took over a year to decide on the final details of the system. Eventually in 1995, the system was tested using the same protocols as previously, plus some additional ones. The final report was completed in August 1995. After receiving and evaluating the test results, ACATS recommended this joint system to the FCC as the proposed U.S. standard for HDTV. The FCC accepted most of the recommendations in December 1996.

Profile of the Client

CRC's Advance Television Evaluation Laboratory (ATEL) was created to lead the subjective testing, which was Canada's share of this collaboration. The U.S. share was carried out through the Advanced Television Test Centre (ATTC), created and funded by the U.S. broadcasters, joined by the receiver manufacturers' association, and through test fees from the system proponents. The sole client was the FCC Advisory Committee on Advanced TV Service (ACATS) - a "blue ribbon" industry advisory panel appointed by the FCC, whose work was open to and included recommendations from all industry stakeholders. ATTC also acted as the general manager of the testing process, following test plans and procedures approved by ACATS. Following the original round of testing in 1991-92, Grand Alliance was formed, which then proposed a composite HDTV system, made up of the best elements of the four competing systems. Following completion of the testing and acceptance of the standard, Grand Alliance formally dissolved.

Roles and Relationships

In the late 1980s before the project began, American broadcasters became aware of the Canadian capabilities in subjective testing of video systems, primarily through ITU, the international standards and regulatory organization. This knowledge, and the understanding that North America would want a single new TV system standard, led to the decision to work jointly with Canada in HDTV testing, taking advantage of Canada's capability in subjective testing.

Under the supervision of the FCC Advisory Committee on Advanced Television Systems, ATTC managed the day-to-day testing program, with CRC acting in effect as a subcontractor, conducting the subjective testing through ATEL. ATTC was a not for profit organization funded by the American broadcasters and other interested parties (ABC, NBC, CBS, CEMA, etc.), with the sole mission to provide neutral thorough credible testing of all HDTV systems vetted and approved for testing by ACATS.

The proponents of the various HDTV transmission systems provided to ACATS the document versions of their planned systems in 1990-91, and their real time working hardware systems in 1991-92, for examination and testing, and received the results of the tests, which were made public. Following the first round of competitive testing, Grand Alliance was formed, made up of the seven proponents of the four digital tv broadcast systems being tested. They then developed a single system, incorporating the best features of the competing systems, which was in turn reviewed, modified and finally accepted for testing by ACATS. This Grand Alliance dissolved following acceptance of their joint system as the U.S. digital TV standard. Another industry body, the Advanced Television Systems Committee, had been established in 1980, to develop HDTV production standards; was asked by the FCC and ACATS to write the DTV transmission standard based on the test results. The CRC joined ASTC as a research organization member, and continues to participate at the present time.

Incrementality / Attribution

CRC and Canada were full partners in the HDTV testing which was done during the development of a U.S. standard for HDTV systems. The test results which were produced played a critical role in decisions about acceptable performance and, ultimately, the combined system developed by the Grand Alliance members. ATEL and the CRC Advanced Video Systems Group played the primary role in the subjective testing which occurred as an essential part of the overall HDTV testing.

As stated by Mr. Peter Fannon, ATTC President, "ATEL's work was uniformly brilliant, and the written reports were excellent - there was never once a complaint about the ATEL work, nor were the results ever challenged". Mr. Fannon's comments were made in the context of his experience with the audio testing work whose quality and credibility had been questioned, causing considerable difficulty in the project.

Technical Results

After viewing of the various proposed HDTV systems video performance (against reference images) by panels of screened viewers following a prescribed protocol, ATEL provided the results of the subjective testing to the client, ACATS. The subjective tests captured viewers' ratings of various attributes of the video image to each system being tested. The test reports were written in a standard format which allowed for straightforward quantitative comparison among the systems, and for statistical soundness and appropriate "exit interview" commentary.

The final test of the "Grand Alliance" HDTV system followed the same approach.

Impacts

The participation of CRC in the HDTV testing through ATEL produced results at several levels.

Overall, the HDTV testing of the various HDTV systems which ATEL participated in led to informed business decisions by the participants. Two proponents recognized that their systems were uncompetitive and dropped out. The others recognized that an integrated system including design elements of several of the proposed systems would be the best result. The Grand Alliance then produced a common HDTV broadcast system. After further testing provided assurance that the quality of the proposed system was equal to or superior to the results in the original competitive round, it was adopted as the U.S. standard. Because of the involvement of CRC in the testing on behalf of Canada, the U.S.HDTV standard became effectively the North American standard.

The professionalism of the CRC involvement in the design and carrying out of this project and the special testing available through ATEL led to a much greater influence by Canada in the development of a North American HDTV standard than would have otherwise been possible. The ability of Canada was recognized to the extent that Canadian representatives contributed to the ACATS became an official member of the Advanced Television Systems Committee, set up to write the HDTV standard in parallel to the testing.

The success of this project has led to a greater awareness in the U.S. and internationally of the quality of research and testing provided by the Broadcast Technology Research Branch, and enhanced Canada's reputation in this field. Canadian firms working with the Branch have benefited from experience gained, and the equipment available.

At the organizational level, CRC and the television research group have improved knowledge and capacity in the area of subjective testing. This includes a well-equipped, functioning laboratory (ATEL) and experienced scientific and technical staff. CRC's success in undertaking this work has contributed greatly to their international reputation and credibility for providing neutral credible high quality research and test results. The availability of ATEL, which was created for this project and the knowledge of staff developed during this project, has allowed the group to pursue further research on DTV, HDTV, and digital audio systems, testing various compression techniques and to move forward into related research on 3D television with Canadian firms. The project has also led to contract work for external clients requiring similar subjective testing.

The equipment and experience gained by the television research groups in the Branch were invaluable to later work in Canada related to the introduction of digital television broadcasting. While the introduction of HDTV has been slow to develop, it is now beginning to move forward. The Canadian television broadcast community has now joined together to form a not for profit organization Canadian Digital Television Incorporated (CDTVI) to study the technical implications of the various options for implementing a Canadian digital TV broadcast system. CDTVI will be working closely with Industry Canada's Spectrum Engineering and the Branch in this area. A test site, similar to the Ottawa test site for digital audio broadcasting, is being set up to test operational characteristics of digital television broadcasting before full implementation.

Individuals Interviewed

Dr. Metin Akgun	Vice President Broadcast Technologies Research Branch, CRC, former Director of Video Broadcast Research Group
Mr. Peter Fannon	former President, Advanced Television Test Center
Mr. Phil Corriveau	Researcher, Subjective Visual Testing, Broadcast Technologies Research Branch, CRC
Mr. Bob Leafloor	former project manager, HDTV subjective evaluation 1990- 1995

Case Study - HDTV Subjective Testing

Project Incrementality (influence)	Direct User Impacts	Industry Sector / Supply Community Impacts	Economy / Societal Impacts
Involvement x project would not have been undertaken without Branch involvement x responsible for major section of project x helped do R&D that otherwise would not have been done	Technical results x new or improved product x new or improved process x advancement of knowledge [] increased technical capabilities x improved quality control [] new skills internally [] increased efficiency / improved productivity x technology transfer Policy/legislative results [] policy behavioral changes [] agreement / accord x legislative / regulation x acceptance of standards Commercial results [] increased sales [] increased market share [] increased profitability [] cost savings Organizational effects [] increase in jobs [] diversification x expansions x strategic alliances / partnerships [] achievement awards / recognition	[] production process efficiencies x increased science and technology information [] increased sales [] cost savings x changes to industry structure (e.g., concentration, competitiveness internationally) [] spin-off companies x technology infrastructure (e.g., standard scientific and engineering data, industry standards, test protocols, and instrumentation) [] training of technological problem-solvers whose talents can be applied in many areas [] establishment of quality standards	[] reduced consumer costs [] protection of environment [] improved energy efficiency savings [] improved public health and safety [] education / awareness x public service efficiency gains [] increased employment [] reduction in subsidies

[] has not occurred
x has occurred
p potential in future

Case Study - DAR Satellite

Project Overview

In early 1997, the radio group at BTRB conducted a study under contract for the U.S Based Communications Equipment Manufacturers Association (CEMA) with respect to satellite transmission of Digital Audio Broadcasting at L and S band. BTRB was chosen based on earlier work they had done for CEMA members related to testing of digital audio broadcasting receivers and pilot studies on the use of the Eureka-147 digital audio system.

In the mid 1990s, the U.S. digital radio community was trying to decide whether to use L band (1.5 GHz), which Canada had already decided to use, or S band (2.3 GHz) to transmit digital radio signals via satellite. There were a number of political and technical factors involved, including the fact that the US military used the L band for telemetry associated with testing new aircraft. The BTRB study was intended to provide an analysis of the technical factors affecting digital audio broadcasting and the characteristics of L or S band broadcasting.

The project consisted of comparing the effects of transmission frequency and other design elements on digital audio broadcasting from satellites. The project compared the performance of various digital coding techniques and other design elements on reception quality at 1.5 and 2.3 GHz.

The study demonstrated that L band (1.5 GHz) was technically superior to S band (2.3 GHz) in terms of minimizing bandwidth requirements for comparable results. The test data showed that use of the 2.3 GHz band would require adjustments to the broadcast transmission design to obtain acceptable results.

The report of the test results was filed with the FCC. It was well received and widely circulated. While the U.S. decided to allocate digital audio broadcasting to the S band rather than the technically superior L band for political reason, the report was instrumental in building awareness of the design implications of using S band.

The report reinforced the reputation of BTRB internationally as a source of neutral, credible, high quality research and testing of digital radio transmission and reception.

Profile of the Recipient / User

CEMA is the organization representing the interests of electrical and electronic manufacturers in the United States. They have been heavily involved in the introduction of digital radio and television broadcasting to the U.S., and the implications for their members. Since the late 1980s,

CEMA has been involved in a number of projects involving the introduction of digital standards for digital radio and digital HDTV.

Project Profile

The project involved CRC conducting tests of the broadcast transmission and reception characteristics of digital audio broadcasting from a satellite at L band (1.5 GHz) and S band (2.3 GHz). All of the radio research groups (systems, transmission, signal processing) were involved, together with the Propagation Group in Radio Sciences.

The project was completed and the report produced in three months in early 1997, a very short time frame. Much of the knowledge necessary to complete the project was already available, due to earlier research of the groups. The price of the contract was $14,000 U.S., however the real cost of the project was about twice that amount.

Roles and Relationships

CEMA had previously worked with the CRC radio research group on a project to assess the characteristics of various approaches to digital audio broadcasting, including the European Eureka-147 system. It was on this basis that CEMA was aware of the capabilities of the CRC group for conducting tests on digital audio broadcasting.

As mentioned, there were two opposing groups in the U.S., one wished to use the 1.5GHz band (which was under-used) due to its superior technical characteristics, while another group, led by the military wanted to reserve the 1.5 GHz band for military use. The other available band was at 2.3 GHz.

The technical report was provided to CEMA and was filed with the Federal Communications Commission. The FCC decided after representations from all interest groups to use the 2.3 GHz band for DAR-satellite communication.

Incrementality / Attribution

The study was accepted by CEMA as credible evidence and was presented to the FCC as input to the discussion about whether to use L or S band for digital audio broadcasting. As such, the work by the Digital Radio Group provided the test results showing that L band was technically superior. There were no disputes about the quality or content of the report provided by CRC.

Licence / Royalties / Revenues

While the project produced revenues of $20K Canadian, it did not include full cost recovery. In fact, total cost of the project was closer to $40K. It was decided within CRC and Industry Canada

that additional effort should be spent to produce a quality report as it was in Canada's interests to try to get the U.S. to follow Canada's example and also use L band.

Impacts

There were several levels of impacts.

While the FCC decided for political reasons to allocate the S band for digital audio broadcasting from satellites, in spite of the technical superiority of L band, data from the study provided valuable input to design considerations by satellite broadcasters. As well, the study had implications for spectrum allocation in the U.S., as it provided data on minimum bandwidth requirements for quality audio broadcasting.

The acceptance of the study without reservation by CEMA and the FCC demonstrated the credibility of the study and enhanced the reputation of BTRB as a high quality world class broadcast laboratory in the U.S., internationally and in Canada.

The study led to requests by U.S. satellite broadcasters for further contract work with BTRB. These were not accepted, as working with the U.S. on improving digital audio broadcasting in S band was considered against Canadian interests, which were still trying to encourage the use of L band across North America.

Individuals Interviewed

Mr. Gérald Chouinard	Special Assistant to the President, CRC, and former Director Radio Research Group
Mr. Ralph Justus	Executive Director, Communications Equipment Manufacturers Association

Case Study - Digital Audio Radio-Satellite Study

Project Incrementality (influence)	Direct User Impacts	Industry Sector / Supply Community Impacts	Economy / Societal Impacts
Involvement x performed R&D and testing essential to project involvement x responsible for production of technical report ▯ helped do some useful R&D that otherwise would not have been done	Technical results ▯ new or improved product ▯ new or improved process x advancement of knowledge ▯ increased technical capabilities ▯ improved quality control ▯ new skills internally ▯ increased efficiency / improved productivity x technology transfer Policy/legislative results ▯ policy behavioral changes ▯ agreement / accord ▯ legislative / regulation ▯ acceptance of standards Commercial results ▯ increased sales ▯ increased market share ▯ increased profitability ▯ cost savings Organizational effects ▯ increase in jobs ▯ diversification ▯ expansions x strategic alliances / partnerships ▯ achievement awards / recognition	▯ production process efficiencies x increased science and technology information ▯ increased sales ▯ cost savings ▯ changes to industry structure (e.g., concentration, competitiveness internationally) ▯ spin-off companies x technology infrastructure (e.g., standard scientific and engineering data, industry standards, test protocols, and instrumentation) ▯ training of technological problem-solvers whose talents can be applied in many areas ▯ establishment of quality standards	▯ reduced consumer costs ▯ protection of environment ▯ improved energy efficiency savings ▯ improved public health and safety ▯ education / awareness x public service efficiency gains ▯ increased employment ▯ reduction in subsidies

▯ has not occurred
x has occurred
p potential in future

Case Study - CRC-COV

Project Overview

CRC-COV is a software package developed by the Radio Broadcast Systems Group which supports the analysis of broadcast coverage for a variety of transmitters and signal characteristics. Development began in the early 1990s, specifically to model the broadcast coverage for the Eureka-147 system for digital audio broadcasting. This system permits low power broadcasting from multiple transmitters, on a single frequency. CRC-Predict is a related software product developed in the early 1990s at CRC, which provides an analysis of signal attenuation over distance under various terrain conditions. It was integrated into the earliest version of CRC-COV, which modelled the reception pattern for the Eureka-147 digital audio broadcast system with a variety of options, including variation in the number, location and power of transmitter sites to improve reception.

Early versions of the software were shown as early as 1991, and received interest from the international broadcast community, particularly in Europe, which was just beginning to introduce the Eureka system. The first official demonstration was at the 1994 World Symposium on Digital Audio Broadcasting in Toronto. This unique product was well received, and raised the international profile of the group, demonstrating its capability and technical skills. In 1996, a DOS version (CRC-COV4) was completed, which has application beyond digital radio to include a wide variety of other broadcast systems (i.e. FM radio, digital TV, military applications.). It has since been licenced to a number of users and, together with the technical assistance and advice to use the software effectively, has led to large revenues for the group, totalling well over $300,000 over the past five years. A more user friendly Windows version, with increased capability, is being developed. A Swiss firm is collaborating on developing CRC-COV for use in the European environment.

Most of the use of CRC-COV has been by the Radio Broadcast Group at CRC, who are familiar with the capabilities of this complex tool. CRC-COV has been licenced to Canadian broadcast consultants for use in their consulting business. While having CRC-COV has enhanced their technical capability and competitiveness, it has not resulted to date in much business, since the change to digital radio and TV has been slow in coming. There are only three digital audio installations which are just being installed in Canada and none in the U.S.

Profile of the Recipient

Many organizations have purchased CRC-COV. They include large Canadian broadcasters with technical capability (i.e., CBC and COGECO), Canadian broadcast consultants who design and troubleshoot broadcast transmission systems and broadcast organizations in other countries, the Canadian military, Environment Canada and the Government of Quebec.

Project Profile

The project has continued since the early 1990s in various forms. It began with a focus on calculating the broadcast transmission coverage for the Eureka-147 system. Since then, the project has expanded to include analysis of other broadcast transmission systems, including digital television and military systems. The Windows version of CRC-COV, which is presently being finalized is a very powerful, multi-faceted design and troubleshooting tool for broadcast consultants and researchers.

Software designers are hired under contract to work on CRC-COV under the direction of permanent staff. The DOS version of the software has been licenced to a number of organizations, along with training in the use of the software. There have been a number of discussions related to transfer of this very successful technology to the private sector. Recently DND became interested in use of the software and provided additional staff under contract through CRC to work on DND related modules of the software. This work has just been completed.

Roles and Relationships

The Radio Broadcast Group has remained the primary group behind the development of CRC-COV since the inception of the project in the early 1990s. The project began as an idea of the group leader, Gérald Chouinard, who began by working with a co-op student on developing the software in 1991. The student was Bernard Breton, who remained at CRC and is now a senior research engineer in the radio broadcast group. As the project showed promise, it became one of the main initiatives within the group, led by Bernard Breton.

Test results from other projects were used as input to the development of CRC-COV. The DAB tests in the early 1990s in Toronto, Montreal and Vancouver were used to verify CRC-COV predictions and improve the software. More recently, the Ottawa test site measurements were also compared to the CRC-COV predictions.

Other countries (Australia, Switzerland, Korea, Taiwan and Potugal) have shown great interest in the software.

With the release of the DOS version CRC-COV4 in 1996, there has been considerable interest in licensing of the software for use by Industry Canada broadcast regulators, broadcasters and consulting firms. The complexity and wide applicability of the latest version of CRC-COV requires extremely skilled personnel with extensive training and experience in its use. This fact has hampered efforts to find a firm interested in licensing the use of CRC-COV4.

Incrementality

The radio broadcasting group is the sole developer of CRC-COV since the early 1990s. Test results from digital radio broadcasting trials in Montreal, Toronto and Vancouver as well as the Ottawa field trial provided experimental data for comparison to CRC-COV. DND provided funding for development of the DND modules under the supervision of the radio broadcast group.

Technical Results

CRC-COV is a unique software tool for research into the complexities of broadcast transmission coverage for digital broadcast systems. The next version, not yet completed, will allow a much broader range of applications into a variety of communications systems beyond broadcasting.

Impacts

CRC-COV is providing important technical support to the design of Canada's digital radio and television transmission system. Industry Canada's broadcast regulatory branch, CBC and broadcast consultants have and use the software to support design of digital radio systems. Use of the software has enhanced the technical capability and competitiveness of broadcast consultants, and resulted in some increased business. The commercial impacts have been small as digital audio broadcasting is only now being introduced in Canada and is still not available in the U.S. Teleglobe Canada is using CRC-COV to plan and deploy MMDS systems in Canada.

CRC-COV has had a considerable impact on the radio broadcast group itself. It has been the foundation of much of their research and development activities over the past eight years, resulting in a large number of publications and presentations and has given the group credibility and enhanced visibility in the international broadcast research community. CRC-COV has also provided more than $300,000 in revenue to the group over the past five years and has supported group research activities, to a large extent devoted to improving CRC-COV.

Potential

Completion of the new Windows version presently being finalized is likely to result in a new wave of interest in CRC-COV, as it can be applied to a much wider range of communications systems.

Licensing of this software and accompanying support for specialized applications is likely to result in considerable revenues and contract work for the group as digital broadcast radio and TV systems are introduced both in North America and world-wide.

Individuals Interviewed

Mr. Gérald Chouinard	Special Assistant to the President, CRC, and former Director of Radio Broadcast Group
Mr. René Voyer	Manager, Radio Broadcast Group
Mr. Gord Henke	Partner, D.E.M. Allen Broadcast Consulting Ltd.

Case Study - CRC-COV

Project Incrementality (influence)	Direct User Impacts	Industry Sector / Supply Community Impacts	Economy / Societal Impacts
Involvement x project was conceived and carried out by Branch [] responsible for technical management of project [] helped do some useful R&D that otherwise would not have been done	Technical results x new or improved product x new or improved process x advancement of knowledge x increased technical capabilities [] improved quality control x new skills internally x increased efficiency / improved productivity x technology transfer Policy/legislative results [] policy behavioral changes [] agreement / accord [] legislative / regulation [] acceptance of standards Commercial results x increased sales p increased market share p increased profitability [] cost savings Organizational effects p increase in jobs p diversification [] expansions x strategic alliances / partnerships [] achievement awards / recognition	[] production process efficiencies x increased science and technology information [] increased sales p cost savings p changes to industry structure (e.g., concentration, competitiveness internationally) [] spin-off companies x technology infrastructure (e.g., standard scientific and engineering data, industry standards, test protocols, and instrumentation) [] training of technological problem-solvers whose talents can be applied in many areas [] establishment of quality standards	[] reduced consumer costs [] protection of environment [] improved energy efficiency savings [] improved public health and safety [] education / awareness x public service efficiency gains p increased employment [] reduction in subsidies

[] has not occurred
x has occurred
p potential in future

Comparison with Other Countries and their Broadcast Research Organizations

As part of the review of the Broadcast Technologies Research Branch, it was decided to gather information about the broadcast standards and regulatory situation and protection of the public interest in other countries and the role of specific broadcast research organizations. Two that were chosen were:

1. the United Kingdom and the British Broadcasting Corporation's Research and Development Department; and,

2. the United States, Federal Communications Commission, Advanced Television Systems Committee and the Advanced Television Test / Technology Centre.

The comparison focused on information related to the review issues and related questions.

1. BBC Research and Development Department, United Kingdom

Background

Traditionally, British telecommunications research was the responsibility of the Post Office. As government cutbacks became more and more severe, the Post Office moved out of that role. In recent times, the Government Radio Communications Agency has been responsible for issues related to different types of use of spectrum. In keeping with the reduced role for government, the Agency's primary role is concentrated on policy decisions and arbitration in the case of disputes or controversy. Operational responsibility has been devolved to the organizations providing particular services and the government monitors the situation.

In the case of television, there is a TV Planning Group made up of the major stakeholders, including the BBC, NTL, a major cable operator, some transmitter operators and other independent companies. One of the responsibilities is to make recommendations on the allocation of spectrum. BBC has the unofficial role of representing the public interest in the group, supported by the government agency monitoring the situation. If there is a difference of opinion over spectrum use, the Radio Communications Agency brings together all stakeholders and develops a policy after receiving input from all interested parties. In the case of the use of the existing analogue TV band, the agency has allowed the TV operators to show that they can introduce digital services with a minimum of interference. The research effort to provide technical support for this group is quite large, and is provided primarily by the BBC and large cable operators.

Profile of BBC Research Department

At the present time, the department has an annual budget of about $13M or $28M Canadian. They have 120 professional engineering staff and an additional 50 to 60 contract workers. The department has about 2M pounds and 20 additional staff temporarily due to the introduction of the digital TV terrestrial service (see below).

The main groups within the Department are:

- Digital Broadcasting (TV, Radio, Text and multimedia);
- Audio Technology (speech recognition, audio coding)
- Virtual Production;
- Production Issues (archive restoration, cable free cameras);
- New Services: Internet; and,
- Spectrum Planning.

With respect to revenue generation, there is no real pressure to licence technology as they operate as an open system. There is no specific marketing expert in the department. There is some contract work, however, the amount of fees charged for projects is variable, depending on the interest of the Department. For example, testing of a digital receiver system may be done at no charge or a reduced fee due to the interest of the department in this area. Some other tests not related to the interests may require full cost recovery (not priced to make a profit). The biggest difficulty in technology transfer and working with firms is intellectual property ownership issues.

Introduction of Digital TV Terrestrial Services

BBC has been a leader in the development of the European digital TV terrestrial service, and was the first to introduce an operational system. The implementation was a priority, and the translation from a laboratory demonstration to an operational system was completed in a short time. The project diverted a considerable amount of the effort of the BB Research department, about 30%, resulting in a reduction in the amount of fundamental R&D being done during that period.

BBC has also being working with digital broadcast equipment manufacturers on new equipment. The decision about whom to work with is based on who can best do the job. They had a bad experience in choosing a British firm with less capability - it didn't work out. Other European countries are benefiting from the pioneering work of the BBC, as equipment manufacturers have developed improved capability and can adapt UK products for use in other countries.

Demonstrating Relevancy - Linking R&D Agency to Clients and Stakeholders

Mr. Shelswell spoke of the need to present technical information to clients and decision makers in a manner they can understand and make use of. It is important to know the purpose of the information and to shape the presentation to address that need. As an example, the BBC Research Department presents a summary of four emerging issues to BBC management quarterly, with a one-page summary of each issue.

Mr. Shelswell also spoke of the priority placed on marketing capabilities to partners and stakeholders. As an example, the BBC Research Department holds a series of one-day open houses or workshops annually to present the results of recent projects, discuss future initiatives and provide tours of the facilities. Individual one-day workshops are held for the various client and partner groups (BBC colleagues, university and other research laboratories, and industry).

The Changing International Regulatory and Standards Development Environment

The United Kingdom has adjusted its strategy towards international standards work recently, as the standardization work of ITU is beginning to be taken up by other groups such as ISO.

As a UN agency, the ITU works on a consensus basis, with the result that often hard decisions on choosing the best approach are not taken. Rather, multiple standards are accepted, reducing the value and effectiveness of standardization. In addition, as a result of the consensus process, development of standards takes a very long time in the ITU system. For these reasons, the International Standards Organization (ISO) is becoming more active in standards development, and the BBC has transferred some attention to ISO and the European Technology Standards Institute (ETSI). For spectrum allocation, ITU remains important.

Points of interest to BTRB:

- work with ISO and other standards and regulatory bodies as well as ITU-R; and,
- market, promote and communicate capabilities through the web-site and annual workshops for clients and stakeholders.

2. *American Digital Television Broadcast Standards Environment*

Background

The Federal Communications Commission in the U.S. operates similarly to the United Kingdom, in that there are no large government standards and regulatory agency charged with protecting the public interest. Rather, proponents of change in the use of spectrum or wishing to introduce new broadcast systems bring forward their proposal, complete with rationale and test data, and the FCC puts it out for public comment. The government role is less expensive and becomes reactive rather than proactive. Essentially the system relies on the proponents serving their own interests by delivering a proposal which meets the test of serving the public interest as well as their own. Typically, a temporary government agency was set up to manage the standards development and regulatory process and protect the public interest until the situation was resolved to the satisfaction of the FCC.

In the case of high definition television (HDTV), it became obvious in the mid to late 1980s that this was likely to be important technology in the future. In order to begin testing for introduction of HDTV in 1988, the broadcast community formed a not for profit testing laboratory known as the Advanced Television Testing Centre (ATTC) to provide fair and equitable testing of any HDTV system presented.

In this case, which was highly unusual, the FCC agreed to set up an Advisory Committee on Advanced Television to manage the HDTV process. Early in the planning stage, it was agreed to collaborate with Canada to share costs and in recognition that any new HDTV standard would be for all North America, not just the U.S. An MOU was written with the FCC in 1989, agreeing to share the testing work for the development of an HDTV system standard with Canada, as it was recognized that the CRC had specialized expertise in subjective testing.

The U.S. private sector broadcast community has developed a multi-element approach to the development, promotion and maintenance of digital television broadcast standards and systems. The elements include a voluntary standards writing element (Advanced Television Systems Committee), a digital television technology development, testing, and verification centre (Advanced Television Technology Centre), and a body representing the consumer digital television manufacturers (Consumer Electronic Manufacturing Association). These groups work with the FCC to ensure that private and public sector interests are both met in the U.S. digital television broadcasting.

Profile of Advanced Television Testing Centre (ATTC) 1988-1995

ATTC was formed in 1998 by the American television broadcasting community for a single purpose, to provide performance testing of proposed HDTV systems. The Centre was supported completely by the private sector, with no government funding. There were eight major sponsors; ABC, NBC, CBS, PBI, National Association of Broadcasters, Association for the Maximizing of Service for TV (MSTV) and several other organizations representing independent television operators and other interest groups.

The centre operated for seven years, from 1988 to 1995. The total budget for that period of time was about $25M or $3M/yr, made up of $15M in fees from members and the remainder from fees paid by those offering HDTV systems for testing. During that time, ATTC had 16 full-time staff, six professional engineers and scientists, six technicians and three support staff.

For the tests, ATTC contracted for the design and construction of specialized tape recording equipment (price $1M) to record high quality video signals from the systems to be tested and sent to the Advanced Television Evaluation Laboratory (ATEL) at the CRC in Canada. ATTC was responsible for the technical testing of the HDTV systems being proposed, including hardware and signals, and recording of the video signals on tape, while ATEL provided the subjective testing of the proposed HDTV video pictures by humans.

Advanced Television Systems Committee

The Advanced Television Systems Committee (ATSC) was formed in the early 1990s to establish voluntary technical standards for advanced television systems, including HDTV. In this way, the ATSC acts on behalf of the broadcast community in discussions with the FCC and ensuring that the public interest is served. In many ways it is similar to the Canadian Standards Association with respect to U.S. digital broadcast issues.

ATSC is closely linked to both public and private sector parts of the U.S. broadcast community, including the FCC, ATTC and Consumer Electronics Manufacturers Association (CEMA). While the Grand Alliance was working with ATTC on technical testing of digital TV systems for use in North America, and the development of a single integrated approach, the ATSC was writing the equivalent standard which represented the Grand Alliance system. The FCC adopted this ATSC Digital Television Standard (A/53) in 1996 as the basis for the next generation of broadcast television. The video and audio compression, data transport structure and modulation and transmission system specified in the standard are mandated for use by terrestrial broadcasters.

Canada was a partner in the deliberations leading to the development of the combined U.S. / Canada standard A/53. Since 1996, other countries have also adopted the standards (South Korea, Taiwan and Argentina). ATSCV continues to promote use of the standards and has developed a joint certification logo with CEMA to identify those broadcast receivers which will accept all digital video signals included in the standard.

Advanced Television Technology Center 1995 - Present

During the period 1988 to 1996, ATTC had a budget of about $3M/year. After the completion of the HDTV standard development in 1995, ATTC was shut down, with all staff but one let go. CBS, which had been the technical leader ATTC, wanted to carry on using the Centre, which had $7M invested in equipment, as a technical resource for the industry.

Immediately after closing, the Centre was restarted and renamed as the Advance Television Technology Centre, with CBS, ABC and PBS continuing to provide financial support. The purpose of the center is to facilitate implementation of digital TV service within the US and around the world, through the development, testing and verification of digital television related systems, services and their component parts. The Center provides testing, product evaluation, certification, training and consultation on delivery and reception of the new U.S. digital television service and HDTV, delivered through a terrestrial transmission system. The new ATTC is now smaller, leaner and meaner with an annual budget of $1.2M. Sony, Panasonic, Phillips, Mitubishi, Samsung, Pioneer, Lucent and other leading television industry organizations have joined and now provide support. The challenge now is whether the Centre can maintain the capability to be an independent laboratory, doing work for members and contract work for non-members.