AN ANALYSIS OF CANADIAN TELECOMMUNICATIONS R&D ACTIVITIES: AN ASSESSMENT OF ITS STRENGTHS, WEAKNESSES AND FOCI

Submitted to the:

Research & Technology Directorate
Communications Development and Planning Branch
Department of Communications
300 Slater Street
Ottawa, Ontario
K1A 0C8

Pursuant to DOC
Articles of Agreement
Number: 36100-2-7930
dated November 23, 1992

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AN ANALYSIS OF CANADIAN TELECOMMUNICATIONS R&D ACTIVITIES: AN ASSESSMENT OF ITS STRENGTHS, WEAKNESSES, AND FOCI

1.0 INTRODUCTION

The Research and Technology Policy Directorate of Communications Canada is, as part of its overall mandate, developing a long-term telecommunications research and development strategy. To assist it in carrying out this work it has retained Lapp-Hancock Associates Limited to carry out *An Analysis of Canadian Telecommunications R&D Activities and an Assessment of its Strengths, Weaknesses and Foci*.

Given below is the final report on this work.

2.0 PURPOSE & SCOPE OF STUDY

The purpose of this Study as a whole was to analyze Canadian R&D telecommunications-based research and development activities and to assess Canadian R&D strengths and weaknesses in this field. The work was confined to generic and broad subsets of technologies rather than specific individual technologies, as appropriate to the development of a long-term telecommunications R&D strategy. The Project Statement of Work identified the following main areas to be addressed:

- wireless personal communications
- informatics and transaction services
- enhanced media services

In addition it was proposed by Lapp-Hancock Associates Limited, and accepted by the Project Authority, that the following subset be included as being a generic requirement to future implementation of the above three subsets.

- Intelligent networks and related items

Finally, any significant telecommunications R&D being carried out outside of these four subsets was identified and analyzed.

As the work progressed, it was found that many of the forward thinking organizations interviewed were found to be carrying out *Enabling Technology* research and development that cut across the product specific listings of the subsets identified in the revised Statement of Work. With the full approval of the Project Authority these were identified separately and described for analysis.

Within each of these categories of technology the following elements were determined:

- Current and planned activities
- Strategic alliances in place or being pursued
- Competition
- Commercialization
- Weaknesses/Barriers
- Strengths/Opportunities

The *time-frame* considered for this study was R&D planned for commercial exploitation between 1998 and 2003.

Finally, detailed analysis of the relative strengths of Canadian R&D activities and government policy and programs with respect to those of major industrialized countries was carried out in the final phase of the study.

3.0 METHODOLOGY

With the agreement of the project Authority the methodology, although defined in the Statement of Work, and at the Project Start Meeting, was revised, based on information received during the Project. The inclusion of an *Enabling Technology* classification, discussed in Section 2, and other modifications are detailed hereunder.

3.1 Information Gathering

The information gathering element of the Assessment was specialized and selective.

It commenced with a literature search. The prime purpose of the literature search was to identify the thrusts of telecommunications R&D through, for example, the types of research supported by the NSERC research granting program; by the review and analysis of research reported in a narrow selection of relevant *learned journals*; and by the detailed review of a small number of recent reports on the subject. The literature search provided a framework for the main information gathering mechanism of the Assessment, that of personal interviews with selected members of the telecommunications R&D Community throughout Canada.

The major information gathering activity took the form of interviews. Some 60 telecommunications research entities, located throughout Canada, were identified. From these, 50 entities were interviewed on their current and future R&D activities, and to solicit their opinions on a number of R&D related matters. These entities were broken down into

the following groups;

- 10 Universities
- 7 Research Institutes & Centres of Excellence (Government and Private Sector)
- 21 Developers and Manufacturers
- 12 Telecommunications Service Suppliers & Systems Developers

The 50 entities are a very high proportion of all Canadian telecommunications research entities, together with a suitable balance between the four classifications. The selection also permitted some minor revisions during the course of the project to take into account the unavailability of some specific interviewees.

The Developers and Manufacturers dominate the sample, with the Universities (representing directed scientific research) and the Service Suppliers and Systems Developers (representing Canada's *end user*) each having a similar representation at approximately half that of the Manufacturers. The smaller number of interviews in the fourth classification, that of Research Institutes and Centres of Excellence, represents however an equal, or possibly even slightly higher, representation for this group, given its smaller overall numbers.

While it was recognized that face-to-face visits are preferable to phone interviews, both the time-frame of the Assessment and its limited budget precluded 100 percent face-to-face interviews. Notwithstanding this, by careful use of the limited travel budget and by taking advantage of travel carried out for other purposes, it was possible to schedule 25 face-to-face interviews.

To facilitate information gathering during the interviews, and to ensure that all interviews were conducted in a form that permitted valid comparison and analysis, detailed interview tools were created. These were aimed at meeting the following objectives:

- the compiling of a brief, but reasonably detailed, background of the status and activities of each organization
- the obtaining of responses (in discussion form) to thirteen (13) detailed questions covering the elements listed in Section 2 above.
- the completion, with detailed footnotes, of activities within the four technology areas, also detailed in Section 2 above, together with information on *enabling technology* activities.

These interview tools, together with descriptive information, are contained in Appendix A to this report.

3.2 Compilation of Findings and Assessment

As information was gained, both in the literature search and from the interviews, it was compiled in a systematic manner. While the results of the literature search were summarized separately, with further details in appendix form, the inputs from the interviews were entered into a data repository, classified (and cross referenced to individual interviews) under the four major types of R&D entity, and the four technology groups. In each case the data was then sorted into the six elements given in Section 2 above. When the data repository was complete the Project Team carried out a detailed analysis of this very large amount of *raw information* to determine findings and assessments.

4.0 LITERATURE SEARCH FINDINGS

In planning the literature search it rapidly became evident that the standard literature search covering the four technological areas of interest, over even a few recent years, would list literally thousands of papers and publications. These would generally be in a form not amenable to analysis, or even readily relatable to the areas of interest.

After general consultation it was agreed that the most appropriate approach to obtain an outline of the direction and strengths of Canadian telecommunications R&D was to survey and analyze the four following elements of the published literature;

- Canadian participation in major telecommunications and related conferences as ascertained from an analysis of the published papers of said conferences.
- Key recent consultative studies on telecommunications in Canada.
- The grants of the National Sciences and Engineering Research Council (NSERC) for the current year in the fields of interest.
- The number of Canadian papers in two key professional journals, the IEEE Transactions on Communications, and the Canadian Journal of Electrical and Computer Engineering.

Together these four elements of the technical and professional literature are considered to provide a framework of Canadian telecommunications R&D publications and research activities against which the inputs from interviews were assessed and will be discussed later in this report.

4.1 Literature Survey to Ascertain Canadian Participation in Major Conferences

The approach taken in this subsection was to *take a snap shot* of research and development activities reported in the open literature by Canadian authors in certain selected journals and conference proceedings.

4.1.1 Selection Process

The journals and conferences are chosen by the Project Team on the basis of their repute and size. ICC and Globecom are the two largest international conferences on telecommunications held each year. ICC 88 and Globecom 92 have been used for this survey. The Vehicular Technology Conference (VTC) is attended by more than six hundred delegates; this was included primarily to cover the area of personal communications systems. VTC 88 and VTC 89 have been selected in order to focus on this discipline. The proceedings of a highly successful conference on selected areas on wireless communications systems (ISCTW '92) was also included.

The IEEE Journal of Selected Areas in Communications (JSAC) issues between 1988 and 1992 were surveyed to an input on the international field. The number of Canadian publications in these different areas is summarized in Table 1.

In Table 1, the first column shows the publication with the number of papers from Canadian sources out of the total shown in brackets. Column 2 gives the number of papers in Personal Communications, column 3 the number on terminals related to interactive communications and 4 gives the number of papers related to high speed networks. Finally the last column gives papers related to telecommunications but not related to the three areas identified as strategic.

4.1.2 Observations

The Canadian participation in international communications conferences ranges from a low of five percent to a high of 31 percent. The participation depends on the venue of the conference whether inside or outside Canada. During the period 88-92, 11.3% of the papers published were from Canadian sources, however upon further analysis it is seen that only 1/3 of the papers published were directly in the areas of interest or closely related to them. A significant observation is the absence of any paper in several issues of JSAC. In 1989, it was observed that in six out of ten issues, no Canadian paper was included. In 1991, this figure was three out of ten. Probing further, it is noted that in these issues the vital topics of secure communications (89), computer networks(89), telecommunications network design (89), Telecommunication software quality and productivity (90), Large scale ATM switching system for B-ISDN, and architectures, protocols for integrated broadband switching were covered. All these omissions were on

network related research. The publications from international sources were from Siemens, AT&T, Bellcore, Hitachi, IBM research, and NTT. This may point either to a lack of publishable work by Canadian industry or to a concern that disclosures may be a disadvantage to the sponsoring company.

Another important area of omission has been Lightwave Technology. In JSAC there were two issues covering this key subject during the survey period but unfortunately there was no Canadian participation.

Details of all these papers are given in Appendix C (i).

TABLE 1

Distribution of Published Work (Number of Publications from Canadian Sources)

Where published	Personal Comm	Terminals	Networks	Others
JSAC 88-92(78/689)	10	3	13	52
ICC88 (28/328)	4	3	6	15
VTC 88 (17/125)	0	0	0	17
VTC 89 (14/140)	0	1	0	13
ICSTW (44/120)	9	2	1	32
Globecom92 (21/368)	3	0	8	10

4.2 Review of Key Recent Consultative Studies on Telecommunications in Canada.

Several major studies of telecommunications in Canada have been conducted in the past few years. These studies have all been concerned with shaping a future for telecommunications that will provide a viable telecommunications industry and an advanced communications infrastructure capable of meeting the competitive challenges of the 21st century.

The studies have been characterized by significant consultation between government, industry, and universities; and participation by system developers, service providers and users. The process has involved representatives from many sectors of society.

Two such recent studies are Search 20, convened by the telecommunications industry and Communications Canada, which has led to the Vision 2000 plan, and the study conducted by the Advisory Committee on a Telecommunications Strategy for Ontario for the Ontario Ministry Culture and Communications, which led to the report: *"Telecommunications: Enabling Ontario's Future"*. Other studies have been carried out by the relevant centres of excellence such as CITR, the Centre for Information Technology Research and TRIO, the Telecommunications Research Institute of Ontario, in determining their research programs. As well, Communications Canada has recently published a policy proposal document; entitled *"The Information Society: New Media - New Choices"*.

Both Vision 2000 and Ontario's Ministry of Culture and Communications recommend immediate implementation of broadband, multimedia digital communication networks and the development of applications for them. Ontario, in fact, has called for tenders to develop an Action Plan to implement a resource and research network in the province. The reports recommend the strengthening of research and development in telecommunications, but, more immediately, they identify the need for products, enhanced marketing and better management to exploit the already strong research and development programs that exist. The emphasis is on activity.

4.2.1 Communications Canada Policy Porposal Document: "The Information Society: New Media - New Choices"

Communications Canada has recently published a statement regarding information policy related to new media. In their view, *new media are combinations of media, technologies and content resulting in a wide range of new information products, applications and services*. The document states that "Canadians require an advanced information infrastructure which will support the sophisticated new media products and services that they are capable of developing". A new enabling policy framework is also required. DOC states that they will follow an integrated approach to:

- provide policy directions which will facilitate the ongoing development of an advanced new media information infrastructure capable of adapting to new media innovations as they arrive;
- develop policies which ensure that Canadian content has a core presence within new media services available to Canadians;
- propose amendments to copyright and intellectual property laws required by new media developments;
- develop policy principles for the guarantee of access to information and the protection of personal privacy;
- identify electronic data bases with Canadian content and ensure their integrity and protection;
- conduct research into the economic, social and cultural implications of the

new media information society;
- develops strategies to maximize Canada's new media resources, in order to strengthen existing organizations and foster the development of new ones;
- develop policies to facilitate the orderly development of new media with regard to technical standards for interconnection, delivery systems, bandwidth availability and spectrum allocation;
- define and develop the domestic market for new media products and services, so that their evolution, distribution and consumption are facilitated.

4.2.2 Telecommunications: Enabling Ontario's Future

This Ontario report was produced by the Advisory Committee on a Telecommunications Strategy for the Province of Ontario which was made up of a diversity of persons representing both technology and society. Four goals were adopted by the study. They are:

- a telecommunications infrastructure which will enable Ontario to enjoy economic growth, competitiveness and sustained employment;
- a dynamic, growing telecommunications sector, including manufacturing, software, services, the information provision industry and *research and development*;
- to ensure that telecommunications enhances the quality of life;
- and the strategic application of telecommunications by the Ontario government.

The needs cited include:

- cost-effective, state-of-the-art, high quality, inter-operable, ubiquitous networks;
- innovative business services;
- value-added services;
- education of work force;
- equitable access;
- development of information technology skills;
- applications in government administration, education, health care, transportation, and tourism.

4.3 A Review of NSERC Grants in the Fields of Interest

The National Sciences and Engineering Research Council, or NSERC, is the federal granting body that supports research in natural sciences and engineering including the

field of telecommunications. The following are the 1992/93 grants in telecommunications and related areas in Canada. Most NSERC Grantees are university faculty or employees of recognized research institutions.

There are 2 grants in Satellite Navigation Systems, 8 in Optics, 15 in Electromagnetics, 115 in Communications, 13 in DSP and Image Processing, 18 in Computer Communications, 1 in Communications Software, and a smattering of others in related areas. This gives a total in telecommunications related areas of approximately 185 out of a total of 10,240 or 1.8%.

The number of grants in communications is surprising given the importance of this area in Canada. What is also surprising is the small effort in communications software, applications of artificial intelligence, information theory, and, as identified by many respondents, systems integration and management. Most grants are in narrow areas, where archival publication can be generated.

One reason for this may be that telecommunications researchers often find it difficult to classify their work according to the NSERC Discipline Codes and Area of Application Codes. While disciplines such as Mathematics have dozens of sub-classes, Information Technology is very poorly classified. The classifications do not represent the extent and breadth of electrical and computer technology. This would be a trivial semantic problem if it were not so important. It is symptomatic of a lack of clear understanding on NSERC's part of the impact of the computer on modern telecommunications. This confusion makes it difficult to explain to governments and other responsible lay bodies just what Telecommunications consists of. It makes it particularly difficult to analyze with any accuracy what specific areas Federal government research grants are supporting.

4.4 A Review of the Number of Canadian Papers in Two Key Professional Journals

4.4.1 IEEE Transactions on Communications

A review of the IEEE Transactions on Communications (December 1991 to November 1992) reveals that of 224 papers, 34 were authored, or co-authored, by Canadians. Of these 34, 5 were co-authored by industrial researchers. Two were authored by employees of Research Institutes (INRS). None were authored by industrial researchers.

4.4.2 Canadian Journal of Electrical and Computer Engineering

Recent issues of the "Canadian Journal of Electrical and Computer Engineering", published by The Canadian Society for Electrical and Computer Engineering (CSECE), which is a Constituent Society of the Engineering Institute of Canada, were reviewed.

The CSECE Journal papers indicate the emphasis in Canadian telecommunications research on mobile and wireless communications. They also reveal how small the group of active researchers actually is. The authors are readily recognizable individuals within the Canadian telecommunications scene.

The state of Electrical Engineering Research in Canada was reviewed for the NSERC Grant Selection Committee by two of its members. Their report was published in Volume 17, No. 2, April 1992: "A. Aitken (CSDA) and H. Kunov (U of T), "Electrical engineering: health of the discipline".

4.5 Publications by Telecommunications Research Coordination Organizations

In order to obtain a broad overview of the telecommunications research and development in Canada, the Project Team made use of publications from two particular organizations that are very active in the coordination of telecommunications research and development activities. Thus these organizations and their publications can provide a comprehensive insight into the trends in R&D. The two organization selected were the Canadian Institute for Telecommunications Research (CITR) and Vision 2000.

4.5.1 CITR Program

The Canadian Institute for Telecommunications Research was formed in June 1990 as part of the Networks of Centres of Excellence (NCE) program initiated by the Government of Canada in the fall of 1989. The research program undertaken by CITR is motivated by the *Network of the Future*, an exciting vision of the telecommunication service environment that will emerge in the next decade or two as a result of extraordinary advances in computer technology, microelectronics and fibre optics. This vision promises ubiquitous connectivity between people, between computers, and between people and computers. The Network of the Future will automatically provide subscribers with the telecommunications resources needed to participate in any type of voice, image, data or multimedia service including such diverse possibilities as:

- multipoint/multimedia communications
- high-speed data communications
- information distribution and retrieval
- entertainment distribution
- transactions processing

Moreover, the service would be accessible to subscribers from wherever they choose to participate. Such capability will have a very large impact on national economics and will be a vital instrument to enhance global productivity.

The research mission of CITR is to carry out pre-competitive, world-class research on key enabling technologies that are critical to the evolution of the Network of the Future. the research must be future-oriented but have the capacity to enhance the competitiveness of Canadian industry in an acceptable time-frame, something of the order of 5 to 7 years. It must also respect the gradual transition between current technology and the Network of the Future since much of Canadian industry is small and directed at niche markets for evolving markets. To this end, the research is oriented to impact two important market trends that are currently stimulating telecommunications product and service providers: *bandwidth on demand*, and *enhanced personal communications services*.

The program is divided into the following major projects:

- Broadband Networks and Services,
- Optoelectronic Devices and Systems,
- Telecommunications Software Engineering,
- Mobile Communications,
- Indoor Wireless Digital Communications, and
- Source and Channel Coding.

4.5.2 Vision 2000

Vision 2000, the organization set up to fulfil the recommendations of Search 20, has identified advanced facsimile as the focus for immediate entry into the world of multimedia communications. This focus is part of the Vision 2000 plan to achieve a system of universal communications providing total information access and management capabilities on a personal basis to all Canadians, whether at work or at home. Their goal is to *empower the individual by fostering and accelerating the development and deployment of advanced systems of personal communications in Canada*. The guiding principle behind Vision 2000 is *the sense of the forces of convergence pulling together the worlds of computing, telecommunications and broadcasting*. The Vision 2000 mission and strategy is based on a need for focus, applications and projects. Their first four project areas were identified as a national system for the interchange of text, data, documents and images, mobile and remote systems, multimedia databases and networks and desktop video systems. Technological progress has almost overtaken these projects, but Vision 2000 has decided on advanced facsimile as a path to the *digital, personal, multimedia world of the future*. The Vision 2000 definition of fax is a document that includes two or more of:

a) text and data
b) graphics and images
c) voice and audio
d) full motion video.

5.0 FINDINGS AND ANALYSIS OF INTERVIEW INPUTS

5.1 Perception of Telecommunications R&D

One of the key generic findings is that each of the four classifications of R&D Entity, namely: Universities; Research Institutes and Centres of Excellence; Developers and Manufacturers; Service Suppliers and Systems Developers, has a significantly different perception of telecommunications R&D, and upon the functions of such R&D. While this isn't surprising given the widely differing objectives of the four groups, it is perhaps appropriate to commence this *Findings and Analysis of Interview Inputs* section by summarizing these perceptions, and their impacts. This information was obtained from the philosophy projected by the interviewees of the different groups, as much as by the specific responses received at the interviews. Given these objectives and philosophies of the various groups, as detailed below, it was possible to give a balanced assessment of the overall telecommunications research and development thrust in Canada, and hence its strengths and weaknesses.

5.1.1 Universities

University researchers rely heavily on research grants from various entities such as NSERC, major public and private organizations such as DND and BNR, and more recently upon grants from centres of excellence typified by TRIO and CITR.

The establishment of *Telecommunications Centres of Excellence* throughout Canada during the last decade or so is encouraging significantly closer links between the universities and the private sector, developers, and manufacturers. There is thus a tendency for university research to become more focused towards economic needs, but this varies from university to university and in most cases appears to be barely out of the embryonic stage rather than being the prime focus of university research. Indeed while many researchers feel that there is more to be done along these lines, it is generally felt that product needs will never, nor should ever, be the prime driver of university research.

As might be expected, the main thrust of Telecommunications R&D in Canada's universities is toward directed scientific research and applied research rather than development leading to specific products. It must be recognized that a prime objective of many university researchers is to publish papers on their research. Given the peer review approach that universities take to promotion, the number of papers published is still a key element in the academic career path of many universities. A number of university interviewees had stated that this leads to excessive specialization and the selection of research subjects that will readily lead to publication, rather than those that are focused towards specific national goals, even if such national goals are deemed to exist.

5.1.2 Research Institutes and Centres of Excellence

Under this classification are included Public Sector Research Institutes, typified by the Communications Research Centre (CRC); private sector telecommunications research laboratories, typified by BNR; and telecommunications centres of excellence, typified by the Telecommunications Research Institute of Ontario (TRIO) and the Information Technology Research Centre (ITRC).

The public sector research organizations have traditionally focused upon the more fundamental research which while of significant importance to the telecommunications industry as a whole, is unlikely to be justifiable to privately owned organizations, and unlikely to be addressed as a whole in a focused manner by individual universities. Typical of such research is that on propagation attenuation of various radio frequencies due to rainfall. While such fundamental work is still carried out by such organizations as CRC, a significant percentage of the interviewees perceive that the proportion of this work is less than it used to be, and getting close to the minimum *critical mass*. It is perceived that a larger proportion of CRC's activities are being directed towards pre-competitive applied research, or experimental development. The concern of the interviewers is not that this is being done, but that it does not appear to follow a well thought out plan in which the private sector has had input. Instead a number of interviewees commented that scarce resources were being used in areas where it was unlikely that Canadians would benefit, or alternatively in areas where companies already had products.

Private sector research laboratories, such as BNR and the soon to be established Satellite Telecommunications Laboratory (STL) focus essentially wholly upon the research needs of their private sector sponsoring agencies.

Centres of Excellence typically represent a bridge between public and private sector needs on one hand, and university researchers on the other hand. Funding is normally drawn from both public (much of it provincial) sources and from private sector sponsors. To an extent determined by the particular organization, the sponsors direct the type of pre-competitive research and development carried out by the university recipients of the funds.

Thus the three elements of this classification, while similar, do have different objectives.

5.1.3 Developers and Manufacturers

In the private sector virtually all R&D activity is heavily biased towards development. Much of this is short-term, (1-2 years) aimed toward the next generation of revenue producing competitive products. As such it is of little direct interest to this analysis, except as an indicator of areas of activities and a pointer towards the future.

Of greater direct interest to this work is the finding that many Canadian developers and manufacturers are carrying out work, which while still of a developmental nature rather than a research nature, is aimed at *enabling technologies*. This is defined as those technologies applicable to a multiplicity of products, and includes, but certainly isn't limited to, the development of architectures and protocols.

The field of *intelligent networks and related development* is particularly rich in such enabling technologies, though this type of work is being carried out in the other fields as well. It is the opinion of many interviewees that such *enabling technologies* development is the key to Canada's international competitiveness in telecommunications.

5.1.4 Service Providers and Systems Developers

This heading encompasses Canadian end users of telecommunications research and development. As such the focus of these interviewees is essentially toward Canadian Networks, rather than an international focus.

In addition, the thrust of research and development in this field is aimed toward more effective networks and network management, rather than toward specific products. Notwithstanding this, it is recognized by the majority of the interviewees that telecommunication systems and network management is a major Canadian strength and one which has international marketability.

5.2 Approach to Analyzing and Presenting the Interview Findings

In the subsequent sub-sections are given the results of a detailed analysis of the inputs obtained from the interviews.

Given that over 600 pages of data were obtained from the fifty interviews, the analysis and presentation of the findings required careful consideration. All data was first classified under the four types of research entity. Under each of these headings the Project Team reviewed the inputs relating to wireless communications, electronic information and transaction services to the home, enhanced media services at home and at work, and intelligent networks. Where the findings were more generic and cut across these technology headings, they were classified under the term *enabling technologies*. For the overall assessment the Project Team used their own background and experience to provide *point form statements* of the general direction and thrusts of the four groups of entities under these five headings.

The findings of each type of entity were then classified against the following six elements; Activities, Strategic Alliances, Competition, Commercialization, Strengths and

Opportunities, Weaknesses and Barriers. It should be noted that under *Strategic Alliances* the names have been withheld for competitive reasons.

The concluding portion of the analysis of the interviews was the identification in the matrices shown in Appendix A of the levels of activity, both current (next two years) and future (two years onward), in the various product specific subsets of each of the four technological thrusts identified by a previous study carried out for the Department[1]. This tabular approach has been strengthened by the use of additional notes.

For ease of assimilation the findings are given in *point form comments*, derived from a detailed analysis of the multiplicity of inputs against each element. All of these statements may be verified against the inputs contained in the data repository. Where an element is missing from the listings below, no input was available.

5.3 Universities

5.3.1 Wireless Personal Communications

Overall Assessment by Project Team

- Wireless personal communications are a major area of interest in a significant number of Canadian Universities. The concept of universally accessible communications, with an individual identified by a personal identification number (PIN), rather than a telephone identified by a number, has captured the imagination of many Canadian researchers. From the view point of directed scientific research and experimentation into personal wireless communications it can be said that Canadian Universities are active and have considerable world class capability.

Activities

- Both terrestrial and satellite wireless personal communications are the subject of research at this time.

- Research tends to be generic and aimed towards wide-bandwidth technologies without defining specific applications other than in the broadest sense.

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[1] C&IT Opportunities Final Report: Nordicity Group Limited: February 1993

- While some current work is going on with regards to hybrid digital and analogue systems, most of the work is aimed towards digital systems, including CDMA.

Strategic Alliances

- The majority of the universities active in wireless personal communications see alliances as linkages to *real life problems*.
- Alliances are frequently with local industry and commonly with centres of excellence such as TRIO, TR Labs, CITR and ITRC.
- Less commonly, but still a significant alliance approach, are collaborations with other Canadian universities.
- International alliances are not at this time common although there are many informal links.

Competition

- Similar teams in other universities, both national and international, are seen as the main competition. However several universities saw centres of excellence as competition for the same limited research funds.
- From the view point of how Canadian Universities, and Canada in general, can stay competitive in the field of wireless communication the findings were:
  - good teaching is an integral part of remaining competitive
  - Canadians should learn from the experience of other global players and change from our current inward looking mentality
  - a greater focus on our strengths, rather than a dissipation of efforts which results from following all new international research approaches.
- Current competitive leaders in wireless personal communications are identified as Bellcore of the U.S. and Siemens of Germany. CNET of France and the Race 2 of the EC programs also doing good work.

Commercialization

- Commercialization of university research is frequently through cooperating with private industry organizations. At other times it is through university development entities or through spin-off companies.

- Over the next five years various universities have identified the following possible areas of commercialization:

  - wireless access to broad-band networks with smart interfaces between indoor and outdoor communications
  - a dual rate system for fading environments
  - low power radio chips
  - low power speech coder, TDMA synchronization, and diversity combining algorithms
  - reliable onboard processing for satellite based wireless personal communication

Strengths and Opportunities

- It is felt that Canadian Universities are strong in software development, modulation and coding schemes and in terrestrial and satellite wireless personal communications

Weaknesses and Barriers

- Lack of funding is cited as the major barrier to research.

- While some universities are conducting work in photonics, this is not generally recognized as a strong area in university research, particularly when compared with work going on in Japan, United States and Europe.

- With the proliferation of centres of excellence the availability of highly qualified research students is becoming a problem

- While there has been increased collaboration between industry and universities, this is still considered by some universities to be a barrier. In particular the need to publish on the part of universities conflicts with the

need to maintain a competitive advantage on the part of industry.

5.3.2 Electronic Information and Transaction Services in the Home

Overall Assessment by Project Team

- This is not a field that the cross section of universities interviewed are addressing. No inputs were received that could be validly considered under this heading.

5.3.3 Enhanced Media Services at Home and at Work

Overall Assessment by Project Team

- This is not a field that the cross section of universities interviewed are addressing. No inputs were received that could be validly considered under this heading.

5.3.4 Intelligent Networks and Related Items

Overall Assessment by Project Team

- This is a field where there is considerable interest in Canadian universities covering many of the advanced concepts at the current leading edge of intelligent network and network management technology.

- It is perhaps appropriate to mention that there is only a fine line between advanced research on intelligent networks and similar research that could validly be classified under enabling technologies.

- Canadian universities appear to be strong in all key areas and are addressing both software and hardware issues. In addition to a number of well respected researchers working in this field there are considerable linkages and synergy with centres of excellence and major organizations such as BNR, MPR Teltech and with Rogers Cable Systems.

Activities

- University researchers are active in many key intelligent network areas including:

  - Broad-band optical networks
  - CDMA (spread spectrum)

- ATM switching for MANS and LANS
- Optical architectures
- Networks for integrated services
- Video compression and coding algorithms
- Acoustic signal processing
- ATM networks

Strategic Alliances

- All universities have a significant number of strategic alliances. These are with industry, particularly with the industry giants, and to only a slightly lesser extent with the centres of excellence. In addition, there are many inter-university collaborations.

- International strategic alliances are primarily, but not exclusively, with universities. The exceptions to this tend to be with major international telecommunications industrial entities such as Boeing, Bellcore and British Telecom.

Competition

- The majority of the universities saw the centres of excellence as being competitive with the university groups, particularly for research funding competition.

- In the field of intelligent networks a very wide range of international organizations were identified. It was generally recognized that this was a key field for future telecommunications international competitiveness and it was recognized by the universities that competition was strong.

- From the viewpoint of the main competitors, the need for an awareness of activities, and the need for appropriate staff to address these fields were the main concerns. It was recognized that Canada is strong in niches such as network management software, intelligent networks and wireless personnel communications. It was felt limited research resources should be focused to these, and other key niches. At the same time Canada should take justified risks to maintain it's world class position in this field.

Commercialization

- Perhaps the most interesting finding under this heading is that there is no

commonality between universities as to the meaning of commercialization in the field of intelligent networks. In some cases the fact that at some point in time research will be used to develop commercial services and networks is considered commercialization, even though there is no consideration of any action to ensure that this happens. Others consider commercialization as an estimate of when the research that is currently being carried out will be used in a commercial situation. In most cases there is a significant lack of an organized approach to the exploitation of research being carried out by the universities. This matter does not seem to be a high priority with Canadian universities.

Strengths and Opportunities

- Canadian universities generally recognize that telecommunications as a whole, driven by intelligent networks and network management, is a major Canadian strength.

- The following sub-disciplines within intelligent networks were identified and are given in order of priority as perceived by Canadian universities:

  - ATM Switching
  - Multimedia
  - Management of mobile networks
  - Satellite networks and their management
  - Spread spectrum
  - Speech recognition
  - Photonics

Weaknesses and Barriers

- Optical communications is seen as a weakness and potential barrier.

- The current comparatively low level of liaison between universities and industry is also seen as a weakness.

- Restricted funding, coupled with a lack of focus causing dissipation of these limited funds, is generally seen as a weakness.

- Notwithstanding the above the general feeling is that Canadian intelligent network research in universities is comparatively strong, and that weaknesses had to be sought for rather than being readily apparent.

5.4 Research Institutes & Centres of Excellence

5.4.1 Wireless Personal Communications

Overall Assessment by Project Team

- Wireless personal communications is a major activity of many research institutes and centres of excellence in Canada. Indeed ubiquitous personal communications is the raison d'etre for the Vision 2000 organization and a very active component of the National Wireless Research Foundation and a number of other research institutes and centres of excellence.

- Acting as catalysts and *honest brokers* bridging the link between universities and industry, centres of excellence have been a significant factor in making Canada one of the world leaders in personal communications. Canada is currently playing a lead role in North American personal communications standards with the national acceptance of the CT2 plus:Class 2 Personal Communications Systems (PCS) standard. The recent licensing (December 1992) of operational nationwide two way PCS systems in Canada, (a world first) also points to strengths of these linkages, while in no way detracting from the role played by manufacturers, service providers and the federal government.

- Beside acting as linkages between universities, manufacturers and service providers, the centres of excellence also work closely with each other in the field of wireless personal communications. This is a most positive sign from the viewpoint of future international competitive activities.

Activities

- There is very considerable activity on the part of both private sector and public sector research institutes, and by centres of excellence, in the field of wireless personal communications.

- These activities span a wide range of applications, which while centred on universal two way wireless telephone, covers a wide range of other wireless personal communications applications. These include:

    - Real time software for the management of personal communications systems, and the workstations related to them
    - In-building communications
    - Transmission of images

- Development of single chip functionality
- Wireless modems
- Integrated facsimile systems
- GaAs front end bipolar processors
- Voice recognition systems
- Low power single chip technology

Strategic Alliances

- Alliances between private industry and universities form a key function of most centres of excellence.
- Such alliances are primarily Canadian but include significant international elements.
- These alliances spread both ways to Universities and to Industry.
- There are also significant agreements and alliances between various centres of excellence, and with both private and public research institutes.

Competition

- There is no appreciable competition between centres of excellence or the private and public research institutes in this field.
- From the viewpoint of providing international competition, it is felt that both the Pacific and European trading groups provide more coordinated and focused research and standardization activities than does Canada, despite Canada's currently strong position.

Commercialization

- There is significant commercialization in wireless communications, primarily through the private members of the centres of excellence.
- Commercialization is not considered to be a strong point in Canadian personal communications R&D, although there is a sense that it has improved recently.

Weaknesses and Barriers

- Lack of adequate funding.
- There is little evidence of federal/provincial coordination.

Strengths and Opportunities

- Personal communications networks, switching, transmission and signal processing in Canada are considered to be important strengths.

5.4.2 Electronic Information and Transaction Services

Overall Assessment by Project Team

- There are few if any research projects being carried out by research institutes and centres of excellence specifically directed to electronic information and transaction services into the home. Notwithstanding this a number of activities are taking place, particularly with regard to fibre links, ATM switching and data processing which can be considered as enabling technologies that would permit developers and manufacturers to access this field.

5.4.3 Enhanced Media Services at Work and at Home

Overall Assessment by Project Team

- This appears to be an area of activity whose time has not yet quite come, from the view point of research institutes and centres of excellence. At the pre-competitive stage it is recognized that work related to the *info-entertainment* field is required if this potential is to be exploited, and indeed multi-media is an area of concentration of at least one centre of excellence. While it is a very interesting area of research the market must be confirmed. Fears of another *Telidon* could be inhibiting more direct activities at this time.

Activities

- A number of research institutes and centres of excellence are carrying out pre-competitive research that recognizes that the *info-entertainment* field is an expanding one that tends to be technology driven.

- While private sector research organizations such as BNR are carrying out considerable research and development that could lead to products in this area, the work tends to be buried within elements of traditional activities such as public switching and transmission, and private networks, rather than being readily identifiable as leading to enhanced media services in homes and offices.

- Centres of excellence are addressing the pre-competitive aspects of this field more directly. However, there is still significant overlap between R&D directed at enhanced media services and enabling technologies.

5.4.4 Intelligent Networks and Related Items

Overall Assessment by Project Team

- The majority of research institutes and centres of excellence are active in intelligent networks and related activities. This is a field where there is very considerable interest by both groups. Projects cover a wide range of advanced concepts, and it is the opinion of the Project Team that this work is of world class and has the potential of keeping Canada in the forefront of international competition over the next decade or so.

- Areas covered include both hardware and software, with the latter being predominant in this field, particularly advanced *realtime* software.

- Again in this field the centres of excellence are acting as catalysts between the universities on one hand, and the manufacturing industry and service providers on the other.

Activities

- The main areas of intelligent network activity carried out by, or sponsored by, the research institutes and centres of excellence include:

  - source coding including waveform coding and data compression
  - channel coding especially Reed-Solomon codes
  - image transmission, particularly traffic characteristics and filtering requirements
  - cryptology and increased security
  - photonics including interconnection of optical boards, signal processing and long haul, high data rate communications
  - dynamic bandwidth allocation

Strategic Alliances

- In the field of intelligent networks, strategic alliances between universities and industry are once more the key to the operation of centres of excellence. In some cases the alliances are formal, in others they represent the linkage formed by the centre of excellence between their industrial members on one hand, and universities on the other.

- Typically a centre of excellence operating in the intelligent network field will have strategic linkages with some twenty or so industrial partners, members or sponsors on the one hand, and several universities on the other.

Competition

- While there are a number of centres of excellence and research institutes in Canada concerned with intelligent networks, they tend to cooperate rather than compete as they deal in pre-competitive research and development.

- Not withstanding the above it must be recognized that in Canada as a whole there are limited funds available for intelligent network R&D, and a limited number of industry sponsors or members. Thus while there is little direct competition with regard to the R&D itself, there is *de facto* competition between centres of excellence for industry sponsors, and federal and provincial government funding.

- Competition for outside funding also exists between the centres of excellence and the universities, paradoxically in some cases the same universities that they sponsor themselves.

Commercialization

- As the research institutes and centres of excellence primarily deal with pre-competitive research and development, commercialization is typically carried out by their industrial partners or sponsors, or through licensing.

- One aspect of commercialization that must be considered is the fact that centres of excellence and research institutes produce considerable numbers of *spin-off companies* that are incorporated to exploit specific intelligent network research results. Such spin-off companies include those small

companies with products in the fields of:

- 3-D graphics
- CCD arrays for whole page facsimile
- cryptography products
- distributed processing in heterogeneous networks
- public key cryptographic products
- photonic sensors

Strengths and Opportunities

- Intelligent networks can be considered one of the areas where Canadian research institutes and centres of excellence are of world class.

- Some of these strengths stem from the concept of centres of excellence acting as linkages between industry and universities, and from the mandates of both the public and private sector research institutes. It should be noted that research institutes in all cases operate their own laboratories while also subcontracting out appropriate research and development. Centres of excellence on the other hand only occasionally operate their own laboratories and primarily facilitate, coordinate and manage the research in a group of universities to meet the pre-competitive needs of a larger group of industry and government sponsors

- Specific intelligent network strengths of Canadian centres of excellence and research institutes include:

  - broadband ATM networks
  - channel error control and implementation in VLSI
  - cryptography
  - opto-electronics
  - advanced high level manufacturing techniques

Weaknesses and Barriers

- As always a lack of funding to carry out all of the research envisaged is a universal barrier

- Areas of intelligent network weakness in Canada include:

  - speech recognition
  - certain intractable problems related to the handling of very large

pieces of real time software required for intelligent networks
- lack of qualified staff is a barrier in some cases, but this tends to be dependant on location with the mid-west being harder hit than other areas

- While significant steps have been taken to bridge the wide differences between the academic culture and the highly competitive time sensitive culture of the telecommunications manufacturing and service provider industries, much is still required to be done in this critical field.

5.5 Developers and Manufacturers

5.5.1 Wireless Personal Communications

Overall Assessment by Project Team

- Wireless personal communications is a major R&D strength with Canadian developers and manufacturers. As expected virtually all thrusts are towards the development of specific products rather than applied research.

- While the number of major players in the field is small, virtually all of them are considered to be world class.

- Although Northern Telecom, supported by BNR, takes the lead in this field, a number of other companies are also active in specific niches. While Canada has taken the lead in the PCS CT2 plus Class 2 field, which uses the TDM/TDD access scheme, Canadian companies are also active in the development of CDMA access schemes which are being considered by various international jurisdictions.

- Of particular importance to Canada is the strong development activity aimed at universal satellite wireless communications. This involves the comparatively new technology of on-board switching, and with SPAR Aerospace, MPR Teltech and Comdev all being very active in this field Canada is again in a strong internationally competitive position.

Activities

- Northern Telecom has developed and is marketing the worlds first, and probably only, complete CT2 plus Class 2 personal communications system. Northern Telecom's product line includes all network elements with the sole exception of handsets. Thus, all Canadian PCS licensees are

expected to be using Northern Telecom's PCS products. The company has significant long term R&D plans for improving and expanding it's products to take advantage of new frequency bands, new features, and the use of data and facsimile in addition to voice for two way PCS systems. It is also working toward the inclusion of such complex features as universal roaming, and non-subscriber access to the 911 system. (Comment of Project Team: Canada has developed and espoused the CT2 plus Class 2 standard as it's national standard for PCS. As Northern Telecom is the only company that has currently developed equipment for this standard, thus the rapid implementation of PCS in Canada and the acceptance of CT2 plus Class 2 in other parts of the world is of considerable importance to Northern Telecom.)

- Other Canadian, and Canadian based companies are active in terrestrial personal communications niches other than CT2 plus. MPR Teltech is actively investigating CDMA approaches to PCS. Ericsson and Novatel are active in the development of digital cellular systems with advanced features, while Glenayre is developing advanced simulcast paging systems. While Motorola Canada is very active in cellular systems it has made the corporate decision not to carry out any PCS development in Canada, and is not developing any CT2 plus Class 2 equipment. In the satellite wireless personal communications field SPAR, MPR Teltech, Comdev and CAL are the major players, with the latter company being primarily active in the aeronautical satellite communications field. (Comment of Project Team: Currently the activities of these companies in wireless personal communications, while significant, are much less than those of Northern Telecom.)

Strategic Alliances

- As this is a highly competitive field, alliances between developers and manufacturers within Canada tend to be few and highly selective. Where they do exist, it is usually in a situation where each partner brings a complementary strength to the table.

- Industrial partnerships on an international basis are more common, primarily as these typically provide a competitive link into new markets.

- Strategic alliances with universities and centres of excellence are fairly common, but their perceived success varies significantly from company to company.

- Strategic alliances also exist between manufacturers and service suppliers within Canada again partially as a marketing tool.

Competition

- While there are a number of Canadian organizations in this field, primarily Northern Telecom, Motorola, Novatel, SR Telecom, Ericsson and Glenayre all address different niches of the broad spectrum of personal telecommunications systems. While there is some overlap nationally, competition is not a major factor.

- Internationally most Canadian companies expect strong and increased competition. It is expected that unique products will evolve with considerable international struggle for market shares.

- While Canada is considered to be of world class, Ericsson, AT&T, Siemens, Motorola, NEC and Fujitsu are all considered to be very major international players in wireless personal communications. There is a general consensus that the way to remain competitive is to find the right niche, do it better, and to bring the product to market first.

- While the U.S. and Europe will remain major competitive areas, both from the view point of the development of new products and of markets, there is a general feeling that the Far East and South America will be the next competitive *battlegrounds* for wireless personal communications markets. There is also the possibility that Japan and the Far East will compete strongly in the development of new systems once the international standardization situation has been finalized.

Commercialization

- Over the next five to ten years in wireless personal communications there is expected to be a fairly rapid, but evolutionary, commercialization of products currently under research and development.

- There is expected to be a convergence of PCS, cellular and paging with a move from microcells to picocells with considerable emphasis on products for in-building communications. It perhaps goes without saying that essentially all plans involve digital systems.

- In North America there is likely to be a *shake-down* between two alternate access schemes, TDMA and CDMA.

- It is generally felt that, toward the end of the time-frame being considered, the satellite personal communications (probably using low earth orbit satellite constellations) will be implemented to compliment terrestrial PCSN in unserved areas, and to provide long haul trunks for the terrestrial systems. Considerable activity is taking place to ensure that these terrestrial/satellite interfaces are essentially transparent to the user.

- Wireless personal communications terminals are expected to evolve into modular systems with the voice (telephone) and paging elements being the core of the subscriber's terminal and of a size that will fit into a pocket, hang on a belt or be kept in a purse. Data, computer and fax elements would be plugged into this core as required.

- In the broad sense of personal communications one of the areas of commercialization is likely to be the aeronautical field where the use of satellite communications for all types of services on board passenger aircraft will become common if not ubiquitous.

Strengths and Opportunities

- It is the general consensus that Canada is strong in most, if not all, of the major niches that make up wireless personal communications in the broadest sense. This feeling was essentially ubiquitous and comments such as:

  "good people, good engineering technology and theoretical ability";

  "Canada is strong in infrastructure, system software and networks";

  "We have good software design strength, and have good understanding of telecommunications networks";

  "Canada's major strength are the sort of things that Canadian Marconi, Northern Telecom and SPAR Aerospace do."

  were very common during the interviews. Satellite personal communications systems are seen as a significant opportunity for Canada, as are digital signal processing and realtime personal communications management software. (Comments of Project Team: The statement above regarding the things that Canadian Marconi, Northern Telecom and SPAR Aerospace do refer respectively to major world wide telecommunications activities in the military telecommunications and aeronautics markets;

switching and general telecommunication markets; and satellites communication markets).

- The smaller companies see Canada's pool of highly trained professionals to be a strength. (note: see also *weaknesses and barriers* below). However there is at times difficulty in competing with the higher salaries offered by larger companies.

Weaknesses and Barriers

- A wide range of weaknesses and barriers were identified during the assessment. This would tend to point to the fact that a number of weaknesses tend to be company specific rather than generic through out the industry.

- A barrier perceived by virtually all of the larger companies interviewed is the lack of skilled staff available in Canada. This contrasts sharply with the smaller companies that feel that this is a strength. It appears that the problem is one of both quantity and quality. The larger companies are typically looking for tens or scores of highly qualified staff usually in very specific fields. While, due to the current economic environment, applicants are generally available these are frequently unsuitable. This due either to lack of specific skills, or due to the fact that frequently the less competent of those who have been laid off and are thus available. The trend is to look to the United States for staff, but the high cost of living and high level of taxes in Canada is a major barrier to attracting people to Canada.

- A barrier identified by a number of organizations, both large and small, is the lack of a good national R&D strategy, particularly from the view point of a national policy to address the international competitive market. While many companies perceive wireless personal communications as being the next major thrust in telecommunications, there is no national plan to push CT2 plus in the various international standards forum, nor is there a concerted *Canada Inc.* approach to marketing Canadian personal communications expertise and products. The current position taken by the Department of Communications in espousing the CT2 plus Class 2 standard as a *stand alone position* is viewed by some members of the industry as having been taken without sufficient industry concensus and one which could be a barrier to international competitiveness. The fact all Canadian companies, with the exception of Northern Telecom, have declined to develop products to this standard is indicative of this lack of consensus.

- Another weakness identified by a number of companies, is the lack of a strong international marketing capability to exploit the many technological thrusts developed in Canada.

- As is to be expected, availability of funds for R&D is commonly considered a barrier. This was expressed in a number of ways. Several companies felt that the tax structure removes too much profit from a company that should be ploughed back into R&D. Others feel that as returns on R&D are long term, and they must be financed by current revenues, a significant cash flow problem can arise, for companies wishing to invest a significant percentage of revenues in R&D.

5.5.2 Electronic Information and Transaction Services into the Home

Overall Assessment by Project Team

- This field is only being addressed in a comparatively limited manner by Canadian manufacturers. Only two identified it as a key area of activity although these are both major companies with significant development activity in this area. Some of the smaller companies indicated that they had some comparatively minor interest in this technological thrust.

  Thus overall Canada can not be considered to be a main player in this area, but certainly it has some competence, and has state-of-the-art niche products that are likely to be successful internationally.

Activities

- There are two major areas of activity in these fields, the ATM switch and associated products, and multi-media networks.

- Canada has developed the first ATM switch and is currently marketing a complete line of ATM products, primarily to the export market.

- There have been at least two multi-media systems developed in Canada and are currently being marketed both nationally and internationally. Others are being used and tested by the Canadian facilities of multi-national companies and will eventually be on the market, but to the knowledge of the Project Team have been developed outside of Canada.

5.5.3 Enhanced Media Services at Home and at Work

Overall Assessment by Project Team

- This field is also being addressed in a limited manner in Canada, by the same two companies that are addressing the field of *Electronic Information and Transaction Services in the Home*. Indeed, the same multi-media products are being developed for both technology thrusts. The areas of video digital compression and advanced digital TV are apparently at this time not being addressed in Canada, although there is significant interaction between the Canadian cable television industry and the Communications Research Centre on the one hand, and Medialab and Cable Television Laboratories in the United States on the other hand, for testing and assessing these technologies.

  It can thus be said that this technology is not one in which Canadian developers and manufacturers are currently taking a major interest. Once again there are niche products, and in the more general sense monitoring of activities going on.

Activities

- Two major Canadian companies are working on multi-media systems that are aimed, in part, at the home market. Both these are currently available and both are being further developed.

- At least one company is planning to carry out R&D into compression algorithms for advanced TV, probably using 64 level coding. They are also looking at higher levels of coding. This work is planned but not yet funded. The driver for the proposed work is the future market for *near video on demand*, which is expected to be of major importance. The company concerned would make the chip sets, or even the whole unit.

5.5.4 Intelligent Networks and Related Items

Overall Assessment by Project Team

- The majority of telecommunications developers and manufacturers are active in one of a number of the elements of intelligent networks. This is field of both high Canadian interest and capability. It can validly be said that Canada is world class in telecommunications network management and intelligent networks. Northern Telecom addresses the majority of the development of this key technology. In addition, many other companies have developed niche markets and a high reputation in this field. While Canada is considered world class, internationally there is very considerable competition and all companies in this field commit considerable R&D effort to it.

- Intelligent networks is considered the key driving technology for all aspects of telecommunications in the future. Those companies concerned with the broader aspects of telecommunications essentially see all other elements as subsets of intelligent networks. The technology, while being *real-time software* based, has considerable hardware and other software peripherals associated with it. Conceptually it is a transparent distribution medium that encompasses the fields of satellite communications, fibre optic communications, microwave communications, wireline communications etc. Much of the research and development currently being carried out address the transparent interface problems related to this concept.

Activities

- Virtually all developers and manufacturers in Canada participate in some form of intelligent network development activity. This includes a wide spectrum of activities addressing virtually all aspects of telecommunications network management. As this is a key competitive field, some of the companies declined to detail their activities, but indicated strong interest and significant activity in their particular field of network management development.

- Key areas of activity that were indicated include:
  - aeronautical network management systems for commercial aircraft
  - advanced high security network management
  - intelligent satellite networks
  - intelligent switching and interactive intelligent networks
  - distributed network control

- network architecture development and network management
- intelligent enhancement of centrex capabilities
- development of network architectures to control inbuilding wireless LANS
- intelligent network management of under ocean fibre optic links including intelligent network gate ways
- self diagnostic tools and software
- intelligent networks using as the ATM network architecture enabling technology for personal communications systems and transactional services
- intelligent networks using CDMA
- band-width-on-demand management
- enhanced 911 products
- real time network management software
- ISDN network management

It can be seen from the above that these activities cover virtually all aspects of intelligent networks.

Strategic Alliances

- Once more, as this is a highly competitive field, alliances between product developers within Canada tend to be few and highly selective. They do, however, exist particularly where each of the parties can bring complementary strengths to the research and development activity. Two major alliances of this type were identified and in each case considered to bring considerable benefit to Canada's international position. Few developers were against the concept of alliances with other Canadian companies to address the international market, but all felt that such alliances should be selected with great care. In a number of cases initial approaches between parties did not lead to an alliance.

- Strategic alliances between manufacturers and service providers were more common, and in at least one case acted as a catalyst for a strategic alliance between two Canadian product developers in the field.

- Alliances with centres of excellence are in place with a large majority of the developers and manufacturers contacted. In particular, this appears to be a major strength of Canadian activity in this field, with most organizations being positive about the results. Similarly there are individual alliances or agreements between specific manufacturers and universities, particularly the local universities working in their field. The benefits of these alliances

appear to be more problematical, with some working well but many not fulfilling their potential.

- International strategic partnerships between Canadian manufacturers and manufacturers or trading companies outside of Canada do exist in the intelligent network field, but only in very few instances. This comment excludes the international segments of multinational companies and relationships set up by companies with headquarters located outside of Canada. It is the opinion of the Project Team that such strategic alliances are even more sensitive to competitive concerns than those between Canadian companies.

Competition

- While in general Canadian companies identify their own niche for intelligent network products, and intend to stick to it, there are competitive overlaps particularly in the case of the larger companies that carry out a broad spectrum of development activities. At the current levels of activity this appears to be beneficial competition that strengthens Canada's overall position. Internationally, Canadian companies compete head on in the intelligent network market with all major multinational telecommunications companies, and have been able to achieve and be recognized a respected position in the market place. This applies equally to international competition for terrestrial networks and for satellite networks.

- Typical of international competition is AT&T, Siemens, Ericsson, NEC, Hughes Aerospace, and Thompson CSF.

- In all international arenas, both large and small, competition is fierce and increasing.

- Competitiveness in the international field of intelligent networks is determined by technological superiority driven by world class R&D. Extremely high levels of R&D investment, and the competence to identify and achieve the right technologies and features for each product generation is critical to remaining competitive.

- The majority of Canadian telecommunications companies have identified and exploited specific niches where they can achieve significant market shares without attracting overwhelming competition from the major multinational companies. From an international competitive viewpoint this is very much Canadian strength in this field.

Commercialization

- Various major upgrades of current intelligent network products form the major thrust of Canada's telecommunications manufacturers over the next five to ten years. These products will not only cover terrestrial networks but will have a significant impact on satellite networks interfacing with terrestrial networks.

- One of the major areas of commercialization projected for the next ten years in satellite intelligent networks is the major use of onboard switching for both geostationary orbit and low earth orbit satellites. These require advanced signal processing products, particularly those related to space antennas, advanced RF switching and advanced multiplexing. These are areas where Canada has particular strength.

- Other areas of commercialization are expected to be advanced network management and interconnection products between various types of distribution media.

Strengths and Opportunities

- The whole area of intelligent networks, including overall management products, software products and niche products in both terrestrial and satellite areas, are particular strengths of Canada's telecommunications industry.

- As a whole this field represents major opportunities for Canada as intelligent networks are required for all major technological thrusts considered in this assessment.

- The likely proliferation of constellations of small, low earth orbit satellites represents a major opportunity for the satellite communications segment of Canada's telecommunications industry.

- Canada's telecommunications developers cover virtually all aspects of intelligent networks from the major distributed network control systems developed by Canada's major telecommunications manufacturers, through to the various niche products developed by Canada's medium and smaller companies. With an appropriate focus and a national strategy to meet international needs, Canada could be in an excellent position to address this expanding field.

Weaknesses and Barriers

- Limitations on R&D funding support and company profit levels from which in house R&D funding is derived, is of course a major concern.

- With the larger companies the lack of skilled people is also a barrier and a concern.

- There is general concern that the government programs are not focused; tend to subsidize the unsuccessful; and to encourage the setting up of regionally dispersed competitors to niche players that have developed their own products.

  (Comments of the Project Team: Manufacturers, both large and small, have tended to find their own niches in intelligent networks and frequently pursue these niches in isolation. While this approach works for the individual companies a mechanism to plan and focus overall R&D would likely strengthen Canada's international position. It is recognized that given the competitive position between companies this is likely to be difficult. The slowly growing trend toward strategic alliances will assist in this as will the trend toward joint funding of pre-competitive development through centres of excellence.)

5.6 Service Suppliers and Systems Developers

In this section the effective end users of telecommunications R&D are addressed. These fall into three main groups. The first group are the telecommunications common carriers, including Canada's two satellite telecommunications common carriers, Telesat and Teleglobe, and the mobile common carriers including personal communications service licensees, cellular service licensees and paging licensees.

The second major group are cable television companies who are moving rapidly towards enhanced media services particularly video digital compression, advanced TV (HDTV) and video on demand/interactive TV.

The third group are the broadcasters. In Canada the CBC carries out the vast majority of broadcast related research and development. Here digital TV and digital audio broadcasting are major R&D thrusts.

It should be recognized that in the development of new networks and services only some of the products and software used may be Canadian. It should also be recognized that Canadian service suppliers and system developers are primarily, if not exclusively,

concerned with their Canadian licensed areas, thus the export of systems R&D, while of interest, is usually not critical to the survival of the service providers (as it generally is to telecommunications manufacturers).

5.6.1 Personal Wireless Communications

Overall Assessment by Project Team

- Canada appeared to be taking the lead in wireless personal communications with the licensing of four national PCS systems in December 1992. These were supported by Canadian products and considerable R&D had been done in a cooperative form between service providers and the major manufacturer in this area. Plans to commence CT2 Plus Class 2 service toward the end of 1993 have been delayed due to the request by the Department, at the beginning of January 1993, that a clearing house be set up to ensure that all four systems were configured so that they could each accept calls from a subscriber registered with any of the four licencees. At the meeting convened to discuss this, it was also suggested that a consortium be formed between the licensees. The concept was that a single network and network management system could be set up under consortium control with the individual licensees purchasing time from the network. While this may be of benefit to those licensees less prepared to implement their systems, it has come as a major blow to licensees who had invested considerable R&D effort in PCS system design. Little progress on these matters has taken place during the first quarter of 1993.

  While there are various estimates of the period of delay likely to be caused by this situation, the Project Team cannot help but view any delay as a serious setback to Canada's lead in this area. It permits potential U.S. and European competitors to *make up time* and could well inhibit the chances of CT2 Plus Class 2 becoming a *defacto* world standard.

- In other areas of personal communications in it's broadest sense, the two groups of cellular licensee, Stentor Mobility and Rogers Cantel, are implementing digital cellular systems. This implementation is likely to continue essentially over the periods under review. For the first five years or so digital and analogue systems will operate in parallel to enable subscribers to use their current equipment. New equipment has *transparent handoff* between analogue and digital systems.

- While both cellular systems have for the last two years or so been offering data services over their cellular systems, the market for this service has not developed and this is limiting further development in this field.

- Digital paging systems with greater and grater coverage are being implemented and this is likely to continue over the time period under review. In some cases these paging services will integrate with cellular systems and with satellite based trunks.

Activities

- Considering wireless personal communications in its broadest sense, encompassing not only personal communications networks but cellular systems and paging systems, there is very considerable system development going on in Canada.

- The major system R&D opportunities form the following three headings:

  - the further development of CT2 Plus Class 2 national networks
  - the further development of digital cellular systems to replace the current analog systems
  - the further development of very wide area *simulcast* digital paging systems
  - the development of satellite based personal communications services of all types through both M-SAT and toward the end of the period under review, through low Earth orbit satellite constellations.

  Canadian common carriers are active in all of these areas, and in each case are considered world class.

Strategic Alliances

- The prime strategic alliance recently put in place is that of Stentor between Bell Canada and the provincial common carriers. In many ways Stentor replaces the old Telecom Canada organization. However Stentor consists of a number of separately incorporated companies each addressing a specific aspect of the business. One of these is Stentor Resource Centre Inc. which represents that portion of the strategic alliance that has a responsibility for the development of products and services for all members of the Stentor organization. The R&D strategy group of Stentor Resource Centre Inc. carries out R&D for all of its members including aspects of wireless personal communications.

- The Popfone and the Telezone PCS licensees consists of a strategic alliance between a number of cable television companies, third party telecommunications resellers, and paging companies.

- There are also a number of alliances with international industry and with Canadian industry.

Competition

- In the broad field of personal communications, including PCS systems, cellular systems and paging, the service provider industry is regulated and thus competition is defined by the regulatory authority issuing the licences.

- In the field of PCS four organizations have been recently licensed on a national basis.

- In the cellular telephone field the CRTC has licensed Rogers Cantel Mobile Inc. on a national basis, and members of Stentor Mobility on a regional basis, to provide two competitive licences in any given area of Canada.

- In the field of paging a multiplicity of licences are typically issues for any major urban area.

Commercialization

- Many service providers expect the next decade to be one of major change in wireless personal communications. As the economics of personal communications systems improve, many more local access features will be developed.

- Implementation and acceptance of the personal identification number (PIN) instead of a phone number tied to a fixed telephone is likely to take place, driving with it significant economic and social change.

- During the next decade the demand for wireless personal communications systems is likely to put significant pressure on the spectrum, leading to the allocation of new frequency bands. This is likely to not only include the 1.8 Gigahertz band currently being considered for the PCS, but also portions of the 20 GHz to 30 GHz band.

- The early part of the next decade will see the commercialization of the MSAT mobile satellite services. These are likely to compliment the terrestrial wireless personal communications market particularly in remote areas for wireless telephony, paging and positioning and messaging systems. Indications are that a grater, but still complimentary impact on personal wireless communications will come with the implementation of lower cost low Earth orbit satellite constellations from the middle of the decade on. While this is likely to have some impact on the wireless personal communications market, a far greater impact is expected by the implementation of low earth orbit mobile satellite services from the middle of the decade on.

- The implementation of low earth orbit satellite personal communications services will increase the rate of progress toward universal global wide wireless personal communications.

Strengths and Opportunities

- Canada's currently very advanced position in wireless personal communications, including cellular, paging and the embryonic PCS industry, is a major strength from which Canada can address the significant changes likely over the next decade.

- The recent regulatory changes, permitting limited competition within the telecommunications industry as a whole, is a further strength of which Canada can address the coming decade of change.

- The reorganization of Telecom Canada into the Stentor group, and in particular the setting up of Stentor Mobility is expected to be a further strength.

Weaknesses and Barriers

- One of the major barriers to wireless personal communications is the lack of international standards. Canada could be vulnerable with its espousement of CT2 Plus Class 2, due to it's comparatively limited market. This market is insufficient to support a major production line on it's own, and Canadian service suppliers could be left with systems no longer supported by the manufacturers.

- The forthcoming decade of change in personal communications will require a stable industry structure and a focused, well thought out, national wireless

personal communications strategy as a subset of a national telecommunications R&D strategy. Such a strategy would include clear standardization policies and policies that would lead to low cost universal personal communications including interfaces with international terrestrial and satellite networks.

- The major changes likely over the next decade can leave the industry extremely vulnerable to government policy changes. A body of opinion feels that the current *start stop* situation in PCS is indicative of this. Licences were issued in December. In January the four licensees, with extremely different corporate backgrounds, were requested by the licensing body to form a consortium, thus delaying the implementation initiative just as it started.

5.6.2 Electronic Information and Transaction Services into the Home

Overall Assessment by Project Team

- This field is currently only being addressed in a very limited manner by service suppliers and system developers. The cable television companies have made a tentative start with pay-per-view services in a number of areas.

- It is considered by the Project Team that the development of true electronic information and transaction services in the home is likely to only take place after the implementation of broadband switched services into the home. While this is a target of many common carriers, the technical and economic problems of installing fibre links into the home have yet to be overcome. Implementation of ISDN services could well produce an initial set of electronic information and transaction services over the next five years, but there is little evidence at the moment that this will be a major area of growth.

Activities

- Cable television companies are implementing what may be termed the first transaction service into the home with pay-per-view television services and interactive television services.

- Telecommunications common carriers are implementing ISDN services over the next five years and these *are planned to* form a vehicle for further electronic information and transaction services into the home.

5.6.3 Enhanced Media Services at Home and at Work

Overall Assessment by Project Team

- This is an area where there is likely to be significant development of new services over the next decade, starting immediately. These include systems carrying digitally compressed video services, at first in the current NTSC format and then in advanced television (high definition television) format. One of the prime thrusts will be to offer *near-video-on-demand* services on cable television in response to the competition that will be offered by American direct broadcast satellite services.

- Virtually all new systems development taking place in this field will be based upon non-Canadian technology and will be driven by the acceptance by the U.S. regulatory body of advanced television standards; acceptance by the North American cable industry of digital video compression standards; and acceptance by the Canadian broadcasting industry of digital audio broadcasting standards. All of these standards, while in most cases having Canadian input, are the results of U.S. or European initiatives. Although most of the hardware for the implementation of these services will originate outside Canada, the development of the systems themselves is largely a Canadian initiative driven by Canada's major cable television companies, the CBC and in the case of digital audio broadcasting, also by the Canadian Association of Broadcasters.

Activities

- Canada's major cable television companies are very active in the development of video digital compression services. These will lay the basis for enhanced media services into the home, with spin-offs into the business environments. These developments are likely to be implemented in an embryonic manner by the end of 1993.

- There is very considerable activity on the part of the CBC to move towards digital TV and the implementation of digital advanced television (HDTV), once standards have been finalized.

- The broadcasting industry as a whole is actively moving toward setting up a research, development and trials institute for digital audio broadcasting.

- One of Canada's major cable television companies has already implemented virtual interactive television services.

Competition

- One of the key drivers to the implementation of digital video compression and hence *near-video-on-demand* is the forthcoming competition to Canadian cable television companies by the U.S. Hughes/Hubbard direct broadcasting satellite. This is expected to go into operation in the first quarter of 1994, using 18 inch diameter dishes with an earth station cost of $700 U.S. The Canadian cable television industry views this service as a major competitive threat. This has greatly advanced development of digitally compressed video services by Canada's cable television industry. Indeed one TV channel has been supplying compressed video to cable company head-ends for some time.

- As the cable television is strictly regulated by the CRTC there is little competition in the normal sense.

- Competition in the broadcast industry, while limited to an extent by CRTC conditions of licence, is far stronger than in the cable television industry as broadcasters compete for advertising dollars. Notwithstanding, this the vast majority of system development in the broadcasting enhanced media field is being carried out by the CBC, with a certain amount being done in the field of digital audio broadcasting by the Canadian Association of Broadcasters.

Commercialization

- Commercialization of digital video compression services is planned to take place toward the end of 1993. Virtual interactive television is already available from one major Canadian cable television company.

- Commercialization of advanced digital television (HDTV) must await the finalization of North American standards, and initial services in Canada are likely to not take place for the next two or three years.

- Commercialization of digital audio broadcasting is also dependant upon the acceptance of the standards being proposed by the industry. Pilot projects of digital audio broadcasting are expected within a year or so following limited trials that took place in 1992.

Strengths and Opportunities

- In the cable television, broadcasting and, telecommunications service provider industries, the next decade is likely to be one of significant opportunities in the development of new enhanced media services. Though driven primarily by non-Canadian technology, Canada has considerable strengths in the systems development and service provider fields.

- The trend for convergence between cable television, broadcasting and telecommunications is a further opportunity for service providers. In particular compressed digital T.V. and advanced T.V. could see further convergence between the broadcasts, and network suppliers, both cable television and telecommunications.

Barriers and Weaknesses

- Virtually all broadcasting R&D in Canada is carried out by the CBC. In the cable television industry R&D tends to be limited to a few major companies.

- On the broadcasting side the regulatory dichotomy on the part of CRTC between the needs of supporting Canadian culture, and the requirement to provide high levels of service is seen to have an inhibiting effect on R&D in the implementation of state-of-the-art media services. These services require quantities of high quality programming that the Canadian programming industry is too small to provide. Thus if CBC implements all the enhanced media services made available with the new compression and digital technologies there is likely to be a conflict with the CRTC's Canadian content requirements.

5.6.4 Intelligent Networks and Related Items

Overall Assessment by Project Team

- While the next decade is likely to be one of change in the use of intelligent networks by service providers, this change is likely to be evolutionary rather than revolutionary, building upon the changes of the last decade.

- Significant among these evolutionary developments are likely to be the greater integration of various types of distribution systems, including satellite distribution, into the overall network management concept.

- With an ever increasing use of telecommunications as a whole, and the evolving information society, there will be greater pressures for the use of all aspects of intelligent networks. These will be required to optimize the use of the more complex networks to a variety of traffic patterns as different modes of use develop.

- Much of this evolution will be software driven, and used distributed control. Much of this hardware and software will be available from Canadian sources and the use of this by Canadian service providers and the federal government is likely to enhance Canada's position in the international market place.

- The next decade is likely to bring further convergence of the telecommunications and cable television networks and the development of intelligent networks to serve them both.

- With the development of digital television and digital radio broadcasting there is significant possibility that these technologies would be implemented by the efficient use of small transmitters throughout a service area, linked together with an intelligent network. This is another path of convergence, and one where Canada could achieve world wide advantage in the development of an integrated architecture and delivery system for digital broadcasting. Such an intelligent network could use either cable television facilities or broadband telecommunications facilities. These alternatives could provide encouragement for competitive development of such intelligent networks.

Activities

- Canada's service providers are active in all areas of intelligent network development. The recent (1st January 1993) incorporation of the various Stentor companies, providing greater linkages between the common carriers, is likely to enhance this development. A further catalyst to intelligent network activities is the recent (1992) decision by the CRTC to permit long distance competition in Canada.

- Greater connectivity between the Stentor companies; research into high speed networks; and interconnections with satellite networks and interconnections with under sea optical networks, will be significant evolutionary intelligent network activities.

- The development of intelligent networks by the cable television and broadcasting industries for the carriage of enhanced media services and digital broadcasting is going on apace.

- Intelligent networks to address the expansion of personal communications services, cellular telephone, increased wide area networking and data transfer are also areas of considerable activity. The efficient use of the long distance network to address the varying traffic needs of these growing applications presents a major challenge for the development of intelligent networks in Canada, and one which is being addressed by all major players.

Strategic Alliances

- Perhaps a prime strategic alliance in intelligent networks is that between the major common carriers in the form of Stentor.

- The new alliance between Unitel and AT&T is also an alliance likely to have a significant impact on the development of intelligent networks by Canadian service suppliers.

- The growing cooperation between major cable television companies and CBC represents a somewhat informal alliance but one which can have a significant impact upon the growth of intelligent networks.

- The alliance between the Canadian cable television industry and Cable Television Laboratories Inc. in the United States is also significant.

- Service suppliers have a number of arrangements with various universities, but these do not appear to be of great significance on an industry wide basis.

- There are few international alliances between the common carriers except for those between Teleglobe and international organizations for the distribution of overseas traffic.

Competition

- As service providers are regulated, there is little national competition within members of the specific groups such as telecommunications common carriers and cable television companies. There is, however, growing competition between the cable television companies and the telecommunications common carriers as the networks of each become capable of carrying the services of the other. Over the next ten years there is likely to be growing competition between the services provided by U.S. direct broadcast satellites and those provided by Canadian cable television companies. Finally, to an extent. broadcasters see cable television as competition in-so-much that they fragment the market for advertising dollars by bringing distant signals into their service areas.

- The exception to the lack of internal competition is that between broadcasters. However as the CBC is the only broadcaster that is apparently considering the development of intelligent networks again in the context of network development, competition is insignificant.

Commercialization

- Commercialization of the various intelligent network activities discussed above is likely to take place on an increasing scale commencing immediately and continuing over the decade of interest.

Strengths and Opportunities

- Intelligent network development on the part of service suppliers can be considered a significant strength for Canada. At the moment network management of the national telecommunications networks is universally considered to be world class, and there is every sign that development activities in place and planned for the next decade will maintain this position.

- International competition represents an opportunity for Canada's service suppliers in the field of intelligent networks. This includes links with satellite and under ocean networks as well as traditional terrestrial fibre optic and microwave network control.

Weaknesses

- Fragmentation within the industry was until recently a weakness. The incorporation of Stentor, and the close relationship between Unitel and Rogers Communications Inc. is likely to have a focusing effect and overcome some of these weaknesses.

- Expenditure on both resources and equipment for R&D by the service providers is limited by revenue and revenue in turn is limited by CRTC decisions. In practical terms this limits R&D expenditures to around two percent of total revenue.

5.7 Matrices of Specific Technological Thrusts

In this section are matrices of the activities of the interviewees under the various areas of activity defined by the scientific authority. Additional comments are provided under each matrix to provide further explanation regarding the activities of each type of R&D entity.

It should be noted however that a significant number of interviewees declined to complete the matrices. The reason for this varied with the type of entity.

With universities, research institutes and centres of excellence the reason for declining to contribute to the matrices was primarily that they were too product specific for the type of research and development being carried out. The reason for declining on the part of developers and manufacturers was also that the matrices were overly product specific, but in this case would lead competitors, particularly overseas competitors, to identify current and future product developments.

Finally service providers and systems developers felt that the system development work that they carried out, while likely to use some of the specific products identified in the matrices, did not necessarily contribute to the development of the products. Not withstanding this, some entities in each of the four groups provided matrix information.

The figures given under the current, planned and alliances columns are the number of responses in each of the four groups that identified activities or interest in the particular activity. It will be appreciated that these figures do not necessarily coincide with the statements made in sections 5.3 to 5.6 above. This is because interviewees, in reviewing

the specific areas of activity included those that they were monitoring or had a very minor interest in, as well as those in which they were significantly active. In addition, as detailed above, a significant number of interviewees did not contribute to the matrices. While as far as possible responses were directed to the definitions given to the areas of activity by the Scientific Authority, in some cases these descriptions were generic enough to encompass a wide variety of activities. In particular, under the "information and transaction services" and the "enhanced media" sections, activities that were common to other technological thrusts were given as indicative of an organization's capabilities.

Thus while the number of organizations given in the columns certainly indicate trends, the broad variation in the quality and quantity of inputs should be taken into account in any assessment.

Given initially is a summary of the findings of the various entities. The table lists the four main category of entity. The first number in brackets to the right tells the total number that were interviewed. The second number in the bracket tells how many of those entities submitted matrices. These totals were arrived at by looking at the broad spectrum of activities within each of the areas. Where an entity was active in four or five areas, as in Wireless Communications for example, it would have been counted as one. So this is not a weighted indication of activity it simply says that there was some activity in the area. At the bottom are the total number of entities active in the particular technology area. Again it should be noted that this is not a true statistical sample and therefore the reliability of the figures and the quantity should be taken into account when drawing any conclusions from these numbers.

As evident in the figure below, the main emphasis is on Wireless Personal Communications and Intelligent Networks.However, there is significant activity in Enhanced Media and Information and Transaction Services.

Summary Table for Matrices				
Interviewee Categories	WC	HE	MS	IN
Universities (10, 7)	6	4	6	6
Research Inst. & Cent. of Excellence (7, 6)	5	5	5	5
Developers & Manufacturers (22, 16)	14	7	6	14
Service Providers & System Developers (12, 8)	6	5	6	6
Totals	31	21	23	31

Legend for Summary Table for Matrices

WC - Wireless Communications
HE - Enhanced Media at Home and at Work
MS - Information and Transaction Services
IN - Intelligent Networks and Related Activities

On the following pages is a more detailed breakdown of the activities matrices. A matrix is given for each of the four technology areas.

In each case a breakdown is given of the sub-technologies that were targeted in this study. Again the breakdown was from the MGL report on Areas of Opportunity in the Telecommunications Technology Areas.

The left hand column of the matrices gives the ranking. The ranking was arrived at by looking at the Current Activities column.
The second column is the area of activity or the sub-technology that was focused on.

The third column, which is titled "Current", is the list of entities that are currently active in that technology area. If for example under the Wireless Communications the Multi Mode Terminals; faxing, paging, phone; two Universities are currently active; five Manufacturers and Developers; three Research Institutes; and one Service Provider. The T= provides the total number of entities that are active in that particular area. The same applies for the Planned column, which is the fourth column.

The final column is Alliances. This column can be very misleading as many of the entities did not check the boxes for the particular areas that they had alliances in.

In the row directly under the title row are given the totals. These totals provide a quasi-way weight to the activity indicator. The figures are weighted only to the extent that if a University is active in four areas for example, it will count as four items in the total at the top of the matrix. This in contrast to the Summary Table which would has counted that University as one.

Again, it is emphasized that this is not a proper statistical sample but simply a quick list of questions that were asked to get a feel for what was happening. The project team noted a considerable variation in the interpretation of the meaning of the individual activities by interviewees, and in the level of interest of activity required to illicit a positive response. Therefore this should be kept in mind when drawing any conclusions from these figures.

WC - Wireless Personal Communications

U = Universities (10)
R = Research Institute & Centres of Excellence (7)
T = Total

M = Manufacturers and Developers (22)
S = Service Providers (11)

Note: The number to the right of the identifier indicates the number of responses received

Ranking	Area of Activity	Current	Planned	Alliances
Totals		U=24R=35 M=66S=19	U=6R=16 M=49S=21	
6	Multi Mode Terminals; Fax, paging, phone	U-2, M-5, R-3, S-1 T=11	U-0, M-5, R-3, S-1 T=9	M-2, R-1
1	Wireless Modems	U-4, M-8, R-4, S-1 T=17	U-0, M-5, R-2, S-1 T=8	M-2
4	Compression/Coding	U-4, M-4, R-4, S-1 T=13	U-1, M-3, R-1, S-1 T=6	M-1
8	Terminal Logic	U-0, M-5, R-2, S-2 T=9	U-0, M-4, R-2, S-1 T=7	M-2
5	Image Transmission	U-5, M-3, R-3, S-1 T=12	U-2, M-4, R-1, S-2 T=9	M-2
8	Improved Feature Sets	U-0, M-5, R-3, S-1 T=9	U-0, M-2, R-0, S-1 T=3	M-2, S-1
7	Increased Security	U-0, M-5, R-4, S-1 T=10	U-0, M-4, R-1, S-1 T=6	
9	Voice Recognition	U-1, M-2, R-2, S-0 T=5	U-0, M-1, R-1, S-3 T=5	S-1
3	Data LANS	U-5, M-5, R-3, S-1 T=14	U-2, M-4, R-1, S-1 T=8	M-2, S-1
2	Interconnection/Integration	U-2, M-7, R-2, S-4 T=15	U-1, M-5, R-2, S-2 T=10	M-2, S-1
3	National and Industry Standards	U-1, M-8, R-3, S-2 T=14	U-0, M-6, R-1, S-4 T=11	
6	International Standards	U-0, M-6, R-2, S-3 T=11	U-0, M-5, R-1, S-2 T=8	

10	Other - 1- mobile AVSAT antennas - 2- voice encoding	U-0, M-3, R-0, S-1 T=4	U-0, M-1, R-0, S-1 T=2	

Areas of Activity In Order of Ranking

1. Wireless Modems (17)
2. Interconnection/Integration (15)
3. Data Lans (14)
3. National & Industry Standards (14)
4. Compression/Coding (13)
5. Image Transmission (12)
6. International Standards (11)
6. Multi Mode Terminals; fax, paging, phone (11)
7. Increased Security (10)
8. Terminal Logic (9)
8. Improved Feature Sets (9)
9. Voice Recognition (5)
10. Other (4)
    1) Mobile AVSAT Antennas
    2) Voice Encoding

Universities, Research Institutes and Centres of Excellence

The major thrust of activities between these three groups of entities in wireless personal communications is remarkably similar. Main activities of interest include multi-mode terminals, wireless modems (in particular), compression and coding techniques, wireless image transmission and wireless data LANS. In addition increased security over wireless links was a significant research activity of the centres of excellence.

Centres of excellence and research institutes also participate in industry and international standards activities.

Developers and Manufacturers

There is significant activity, both current and planned, by manufacturers in all areas of activity defined by the Scientific Authority with the exception of voice recognition. Wireless modems, interconnection and integration and participation in standards activities represent the highest area of activity. In wireless modems the thrust is towards higher data rates.

Service Providers and System Developers

Comparatively few inputs were received from service providers, with most responses being with regard to connection and integration activities of wireless personal communications to the public switched satellite network. There is however, significant participation in standardization activities.

HE - Information and Transaction Services

U = Universities (10)
R = Research Institute & Centres of Excellence (7)
M = Manufacturers and Developers (22)
S = Service Providers (11)

Note: The number to the right of the identifier indicates the number of responses received

Ranking	Area of Activity	Current	Planned	Alliances
Totals		U=11,M=26 R=14,S-23	U=2,M=0 R=2,S=0	
3	Multi-mode terminals	U-2, M-4, R-2, S-2 T=10	U-0, M-5, R-0, S-2 T=7	M-2, S-3
6	Home Transaction systems	U-1, M-2, R-1, S-3 T=7	U-0, M-2, R-0, S-4 T=6	M-1, S-3
1	Domestic & interactive information retrieval	U-2, M-4, R-2, S-4 T=12	U-0, M-3, R-0, S-3 T=6	M-1, S-3
2	Activities leading to Multi media	U-2, M-3, R-3, S-3 T=11	U-1, M-3, R-0, S-3 T=7	S-2
6	Standards & management	U-1, M-3, R-0, S-3 T=7	U-0, M-3, R-0, S-2 T=5	S-1
4	Friendly interfaces	U-1, M-3, R-2, S-3 T=9	U-0, M-3, R-1, S-2 T=6	M-4, S-2
3	Convergence of phone & cable systems	U-1, M-3, R-4, S-2 T=10	U-0, M-3, R-1, S-2 T=6	M-1, S-3
5	Compression and coding	U-1, M-4, R-0, S-3 T=8	U-1, M-3, R-0, S-2 T=6	M-1, S-1
	Other			

Areas of Activity in Order of Ranking

1. Domestic & Interactive Information Retrieval (12)
2. Activities Leading to Multi Media (11)
3. Multi Mode Terminals (10)
3. Convergence of Phone & Cable Systems (10)
4. Friendly Interfaces (9)

5. Compression & Coding (8)
6. Home Transaction Systems (7)
6. Standards & Management (7)

Universities, Research Institutes and Centres of Excellence

Few specific activities are taking place in the universities, research centres and centres of excellence on information and transaction services into the home. The main areas of interest are activities leading to multi-media services and the convergence of the phone and telephone systems, both fairly generic activities.

Developers and Manufacturers

Again the specific interest in this field is comparatively low with most of the activities being spin offs from other work.

Service Suppliers and System Developers

Given the small number of service providers interviewed the response was high as compared with the manufacturers. However, it mainly involved the possible implementation of pay-per-view and ISDN services.

MS - Enhanced Media Services at Home and at Work

U = Universities (10)
R = Research Institute & Centres of Excellence (7)
T = Total
M = Manufacturers and Developers (22)
S = Service Providers (11)

Note: The number to the right of the identifier indicates the number of responses received

Ranking	Area of Activity	Current	Planned	Alliances
Totals		U=22,M=25 R=19,S=33	U=6,M=25 R=9,S=31	
5	Integrated data & TV terminal	U-0, M-3, R-3, S-1	U-0, M-4, R-2, S-1	
8	Digital Audio Broadcasting	U-0, M-1, R-1, S-2	U-0, M-1, R-1, S-1	M-1
9	Flat screen TV display technology	U-0, M-0, R-1, S-2	U-0, M-1, R-1, S-1	M-10
6	Portability of terminals	U-3, M-1, R-0, S-2	U-1, M-0, R-0, S-2	S-1
5	Interactive TV	U-1, M-3, R-0, S-3	U-0, M-2, R-0, S-3	M-1, S-1
5	Full motion video conferencing	U-2, M-2, R-1, S-2	U-1, M-2, R-0, S-3	S-1
8	Digital HDTV	U-2, M-0, R-0, S-2	U-0, M-1, R-0, S-4	M-1, S-1
4	Direct broadcast satellite digital TV	U-2, M-2, R-1, S-3	U-0, M-1, R-0. S-3	S-1
2	Video compression	U-4, M-2, R-3, S-3	U-1, M-2, R-1, S-3	M-1, S-2
1	Broad-band switching	U-3, M-3, R-4, S-5	U-2, M-3, R-2, S-4	M-1, S-2
7	Merge display and HD/computers	U-2, M-1, R-1, S-1	U-1, M-2, R-1, S-1	
3	Digital standards voice/text/video integration	U-2, M-3, R-1, S-3	U-0, M-2, R-0, S-2	S-2
2	Standardized interfaces	U-1, M-4, R-3, S-4	U-0, M-4, R-1, S-3	S-2
	Other			

Areas of Activity in Order of Ranking

1. Broad Band Switching (15)
2. Video Compression (12)
2. Standardized Interfaces (12)
3. Digital Standards Voice/Text/Video/Integration (9)
4. direct Broadcast Satellite Digital TV (8)
5. Integrated Data & TV Terminal (7)
5. Interactive TV (7)
5. Full Motion Video Conferencing (7)
6. Portability of Terminals (6)
7. Merge Display & HD/Computers (5)
8. Digital Audio Broadcasting (4)
8. Digital HDTV (4)
9. Flat Screen TV Display Technology (3)

Universities, Research Institutes and Centres of Excellence

Again the interest here is in the more generic areas, specifically video compression, broadband switching,standard interfaces and portability of terminals.

Developers and Manufacturers

There is little interest in this field by the manufacturers except for digital standards and standardization interface activities.

Service Suppliers and System Developers

There is considerable activity in this field by service providers particularly with regard to interactive TV, digital audio broadcasting, digital HDTV, direct broadcast satellite technology, broadband switching and video compression. Standards and standardization interfaces are also and area of considerable interest.

IN - Intelligent Networks and Related Activities

U = Universities (10)
R = Research Institute & Centres of Excellence (7)
M = Manufacturers and Developers (22)
S = Service Providers (11)

Note: The number to the right of the identifier indicates the number of responses received

Ranking	Area of Activity	Current	Planned	Alliances
Totals		U=63, M-98 R=56, S=64	U=21, M=85 R=24, S=57	
7	Terminal and Transmission schemes	U-4, M-4, R-4, S-2 T=14	U-1, M-2 R-2, S-2 T=7	M-1, S-2
2	Network management	U-6, M-8, R-4, S-4 T=22	U-2, M-7, R-2, S-4 T=15	M-2, S-2
3	Distributed network Control	U-5, M-7, R-3, S-5 T=20	U-1, M-7, R-2, S-4 T=14	S-2
1	Network Architecture	U-6, M-8, R-4, S-5 T=23	U-2, M-7, R-1, S-4 T=14	M-1, S-2
4	Network Software	U-4, M-7, R-4, S-4 T=19	U-0, M-6, R-1, S-4 T=11	M-1, S-2
6	Impact of ISDN	U-4, M-6, R-2, S-5 T=17	U-2, M-7, R-1, S-4 T=14	M-1, S-2
10	Implimentation of new frequencies and bandwidth	U-1, M-5, R-3, S-2 T=11	U-0, M-3, R-0, S-1 T=4	
14	Partial distribution over cable TV networks	U-0, M-1, R-2, S-1 T=4	U-0, M-1, R-1, S-1 T=3	
8	Network implimentation at 1.8 GHz	U-4, M-3, R-4, S-2 T=13	U-1, M-4, R-2, S-1 T=8	M-1
5	Bandwidth on demand	U-4, M-5, R-3, S-6 T=18	U-1, M-5, R-2, S-4 T=12	M-4, S-2
11	Networks based on ring systems	U-2, M-2, R-2, S-3 T=9	U-0, M-2, R-2, S-3 T=7	S-2

7	CDMA	U-5, M-4, R-3, S-2 T=14	U-2, M-5, R-2, S-1 T=10	
8	Expanded fibre network by telcos and catv	U-3, M-4, R-3, S-3 T=13	U-1, M-3, R-2, S-3 T=9	S-1
15	Universal election referenda and polling facilities	U-0, M-2, R-0, S-1 T=3	U-0, M-0, R-0, S-1 T=1	M-1
14	Electronic self-scan and test system	U-0, M-2, R-0, S-2 T=4	U-0, M-2, R-0, S-2 T=4	
9	Deploy ATM switches in fiber networks	U-4, M-2, R-3, S-3 T=12	U-3, M-3, R-1, S-4 T=11	M-4, S-1
10	National, Industry and International Standards	U-2, M-3, R-3, S-3 T=11	U-0, M-3, R-2, S-3 T=8	S-2
12	Satellites - Iridium type	U-1, M-4, R-2, S-1 T=8	U-0, M-3, R-1, S-2 T=6	S-1
13	Other LEO constellations	U-1, M-4, R-0, S-1 T=6	U-0, M-2, R-0, S-1 T=3	
9	Intelligent network gateways	U-2, M-5, R-2, S-3 T=12	U-1, M-5, R-0, S-4 T=10	U-1, S-2
9	Intelligent interconnection of analogue and digital systems	U-2, M-4, R-3, S-3 T=12	U-2, M-4, R-0, S-2 T=8	
8	Very High Capacity Systems	U-3, M-5, R-2, S-3 T=13	U-2, M-3, R-0, S-2 T=7	S-1
16	Other (secure radio relay)	U-0, M-1, R-0, S-0 T=1	U-0, M-1, R-0, S-0 T=1	

Areas of Activity in Order of Ranking

1. Network Architecture (23)
2. Network Management (22)
3. Distributed Network Control (20)
4. Network Software (19)
5. Bandwidth on Demand

6. Impact of ISDN (17)
7. terminal Transmission Schemes (14)
7. CDMA (14)
8. Network Implimentation (13)
8. Expanded Fibre Network by Telcos & CATV (13)
8. Very High Capacity Systems (13)
9. Deploy ATM Switches (12)
9. Intelligent Network Gateways (12)
9. Intelligent Interconnection of Analogue & Digital Systems (12)
10. Implimentation of New Frequencies & Bandwidths (11)
10. National, Industry & International Standards (11)
11. Networks Based on Ring Systems (9)
12. Iridium type satellite (8)
13. Other LEO Constellations (6)
14. Partial Distribution Over Cable TV Networks (4)
14. Electronic Self-scan & Test System (4)
15. Universal Election Referenda & Polling Facilities (3)
16. Other (1)
    1) Secure Radio Relay

Universities, Research Institutes and Centres Excellence

While there is considerable work going on in intelligent networks and related activities it tends to be generic and aimed at broad areas of activity. These include distributed network control, terminal and transmission schemes, network management and the like. Thus caution should be taken in any analysis of the figures given above.

Developers and Manufacturers

This whole field is one of very high activity on the part of manufacturers and developers. Again the comparison of the numbers given above should be treated with caution as a significant number of manufacturers declined to complete this information for competitive reasons.

Service Providers and System Developers

Again this is a very major area of interest on the part of service providers and system developers with essentially all specific areas of activity being covered by the service providers addressing the specific niches of activity.

5.8 LEVELS OF R&D IN THE CANADIAN TELECOMMUNICATIONS INDUSTRY

This section addresses the resources made available for R&D by the two industrial groups considered, Developers and Manufacturers, and Service Providers. Only a very small number of organizations have provided R&D resource figures. There are two reasons for this. The first being that many of the organizations are sensitive to revealing financial information and the second being that in some cases the information was not available. Where information was available, only occasionally was it in a format that could be used in the matrices. A larger number provided informal information on R&D funds as a percentage of revenue.

The national average for Canadian research and development expenditures covering all industries is frequently stated to be around 1.4% of GNP. Based on the limited response received and on the consultant's general impressions, it appears that on average most developers and manufacturers interviewed are spending between 8% and 25% of the total revenues on R&D. These figures are not dissimilar from the 4% to 20% (with the majority between 10% to 12%) quoted in the D.A. Ford Report[1] of 1992.

These figures thus represent around an order of magnitude greater than national research and development expenditures, and indeed are similar to international telecommunications R&D levels.

ComDev have given permission to use their figures. These are given below as an example.

The following are the levels of R&D in relation to annual revenue achieved at ComDev over the last two years. It should be noted that these are conservative figures, with only activities that meet the rather stringent Revenue Canada criteria of R&D being included.

ANNUAL REVENUE	R&D EXPENDITURES	R&D (% OF REVENUE)
1991 $60M	$16M	26.7%
1992 $70M (estimated)	$19M (estimated)	27.1%

It can thus be seen that ComDev *ploughs back* a very large percentage of its revenues into R&D. It should be noted that ComDev is a privately owned company. However the

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[1] D.A. Ford and Associates Ltd. (*Telecommunications R&D in Canada* March 1992 (A study carried out for DOC)

findings of both this study and that carried out by D.A. Ford[1] in 1992, show that service providers allocate considerably lower percentages of revenue to R&D, typically in the order of 2%. However direct comparisons can be misleading, insomuch that most service providers are closely regulated with regard to both revenues and expenditures.

5.9 DETERMINING AREAS OF R&D

It was found that the determination of areas of telecommunications R&D vary significantly between the groups of R&D entities, primarily between the universities and research institutes on one hand, and centres of excellence, developers and manufacturers and service providers on the other. It is perhaps self evident that the key driver for selecting areas of R&D for universities and research institutes is the pursuit of knowledge, combined with the potential for professional recognition and advancement. On the other hand the market is the key driver for developers and manufacturers, and for service providers and system developers.

To an extent market also drives the selection of R&D projects by centres of excellence. Here. however, the thrust is more to link the activities of the universities to the needs of industry and to increase the current tenuous links between these two groups of organizations. The R&D carried out is of course primarily pre-competitive and the definition of pre-competitiveness acts as another R&D selection criteria for centres of excellence.

More specific criteria provided by individual interviewees are given below under the two major groups identified above.

Universities and Research Institutes

Areas of research are frequently developed by collaboration both within the university and outside by setting up advisory departmental committees, liaison committees and research committees. In some cases projects which are of interest to industry are selected providing they meet academic criteria.

Some universities are guided by local as well as global activities and they attempt to forecast what applications and services will be required in the time-frame from five to ten years and beyond. Keeping contact with world industrial leaders through research conferences helps determine these trends. Much of this is accomplished through personal contacts. It should perhaps be empathized, that, while most universities do have a formal, or semi-formal organization in place for their selection of research projects, in practice many are selected by individual researchers on the basis of personal contacts,

[1] D.A. Ford Report

areas of interest and the potential for academic publication. In many cases this is also true of public sector research institutes.

Private sector research institutes tend to be more market driven, while to an extent all the factors identified above still apply. Commonly the sponsoring agency(ies) will outline where they would like to see the businesses evolve in terms of product. The specific attributes of those products are then identified, by the private sector research institute, as is the technology required to deliver those attributes. From this decisions are made as to what internal R&D is carried out. The cost of such R&D in terms of return-on-investment from the product is of course one criteria in the selection process.

Manufacturers

Manufacturers determine areas of R&D based on market needs. Market needs are identified through variety of methods: direct feedback clients, market surveys, studies made available through third parties (govt, centres of excellence, research institutes, etc). This is the primary factor for determining R&D.

Other factors included:

- Identifying who else is active in a particular area of research and what resources they have available
- Does the potential area of R&D support a coherent direction established by general projects and corporate strategy.

For many manufacturers the possibility of obtaining R&D tax credits for the development to be carried out is another specific criterium in the selection process.

It should be emphasized however that while some manufacturers and service providers have formal processes for selecting R&D, others are quite *ad hoc* while still being market driven. To clarify this range of processes the following quotations from interviews with developers and manufacturers are given:

> "*R&D areas must be selected for their potential return on investment in the competitive international market place rather than for what is interesting to scientists, the government or universities.*"

> "*.... the space station is not in the industries best interest. We need some small projects in which Canada can compete and get contracts that will feed into the Canadian economy.*"

".... look for niche products that large companies won't touch because there is not enough volume for them to bother."

".... there is a weighting, so that areas that we feel that we are good at and competent in, can get a greater weighting over areas that we are not particularly competent in and good at."

"Strategic customers provide input to the R&D process, for example Bell Canada and Telecom Sweden. We then also do general marketing to determine what our focus will be."

"We determine our research and development activities based on market activity this input is generally provided by the marketing group and by the president himself."

Service Providers

Service providers all determine their R&D primarily by the needs of the market. Again a few quotations from the service provider interviews are given to expand upon this statement:

"We determine market needs and fulfil them consistent with corporate business thrusts."

"R&D is determined as a result of R&D trends appropriate to the market."

"There are two primary thrusts that help determine areas that we focus our R&D on. The first is market analysis and the second is opportunities."

"Our operational need also determine what areas of R&D we will focus on. The primary thrust of this is to make our operational activities more cost effective. Once we have developed technologies for ourselves we may offer them as services to our clients."

5.10 ENHANCING R&D

The general feeling with regards to enhancing R&D in the Canadian telecommunications industry is best conveyed by the following quote from one centre of excellence.

> **"we need to change the mindset of professors, companies, and governments. We need to understand what targeted research means."**

The findings on ways to enhance Canada telecommunications R&D have been presented by addressing what could be done by each of:

- Federal Government
- Provincial Government
- Research centres
- Universities
- Others

5.10.1 Federal Government

The majority of interviewees felt that the appropriate role of government in terms of R&D is one of encouraging or providing an incentive, and to involve industry when developing strategies and policies.

In general the level of government providing support is not considered to be important provided the efforts are completely coordinated and address the needs of industry and the market. National strategies and policies are considered to be an exception to this as they must logically be provided by the federal government.

The common theme of the responses was that a sound strategic plan and policy for telecommunications is mandatory to maintaining Canada's national and international position. The strategy should address the following:

- Keep programs and policies simple.

- Individual efforts and innovation are also critical to Canada's economic success and must not be overlooked. Support smaller companies, companies with fewer than 20 to 50 employees, both financially and technically. A concerted effort to maintain and improve Canada's entrepreneurial spirit is required. Companies must be encouraged to take R&D risks.

- A federally directed national telecommunications strategy which is responsive to changes in the marketplace and environment in which

companies operate is needed. The portion of the strategy dealing with industrial R&D should consider all aspects of a company's operations impacting on R&D including: marketing, manufacturing, market knowledge and access.

- Canada must present a coordinated integrated whole to international markets. If you will a Canada Inc. mentality. Industry, universities and all levels government must recognize the real competitive threats and challenges are in the international marketplace not at home and collaboration within Canada is needed to overcome these threats.

- Focus on areas in which Canada is strong. Canada must continue to concentrate on niche markets and remain or become internationally recognized in these markets.

- Reduce non-tariff barriers and counter-balance potential trade agreement legislative actions which could be used as an international competitive tool to reduce Canada's international effectiveness. The government must take a more active role in dealing with countries that do not provide equal access for Canadian companies to their markets. For example, the Buy America Act takes precedence over the Free Trade Agreement when selling to U.S. Municipalities.

- Greater recognition of the economic power of International Standards is required, together with appropriate diplomatic and technical support at international standards fora.

- Canada must make more of an effort to determine the capabilities of Canadian companies and have more confidence in them. Government departments have been known to let contracts to foreign companies after the R&D had been carried out (satisfactorily) in Canada. In some cases Canadian companies were not even aware that there was a manufacturing requirement until after contract had been signed.

- A central point of contact is required for obtaining information. Perhaps a database or one organization that could be contacted to assist organizations obtain information such as who is involved in specific R&D activities, technical information, policy information, and financial and management assistance.

- A business case approach should be used to promote R&D. One example of this is to support those portions of the industry which are strong, and not

prop up ineffective organizations, while recognizing the needs of start up R&D companies.

- Government can assist by acting as testbeds for new products. For example the United States subsidizes its high-technology industries by providing government contracts which aid in the creation of commercial spin-off products. This is particularly true of cost-plus contracts.

- Government technology transfer program can be of great assistance to industry.

- Responses regarding regionalization varied. The majority of individuals felt that regionalization was counter productive and that Canada needs a nucleus of technology like Boston and Silicon Valley in the U.S.A. However, a minority thought that regionalization was positive particularily since it distributed the resource pool from which organizations could draw from and had access to.

- Focused funding - Canada cannot afford to spend limited funding on a wide range of research. It must aim at getting products to market. In other words:

  "*put five dollars on one thing, not five cents on each of 100 things.*"

- Industry must be involved in federal (and provincial) boards that are allocating R&D funding.

- Funding issues should include competitive international financing such as grants, bridge financing, low interest loans etc. This is an area where Canada frequently loses out when bidding internationally.

- Long term strategies are required as short term money does not solve R&D problems. To quote one interviewee:

  "*There is no real strategy, there is no plan here that allows for some sort of continuity. Every two years it is another program to support some other magic, agenda and they are not tied together so it is a waste.*"

- R&D tax credits are considered a good basic approach but could be improved. For example, providing tax credits up front would make a significant contributution to an organizations operating capital.

5.10.2 Provincial Governments

Where applicable methods of enhancing research and development that apply to the federal government apply to provincial governments. These have not been repeated in this section which is restricted to programs which are currently under provincial jurisdiction.

- Greater collaboration with industry is required regarding education. More training subsidies and skills development are needed. Funding for co-op students is one possibility to consider.

- More assistance is required for management training. Mentoring programs are considered to be very effective. At present the issues to be addressed are identifying the experts that are qualified and financial assistance which will make these types of programs accessible. This is particularily important for small to medium sized companies.

- Other provinces besides Quebec, Ontario and New Brunswick should consider R&D tax credits.

5.10.3 Research Centres

It is recognized that there is a need for research centres to carry out the long term research into areas, such as propagation, that it is difficult for other organizations to justify. In addition some interviewees felt that these research centres may prove to be one solution to "*applied R&D*" for industry at large. Some individual companies did not benefit directly but recognized the benefit to Canadian companies as a whole.

Centres of excellence such as TRIO, National Wireless and TR labs are considered useful. A lot of good work has come out of these Centres on the intelligent networks, enhanced media and information transmission. They can enhance the R&D activities by providing a cooperative environment in which pre-competitive research can be done. This reduces the time delay and cost of the pre-competitive stage of product development.

While the concept of centres of excellence is recognized to be an excellent one, fears were expressed that too many had been incorporated producing overlap and an ineffective dilution of scarce funds.

In addition a number of interviewees also felt that while the larger companies could readily benefit for pre-competitive research carried out by centres of excellence, it was more difficult for the smaller companies to exploit these activities.

5.10.4 Universities

Universities play a key role in enhancing R&D in Canada. It is apparent from the interviews that the focus of universities and industry is different. The difference is primarily in relation to research,to gain knowledge and the exploitation of that knowledge in particular, the fixed timeframe of the latter. Universities feel that industry does not place enough emphasis on long term R&D and staff development.

Industry opinion concerning the university's current contribution to the telecommunications industry in Canada varies considerably and is dependent on the nature of individual relationships. In general the interviewees recognize that universities are valuable in terms of enhancing R&D. Closer collaboration with industry and all levels of government was desired.

The following comments and suggestions were made by the interviewees.

- Require more collaboration with industry and all levels of government. Many, but not all, university researchers are preceived to be in an "ivory tower". Universities can enhance R&D by developing a better understanding of industry in areas such as:

  - problems faced
  - directions
  - market requirements
  - need for space, facilities, infrastructure, core support staff
  - assistance with short term as well as long term problems
  - industry concept of a deliverable
  - theory is necessary and good; however, it needs to bridged to practicle applications
  - could act as product testbeds

- One interviewee felt that students and university researchers alike need experience in industry. This can be achieved through building stronger alliances with industry and making use of executive exchanges. Executive exchanges could promote a better understanding and appreciation of the challenges each faces.

- The root of industry's *Ivory Tower* image of universities may be the method of funding universities. At present funding is based to a large extent on the papers that are published. Consideration should be given to linking funding to commercialization that has resulted from research conducted.

5.10.5 Industry

The following findings were drawn from interviews with Universities and Research Institutions:

- Industry must consider the long term and plan accordingly. A balance between short term and longterm R&D must be found.
- Industry should hire more graduate students and lengthen their time horizon.
- Industry should be sensitive to training needs of staff and provide more opportunites and time for staff development.

Additional general findings included:

- Productivity Centres and Value Engineering could be of great importance to industry. These could show people how to produce more effectively. Japanese manufacturing techniques and methodologies could be used to do this.
- A few Municipalities have programs to support R&D in the telecommunications industry which are considered successful. Other municipalities should be encouraged to follow these examples.

6.0 REVIEW OF INTERNATIONAL TELECOMMUNICATIONS R&D THRUSTS

6.1 Preamble

To permit a valid assessment of the strengths, weaknesses and foci of Canadian telecommunication R&D, it is necessary to compare Canadian activities with those of the rest of the world. In practical terms this means the telecommunications strategies, policies and activities of the three main trading groups of North America, Europe and the Pacific Rim.

As the analysis of international R&D was not part of the study, this section provides a summary of the status of international telecommunications R&D. This was obtained from other studies carried out for the Department of Communications, from other documents available to the Project Team and from the knowledge of the Project Team. In particular, the following documents were used in this summary:

1. International Communications R&D: Draft Final Report; a study carried out for the Department of Communications by NGL Consulting Group Ltd. dated February 15, 1993.

2. Telecommunication R&D in Canada: Final Report; a study carried out for the Department of Communications by D.A Ford and Associates Ltd. and E B Systems Limited dated, March 1992.

3. Andy Coghlan: Dying for Innovation; New Scientist, January 9, 1993, pp 12-14

Where inputs are used from these documents, this is indicated by showing the relevant reference number in parenthesis.

It should be emphasized that no new material has been used in the first part of this section. However, the section does conclude with inputs received from the companies interviewed with regard to their perception of the international R&D field.

6.2 Europe

6.2.1 The European Community (EC) (1)

Much of the EC's telecommunications R&D activity is centred on the so called framework programs. These are as follows:

- **EUREKA - (European Research Coordination Agency)**

  This is a framework for encouraging industry led, market driven, collaborative projects aimed at producing high technology goods and services to compete in world markets against the North American and Pacific Rim trading groups.

  Eureka programs are designed to exploit a wide range of technologies including the following related to telecommunications:

  - Information and telecommunications
  - Robotics
  - Lasers

  These projects are for civilian use only and involve both the public and the private sectors. In January 1990, information/communication projects represented 37 per cent of the total investment in EUREKA projects.

  There are currently over 2000 companies participating in EUREKA projects.

- **Program on Research and Technological Development (R&TD)**

  The EC R&TD framework program is an umbrella for large themes under which activities in specific sectors is undertaken. The principle R&TD programs relating to telecommunications are given below. They each require 50 percent cost-share on behalf of the participants.

  - **R&D in Advanced Communications Technologies in Europe (RACE)**

    RACE was set in place in 1987 and is aimed at promoting pre-competitive R&D in the area of Integrated Broadband Communications (IBC) to enable Europe to establish an IBC network in the 1995-2000 timeframe. The total budget was about 1.2 billion ECU for the period of 1987-1992. The estimated budget for phase II is approximately ECU 1 billion for 1990 to 1994.

As of January 1992 more that 550 organizations were involved in 186 RACE projects. Many of these are collaborative projects as demonstrated by the fact that 26 of the key groups are involved in 96 percent of the projects.

The analysis of the communications projects of the top 14 organizations demonstrates that these organizations are involved in projects which either provide a common technology base or evaluated and developed advance technologies cutting across all four areas. Indeed this was the expressed direction of *RACE Phase I.*

RACE Phase II focused on new applications, services, operations and management structures. Of the four subsectors enhanced media services became the focus of many of the organizations. High speed network technology is the second area of interest. In phase II the number of partners permitted was limited to 7 partners in an attempt to limit overhead costs.

In contrast to the key organizations a defined pattern or trend for R&D is not apparent for the remaining organization. These organizations typically are involved in R&D related entirely to their field or to providing a common technology base.

European Strategic Program for R&D in Information Technologies (ESPRIT)

ESPRIT was launched in 1984 to promote industrial co-operation and to provide the technological base to ensure international competitiveness. The budget is approximately $4 billion Canadian for phase III which will focus on industrial projects.

Phase III is active under the umbrella of the Third Framework Program. This phase takes into account the fast changing industrial scene by requiring new proposals to include a new element, market forecasts. This phase of the program focuses on 6 technological areas:

- Microelectronics
- Information processing systems and software
- Advanced business and home systems with peripherals
- Computer integrated manufacturing and engineering
- Open microprocessor systems initiative
- Basic research

- **Telematics Programs**

  The Telematics programs will strive to contribute to the completion of the internal market by providing truly Europe-wide services through the exchange of information using increasingly powerful, integrated and interconnected information exchange systems. Telematics promotes the development of integrated information and/or communications systems in the following areas:

  - Public authorities (e.g., border police)
  - Transport services - DRIVE (Dedicated Road Infrastructure for Vehicle safety in Europe)
  - Health care - AIM (Advanced Informatics in Medicine in Europe
  - Distance learning - DELTA (Developing European Learning through Technological Advance)
  - Libraries
  - Linguistics
  - Rural areas - ORA (Opportunities for Rural Areas) one objective is to create conditions for small business to provide more diverse employment opportunities

  The budget is ECU 380 million.

- **Pan-European High-Speed Network**

  Recently the development of a Pan-European High-Speed Network was identified as being of strategic importance by an EC Working Group.

6.2.2 United Kingdom (UK) (3)

Support schemes in the UK are uncoordinated, putting small and medium enterprises (SMEs) at a disadvantage. SMEs have been described as the engines of economic recovery. They can set up quickly and want to expand. UK spending for support of small companies falls short of that available in Japan and Germany.

Recently the UK has recognized these shortcomings and the Department of Trade and Industry (DTI) has ordered a review of the R&D funding schemes for small and medium sized companies. DTI has also announced plans for a pilot project to disseminate business and technology information locally. The DTI spent £18.7M in the last fiscal year on R&D projects. Besides this the department has operated several other schemes to assist small companies.

Among these is LINK, under which companies receive up to half the cost of the projects set up jointly with the academic institutions in areas such as electronics and advanced manufacturing. SMEs participate in 40 percent of the projects.

Under the SMART scheme companies compete for grants to stimulate innovative technology projects. The DTI has approved a budget of over £30 million over 3 years.

Through SPUR, the DTI offers grants for SMEs to develop new products and processes that demonstrate a significant technological advance. So far the government has allocated 180 grants worth £17 million.

Government critics argue that the local support offered by the DTI is haphazard. Four years ago, it set up Training and Enterprise Councils (TECs) to provide local services to small firms, but their success has been limited and they are acting mainly as training offices. The enterprise aspect has not been addressed. The government has recognized the proliferation of programs and has set up *one stop shop* programs. They have tried to do it in the past but have not been successful.

The practice of large British companies of shopping around for suppliers can have adverse effects. The result is very often an amalgam of mistrust, fear and dishonesty.

In Wales and Scotland regional networks are also being created to support industry, particularly SMEs.

6.2.3 Germany (3)

In the Telecommunications sector, the Deutsche Bundespost (DBP) had restricted its role in computer communications to the sole provider of the network facility , i.e. the integrated text and data network (IDN). It has a leading role as a provider of infrastructure for telecommunications and basic public service. Now that competition is allowed in Germany (except for terrestrial telephony services), with DBP Telecom as one of he competitors, the market environment will change. Allowance of shared use of leased circuits will also open up vast opportunities to exploit corporate networks (both intra and inter-firm networks) to reinforce their competitive advantages. It is to early to determine what the impact will be.

The level of Government intervention in the promotion of IT-applications is low in Germany. Decisions on the use of IT-applications are left to the individual entrepreneurs.

The government prefers to take advantage of the mechanism of free market stimulus to increase the strategic use of IT-based systems and equipment in the economy. The role of the Government is to ensure the basic conditions to develop the use of IT.

These directions are being taken within a total science and technology expenditure envelope of DM[2] 90 billion in which DM 70 billion goes towards R&D (2.8 percent of GDP). Industry accounts for 64 percent of R&D expenditures and 71 percent of all R&D. Increasing importance is being given to participation in international programs.

Industrial strength created by localized support for small companies is also a key feature for Germany. Baden-Wurttemberg in the south western corner of Germany, for example, is home to the unique Steinbeis Foundation, which directs small firms to the technologies they need and controls 114 technology transfer centres employing 2550 staff. Add to this the thirteen government assisted Fraunhofer industries in the state for transferring applied research into industry and the depth of the technology support becomes clear.

Another strength of the system is that all German companies must by law belong to a chamber of commerce. In consequence, the chambers are better resourced, German support for small to medium enterprises (SMEs) is also generous at the federal level. As far back as 1984 the government in Bonn recognized the importance of SMEs and introduced national schemes to encourage collaboration between small companies and university departments in advanced technology. In all federal support for SMEs in 1990 amounted to DM678 million (£283 mill). Germany's Science Minister stated the strategy has been a resounding success. In the past decade, SMEs have built up their research capacity faster than large companies. Within eight years, they had doubled the expenditures for research and development by SMEs and raised the proportion of national research funding by industry generally from 56 percent to 65 percent.

6.2.4 Denmark (3)

Denmark has innovative policies and support systems that are highly decentralized and local technology centres keep SMEs abreast of leading edge technologies.

6.3 United States (3)

Small companies in the U.S. will receive at least $500 million from federal sources. Another $500 million has been promised to set up a network of regional centres.

The U.S. suffered in the 1980's from the government not intervening in industry. The one scheme created by the Republicans to have had any real impact on innovation on SMEs is the Small Business Innovation Research Program set up in 1982, for which governments set aside a portion of their budgets every year. Next year, the budget will hit $500 million.

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[2] One DM is approximately $0.76 (Canadian).

Small companies may be able to receive another shot in the arm as the new President is known to approve of the Japanese system of supporting SMEs and has stated that if Japan has 170 R&D centres, the U.S. would have the same. Each centre would provide information on areas such as technology and training. If more complex problems required solving the centres would act as a bridge with local universities or with the National Institute for Standards and Technology, or with national laboratories.

Regional networks already exist in some states. One of the most successful was setup by the President of the Montgomery County High Technology Council in Maryland. Using $220 million in public grants and more than $600 million from the private sector, it helped to create more than 800 new companies and has provided 15,000 jobs. Under the scheme the state government gives grants to four regional technology centres for rapid R&D education and training. Each of the four regional technology centres concentrates on four areas, including computer aided design and robotics. They also offer business advice and services.

6.4 Japan (3)

Japan has extensive regional support programs to disseminate information about technology and provide low cost support. It also has innovative policies and support systems that are highly decentralized and local technology centres keep SME abreast of leading edge technologies.

In Japan, agencies provide a range of assistance to firms, ranging from favourable loans and credit guarantees through equipment leasing programs, to tax incentive programs for investing in equipment. The Central government sponsors a number of regional innovations designed to stimulate the exchange of information about technology, and to make sure that knowledge filters down to smaller enterprises. Prefectures, the 47 regions into which Japan is divided, pursue similar strategies in concert with Tokyo. The variety of programs makes it hard to calculate total spending for small company technology assistance in Japan. But estimates run into billions of dollars.

Two aspects of Japan's support for small firms stand out. The first is the coordinated network of 170 regional centres that channel support for innovation and research into companies with fewer than 300 employees. Three-quarters of the staff at these Kohsetsushi centres are engineers who carry out applied research and product testing, and offer training or advice. Spending on the centres is some $500 million dollars a year. Around 80 percent of this is contributed by the prefectures and local governments, and the rest by Tokyo. With their easy access and nominal fees the Kohsetsushi centres provide small Japanese firms with an effective source of assistance to improve their manufacturing operations and products.

Secondly small firms in Japan have a much closer relationship with the large firms they supply. Unlike the U.S. where relationships between large firms and their subcontractors are often adversarial, short term, and dependant on price, large Japanese firms usually maintain collaborative, longer term associations with their smaller suppliers. While large firms impose pressure on small firms to modernize by demanding strict costs, quality and delivery requirements, they also help to bring on suppliers by sharing information, technology and personal, often researchers.

Japan has a planned economy. The Ministry of International Trade and Industry effectively directs certain industries to meet economic objectives.

6.5 Foreign R&D Tax Incentive Programs (2)

6.5.1 United States R&D Tax Incentives

In the U.S., current R&D expenditures are 100 percent deductible in the year incurred. A U.S. corporation may also elect to amortize current expenditures over a minimum period of 60 months.

The U.S. government makes available to companies a 20 percent investment tax credit on the increase in current qualifying R&D expenses over a specified expenditure base. The expenditure base is the average of R&D expenses for the three prior years.

At the state level, California offers an 8 percent R&D tax credit. The California credit is based on increases in R&D expenditure and conforms to the definitions of the federal tax credit, including taxability of 50 percent of its value.

6.5.2 Australian R&D Tax Incentives

Although there is no tax credit available for R&D expenditures, companies incorporated in Australia can write off up to 150 percent of current expenditure for R&D incurred in the year.

Capital R&D expenditures for machinery and equipment are also written off to the extent of 150 percent, but over three years on a straight-line basis. Capital expenditures on buildings are 100 percent deductible, but are written off over three years on a straight-line basis.

6.5.3 Japanese R&D Tax Incentives

In Japan, current R&D expenses are fully deductible in the year incurred. Alternatively, the expenditures may be amortized over a period of not less than five years. Capital R&D

expenditures in most cases must be depreciated.

A 20 percent tax credit for research and development expenditure is also available in Japan. The credit is allowed against the corporate tax on increases in R&D expenses. A base for calculating an increase in a current year is defined as the largest amount of R&D expenditure incurred in any of the previous accounting years since 1966. The eligible expenditures include current R&D expenses and depreciation allowance for R&D machinery and equipment. Depreciation allowance for buildings is not included. The R&D tax credit is not taxable, and therefore it does not reduce the deductible base for R&D expenditures.

6.5.4 United Kingdom R&D Tax Incentives

In the United Kingdom, both current and capital R&D expenditures are fully deductible from taxable income in the year they are incurred. Aside from this provision, there are no other tax incentives affecting R&D. However, it is understood that legislation is currently being drafted that will reflect in part the Canadian approach to R&D tax incentives.

6.6 Canadian Perceptions of the International Telecommunications R&D Situation

From the inputs received from the interviews the following summary of the industry's perception of the international telecommunications R&D situation was drafted.

The major trends that characterized international telecommunications and related R&D throughout the 1980's were:

- the increasing technological content of products and processes, requiring increasing investment in R&D
- the application of digital technology to communications products and the emergence of an information technology; sector through the merger of computing and communications;
- the liberalization of markets in industrialized countries;
- the increasing significance of Third World, particularly, Asian markets;
- the consolidation of the industry through merger, acquisition, joint ventures, strategic alliances and research consortia

These trends are expected to be part of the 1990's as well. Added to them, however, are two new trends:

- the feasibility of delivering broadband communications to the home, potentially leading to the convergence of telephone and broadcast

communications;

- the emergence of personal communications networks, whereby communications are freed from the constraints of where wires have been placed.

Technology driven by R&D is a major element of a number of these trends. Changes in technologies often pose a threat to existing players in an industry and an opportunity to new players. The implementation of these technologies will require significant investment, not only in product development, but in the technologies themselves. Other countries, have already taken positions in these technological areas. The European Community, for example, is investing over $3 billion Canadian in RACE to position its industry in the area of broadband communications. Japan has begun to make a concerted effort in promoting broadband access to the home, the first important step in converging telecommunications and the other information media.

Japan, Europe and the U.S. are all spending greater relative and absolute sums than Canada is, relatively and absolutely, on the enabling technologies. This will tend to move the focus of industrial activity that depends on these technologies.

One of Canada's strengths is its concentration on niche technologies. Other countries typically have broader scope in terms of their research and development objectives.

Europe will become an opportunity if Canadian industry is willing to make the necessary market development investment. Tremendous opportunities will continue to exist in developing countries; while some will be accessible by firms with good products and with smart marketing who perseverance many will only be open to companies that bring government money with them.

7.0 ASSESSMENT OF CANADIAN TELECOMMUNICATIONS STRENGTHS AND WEAKNESSES

7.1 The Mechanism of Telecommunications R&D

In considering Canada's telecommunications R&D strengths and weaknesses it is perhaps appropriate to first consider the mechanism of R&D from the initial concept of a technology through to the incorporation of this technology in usable, saleable and competitive products.

In this analysis of Canadian telecommunications R&D activities this mechanism has been addressed by assessing the R&D activities of the four main groups concerned with R&D, namely universities, research institutes and centres of excellence, developers and manufacturers, and service providers and system developers. In very general terms this

flow of R&D activity from universities through to service providers can be looked upon as a *snapshot* of the lifetime of a technology. It will be appreciated that individual variations occur modifying the *classical* model given below:

> A new concept or approach is frequently conceived in a university environment, using previous research achievements, often in a number of disciplines,as stepping stones. As the prime objective of university research is seldom the application of the results of the research, frequently the knowledge of such research will languish in theses and in comparatively obscure learned journals.
>
> Traditionally the next stage in the development of a technology would be initiatives on the part of private or public research institutes to identify, from the knowledge generated from university research, directions for applied research that could lead, if successful, to new applications. Traditionally there has been little overall organization or systematic direction to the linkages between these two groups of activities.
>
> The applied research carried out by research institutes will normally be published in journals and magazines with a comparatively wide circulation, or be made readily available to the sponsors of the private sector research institutes.
>
> From both of these sources the engineers and scientists in the R&D departments of manufacturers would obtain the initial knowledge to develop new products directed at the marketplace.
>
> In telecommunications the final player in the lifetime of a technology are the service providers. In other words the telecommunications common carriers or private common carriers who use the products of the manufactures to develop telecommunications networks and make the services provided by such networks available to their subscribers.

In Canada, and in much of the developed world, the links between the telecommunications developers and manufacturers and service providers have been strong and indeed they commonly have corporate ownership linkages. The linkages between universities, research centres and the developers and manufacturers have traditionally been far more tenuous.

In any analysis of the strengths and weaknesses of Canadian telecommunications R&D, the consideration of all the linkages between Universities, Centres of Excellence, Manufacturers and Service Providers is considered to be just as important as the identification and analysis of the actual technologies and products being researched or developed.

Over recent years Canada has implemented a new concept, that of centres of excellence, that is having a major impact on the strengthening of the previously tenuous link between university research and the exploitation of such research by Canada's developers and manufacturers. This has occurred at a time when telecommunications and information technology is being regarded as a key infrastructure in not only national, but also international economies. This recognition of telecommunications as a critical infrastructure has brought with it a high level of international competition.

It is thus appropriate to commence this section on the strengths and weaknesses of Canada's telecommunications R&D by highlighting telecommunications "Centres of Excellence" as a significant potential strength in reducing the critical time period between the conception of a key technology and its availability in the marketplace.

It should be recognized that centres of excellence are not a panacea. They are still in the early stages of development and require careful nurturing by appropriate strategies and policies. Notwithstanding this they have already shown signs of adding very considerable strength to Canada's already strong position in the international telecommunications market place.

The remainder of this section will address more specific strength and weaknesses.

7.2 The World Standing of Canadian Telecommunications R&D

In this sub-section the strength and weaknesses of Canadian telecommunications R&D will be assessed from the viewpoint of the standing of Canadian technology in the world in it's broadest sense. The overall telecommunications infrastructure will be examined as will the approaches that Canadian companies take to the national and international markets. Canadian strengths will be identified, as will those areas that Canada does not emphasize and in which it has few strengths.

7.2.1 Canadian telecommunications infrastructure

To provide a framework against which Canada's technological world standing can be assessed it is first necessary to identify and review the overall telecommunications infrastructure.

Canada is fortunate in having a strong and comprehensive telecommunications infrastructure.

A core of Canada's world class universities, including McGill, Waterloo, Toronto, Simon Fraser and Carleton, among others, have strong telecommunications and informatics

research groups. Using the strength from these universities, together with research carried out world wide, Canada has a strong infrastructure of telecommunications related research institutes and, more recently, telecommunications centres of excellence. These include world class organizations such as Bell Northern Research (BNR), The Communications Research Centre (CRC), The Telecommunications Research Institute of Ontario (TRIO), and The Information Technology Research Centre (ITRC) to mention but a few. These research institutes and centres of excellence carry out very considerable pre-competitive telecommunications research in the fields of interest to the Canadian telecommunications manufacturing and service provider industries.

The Canadian telecommunications manufacturing industry is also a strong and comprehensive one. It's main driver is the Canadian owned major telecommunication international company of Northern Telecom. Universally recognized as world class, it is currently third in the international standings of telecommunications revenue world wide. Northern Telecom's products cover all major facets of telecommunications.

Broadening Canada's manufacturing infrastructure are a reasonable number of medium to large organizations, again typically of world class, and providing strength, not only overall, but in specific technological niches. Typical of these are MPR Teltech Inc, whose strengths include both terrestrial and satellite telecommunication, together with Mitel, Newbridge, Novatel and Canadian Marconi, all of whom are strong in terrestrial communications, and Comdev, Spar and SED who are typical of Canada's strength in satellite communications. In addition there are a significant number of major foreign owned facilities that also carry out telecommunications in Canada. Typical of these are Motorola, Raytheon and Ericcson.

Adding further a further dimension to the manufacturing infrastructure are a large number of small and medium enterprises (SME's) typically addressing niche markets and having particular strengths in software as well as hardware. While these are too numerous to give a representative sample, companies such as Glenayre, MPB Technologies, Positron, TeeCom and SR Telecomm are typical of this portion of the infrastructure.

The final major element of Canada's telecommunications infrastructure are the service providers. Driven by the twin catalysts of huge geographic distances and a dynamic but small population, Canada's telecommunications network has for many years been internationally recognized as being within the first three in the world, and frequently the world leader. The two major telecommunications service providers have been for many years Bell Canada and Unitel who traditionally have represented voice and data transmission respectively. However Canada's telecommunications system is a complex one consisting of Bell Canada serving Ontario and Quebec, with the rest of Canada being served by provincial telecommunications companies. As federally incorporated companies, Bell Canada, BC Tell and certain other common carriers have always been

federally regulated. Subsequent to a recent court decision, the federal government is now recognized to have a degree of control over all telecommunications common carriers. From the earliest times these companies have linked together to provide coast to coast seamless service. They are now represented by the Stentor group of companies. Unitel, after many years of attempting to access the lucrative long-distance voice, as well as data market, has now received permission to compete with the Stentor group of companies. It has recently sold 20% of it's shares to AT&T, the American headquartered telecommunications multinational, in return for AT&T's management services.

Over recent years third party resellers of telecommunications services have sprung up to address needs for private networks. These are typified by Callnet. In addition, Canada's communications satellite networks are also of world class, with the major players being Telesat Canada for domestic satellite communications, Teleglobe for international interconnection, and Canadian Satellite Communications Inc. (CANCOM). Addressing telecommunications in it's broadest sense, Canada's traditional telecommunications service providers are joined by broadcasters and cable companies. Here again Canada has very considerable strength with CBC being recognized for it's excellence world wide. Canada's cable television industry provides Canadians with close to the highest penetration of cable TV in the world, with a diversity of services, equalled only by the United States. Typical of the major players in the Canadian cable television industry are Rogers Cable TV, Videotron Ltd. and McClean Hunter Cable TV.

In what might be termed a typical Canadian manner this huge and diverse infrastructure of service suppliers, both private and public, combine together to serve Canada's population in a manner (frequently unrecognized in Canada) which is the envy of the world.

From the above it can be seen that overall the Canadian telecommunications infrastructure is comprehensive, having breath and support in all areas, and given it's comparatively small absolute size it has a very strong world wide position.

The assessment made from the above is that from a world wide perspective a major strength of Canada in telecommunications as a whole is it's integrated and comprehensive telecommunications infrastructure which is strong in all elements and combines the best in both private sector and public sector mechanisms while minimizing their weaknesses.

7.2.2 Key Characteristics of Canada's Telecommunications Manufacturing Industry

As can be seen from the infrastructure description above Canada's manufacturing industry is dominated by Northern Telecom that gives it it's broad, and multinational, core. Recognizing this, virtually all other elements of Canada's telecommunications

manufacturing industry address what may be termed niche markets. In some cases these are large, as typified by the terrestrial and satellite communications strength of MPR Teltech and the satellite communications strength of SPAR Aerospace. In other cases they are quite narrow as typified by the network products of Newbridge and the satellite RF products of Comdev. However this whole gamet of small to quite large companies have one thing in common. They have identified a niche where they can excel rather than provide mediocre products. It is considered that this *pursuit of excellence in niche markets* is one of the main strength of Canada's telecommunications industry.

In summary Canada's telecommunications manufacturing industry can be said to have two key strengths. The first is the world class position of it's sole multinational, Northern Telecom, who produce a very wide range of telecommunications products. The second is the *pursuit of excellence in selected niches* , an approach taken by virtually all other Canadian telecommunications companies from the smallest to the largest. While this niche approach does not eliminate competition it tends to reduce potential overlap and duplication of effort.

7.2.3 Product Strength and Areas Not Addressed

From the findings in the body of this report the assessment has been made that Canada is strong in two prime telecommunications product areas namely:

- **Intelligent Networks and related activities**
- **Wireless personal communications in the broadest sense**

In these two main areas Canada is currently more than holding it's own both nationally and internationally. It should be recognized, however, that this position is not a sinecure. There are very strong international competitive forces in all major trading areas who also see intelligent networks and wireless personal communications as two of the key technologies of the future.

Canada's telecommunications manufacturers have chosen not to address in any strong manner the fields of informatics and transaction services to the home, and the field of enhanced media services from the home and office. While there is some activity in these fields they can not at this time be considered Canadian strengths. Nor indeed is there any evidence that action is being taken to make them Canadian strengths. Given that there are major international strengths in both of these areas in all three of the major trading areas, combined with the *excellence in niche products* philosophy in Canadian industry, this analysis has not unearthed any evidence to show that this is a weakness. Indeed it shows focus and a recognition that Canada is not and does not need to be, all things to all people in telecommunications R&D and telecommunications products.

7.3 Canadian Telecommunications, Strategy, Policy and Regulations: How Do They Compare ?

The three main trading groups of the world, North America, Europe and The Pacific Rim are unanimous in their recognition of telecommunications and information services as a key national and international infrastructure. In all cases they are attempting to find the appropriate balance regulated and unregulated modes of service while confronted by ever changing and ever improving technologies.

It may be validly stated that the major thrust world wide is an attempt to address the opportunities of this rapidly changing situation while preventing the chaotic behaviour common in complex and rapidly changing systems.

All three groups recognize that telecommunications R&D must have direction and support. In the European community quite large sums of money are being used to address telecommunications and information technology R&D in a concerted and comprehensive manner. **All three trading groups recognize the importance of what is termed as *small and medium enterprises* (SME's) in driving telecommunications research and development . Small and medium size companies typically are able to react speedily to the massive changes in technology which are taking place in telecommunications.**

The European Community and Japan appear to have well planned and comprehensive telecommunication strategies that use the strength of both the private and public sector in concert. Both trading groups openly recognize that the international market place is the main challenge, and unabashedly direct their strategies to maximizing their international market share. The United States, whilst recognizing this, is only slowly addressing it in a concerted manner, joining the strengths of the public and private sectors.

Canada's last comprehensive review of telecommunications strategy took place in the mid seventies. Much of Canada's policy, legislation and regulation over the last eighteen to twenty years has been based on these *policy green papers*. Given the rapid change in the telecommunications environment over the last twenty years it is not surprising that many members of the telecommunications industry see Canada's currently strong position in the international market place as extremely vulnerable. **A highly focused, timely national telecommunications strategy, aimed specifically at the international market place is considered mandatory. This strategy should identify major international markets and international competition, and compare Canada's strengths and weaknesses, as defined in this report, to develop major Canadian thrusts. In other words take the best from the European and Japanese national strategies to ensure the maintenance of Canada's place in the international**

telecommunications market. The lack of this is currently a serious Canadian weakness. It is also considered mandatory that such a strategy should not only have private sector input, but should be implemented jointly with the public and private sectors as equal partners.

In addition to its lack of a comprehensive telecommunications strategy, **Canada does not currently have in place a program to encourage SME's. This group is recognized by the rest of the world as key in addressing fast changing telecommunications technologies. Indeed Canada's major R&D Support program, R&D tax credits, tend to work against small companies by having a very low *small company limit* ($2 million revenues or $200,000 profit), and by only providing such credits some considerable time after the work is done. This is also considered a weakness.**

8.0 CONCLUSIONS AND RECOMMENDATIONS

Given below are the conclusions drawn by the Project Team on the strength, weaknesses and foci of Canadian telecommunications R&D activities.

For ease of review these conclusions are organized from the generic to the specific, with the latter in groups covering the four main technology thrusts of Wireless Personal Communications; Electronic Information and Transaction Services into the Home; Enhanced Media Services at Home and at Work; and Intelligent Networks and Related Items.

Again for ease of review, following each group of conclusions are given the recommendations of the Project Team relating to those conclusions.

8.1 Generic Conclusions and Recommendations

Conclusions

- With the growing convergence of telecommunications and computer technologies; the convergence of telecommunications and entertainment services; and the overall trend toward an *information driven society*, telecommunications is now recognized by all developed countries as a key infrastructure having a significant impact upon both national economies and upon the world wide economic situation.

- Telecommunications and its subsidiary technologies are continuing to change at a very rapid rate, driven by advanced research and development in a variety of generally related fields. Competence and strength in telecommunications R&D is therefore critical to Canada remaining being a

world class player in the highly competitive international telecommunications and information technology markets.

- Telecommunications is currently a major strength of Canada. This conclusion embraces telecommunications R&D, telecommunications products and telecommunications networks and services. Canada's domestic telecommunications networks are internationally recognized for their excellence.

- International telecommunication competition between the three major trading blocks of North America; the European Community; and Japan and the Pacific Rim, is increasing significantly, and shows signs of continuing to increase. Canada also faces increased competition within North America from the United States.

- It is concluded that a dynamic, focused and cohesive national telecommunications strategy is mandatory to the maintenance of Canada's international strength in this field. Failure to maintain this international strength in telecommunications is likely to have a significant negative impact on Canada's future economic health. This strategy should have the full support and participation of the private sector acting in a partnership role.

- While definitive information on the level of R&D expenditures by Canadian developers and manufacturers was unobtainable, limited information was made available. On the basis of this it is concluded that these expenditures vary between 8% and 25% of total revenues and are not incompatible with international levels for the telecommunications industry.

- In some cases the R&D expenditures by service providers are *de facto* limited by the regulatory authority who define expenditure limits, including R&D expenditures. From the limited information available in is concluded that Canadian services provider levels of R&D are in the order of 2% of revenues.

- Competitiveness in the international telecommunications field is determined, like most industries, by the technological excellence of the offering. To a large extent international competitiveness can thus be said to be R&D driven, and largely dependent upon the research and development skills of Canadian companies, and their ability to invest significant funds in these efforts. Both national and international levels of telecommunications research and development are typically in double figures (ranging between 8% and 25% of revenue), approximately an order of magnitude greater than

the national average. Maintenance of these investment levels, and the maintenance of the quality of Canada's telecommunications R&D are absolutely critical to maintaining and expanding Canada's position in the world telecommunications market place.

- The determination of areas of telecommunications R&D vary significantly between the groups of R&D entities, primarily between the universities and research institutes on the one hand, and centres of excellence, developers and manufacturers and services providers on the other. The key driver for selecting areas of R&D for universities and government labs is the pursuit of knowledge, combined with professional recognition and advancement. On the other hands the market is the key driver for developers and manufacturers, and for service providers and system developers.

  In a sense, market needs are also the driver for selection of R&D projects by centres of excellence. Here, however, the thrust is more to link the activities of universities to the needs of industry and to improve the currently tenuous links between these two groups of organizations. The R&D carried out is primarily pre-competitive and the definition of pre-competitiveness acts as another R&D selection criteria for centres of excellence.

Recommendations

- It is strongly recommended that the development of a Canadian national telecommunications strategy be given high priority and have as it's key objective the maintenance and improvement of Canada's currently strong position in the international telecommunications market place. This strategy should identify major international markets and international competition, and compare Canada's strengths and weakness as defined in this report to develop major Canadian thrust. In other words take the best from the European and Japanese national strategies to ensure the maintenance of Canada's place in the international telecommunications market. This strategy should be developed and implemented by the government and the private sector acting in concert as partners.

- That this strategy be aimed at supporting and improving Canada's current technology and product strengths rather than upon attempting to address those technology gaps that are currently fully addressed by other international entities. Such gaps are typified by video digital compression and high quantity domestic electronic products.

- That special consideration be given to methods of encouraging and nurturing small and medium sized companies active in the overall field of telecommunications research and development.

8.2 Wireless Personal Communications Conclusions and Recommendations

Conclusions

- Research and development in personal communications is a major R&D thrust for the Canadian telecommunications industry.

- While Canada is currently seen as the world leader in two-way personal communications systems with it's CT2 plus Class 2 standard and with operational across country licences already issued it is ahead of other major counties in this field. It remains to be seen however whether or not Canada's standard will be recognized world-wide. Northern Telecom has invested significant funds in the development of products to meet this standard. There are however not only competing standards, but competing technologies. Canada currently has a lead in this field in the face of strong competition, but it requires a focused and concerted effort to maintain momentum and to insure that CP2 plus Class 2 becomes a world wide standard.

- Wireless personal communications are a major area of interest in a significant number of Canadian Universities. The concept of universally accessible communications, with an individual identified by a personal identification number (PIN) rather than a terminal, has captured the imagination of many Canadian researchers. From the view point of directed scientific research and experimentation into personal wireless communications in can be said that Canadian Universities are active and have considerable world class capability.

- Wireless personal communications is a major activity of many of the research institutes and centres of excellence of Canada. Indeed ubiquitous personal communications is the raison d'etre for the Vision 2000 organization and is a very active component of the National Wireless Research Foundation and a number of other research institutes and centres of excellence.

- Acting as catalysts, and *honest brokers* to bridge the link between universities and industry, centres of excellence are beginning to be a significant factor in maintaining Canada as one of the world leaders in

telecommunications.

- Wireless personal communications is a major R&D strength with Canadian developers and manufactures. As is to be expected virtually all thrusts are towards the development of specific products rather than applied research. While the number of major players in the field is small, virtually all of them are considered to be world class.

- Although Northern Telecom, supported by BNR, takes the lead in this field, a number of other companies are also active in specific niches. While Canada has taken the lead in the PCS CT2 plus Class 2 field, which uses the TDM/TDD access scheme, Canadian companies are also active in the development of CDMA access schemes which are being considered by various international jurisdictions.

- Of particular importance to Canada is the strong development activity aimed at universal satellite wireless communications. This involves satellite-on-board-switching, and with SPAR Aerospace, MPR Teltech and Comdev all being very active in this field Canada is again in a strong internationally competitive position.

- Canada appeared to be taking the international lead in wireless personal communications with the licensing of four national PCS systems in December 1992. These were supported by Canadian products and considerable R&D had been done in a cooperative form between service providers and the major manufacturer in this area. While plans had been made to commence CT2 Plus Class 2 service toward the end of 1993 this has now been delayed by discussions regarding the setting up of a clearing house to handle the subscribers "foreign" to a given system, and on the suggestion that a consortium be formed between the licensees. The Project Team cannot help but draw the conclusion that any delay is a potential setback to Canada's lead in this area. It permits potential U.S. and European competitors to *make up time* and could well inhibit the chances of CT2 Plus Class 2 becoming a *defacto* world standard. This in turn would be a severe set back to Canada's long term R&D and international competitiveness.

Recommendation

- That all possible steps are taken to ensure that CP2 plus Class 2 services are made available to Canadians in the shortest possible time and that full support is given to all international activities that will enhance it's acceptance

on an international basis. Such acceptance is one of the keys to the maintenance of Canada's long term international competitiveness in wireless personal communications. It would also encourage long term R&D in this field.

8.3 Conclusions and Recommendations Relating to Electronic Information and Transaction Services into the Home

Conclusions

- This is not a field that the cross section of universities interviewed are addressing. No inputs were received that could be validly considered under this heading.

- There are few if any research projects being carried out in Canada specifically directed to electronic information and transaction services into the home. Notwithstanding this a number of activities are taking place, particularly with regard to fibre links, ATM switching and data processing which can be considered as enabling technologies that would permit developers and manufacturers to access this field.

- Canada cannot be considered to be a main player in this area, but certainly it has some competence, and has state-of-the-art niche products that are likely to be successful internationally, without Canada becoming a major player.

- This field is currently only being addressed in a very limited manner by service suppliers and system developers. The cable television companies have made a tentative start with pay-per-view services in a number of areas.

- That the development of true electronic information and transaction services in the home is likely to only take place after the implementation of broadband switched services into the home. While this is a target of many common carriers, the technical and economic problems of installing fibre links into the home have yet to be overcome. Implementation of ISTN could well produce electronic information and transaction service offering over the next five years, but there is little evidence that this will be a major area of growth in Canadian R&D.

Recommendation

- It is recommended that a watching brief on this technology be maintained

by the industry and the Department of Communications in collaboration. In addition it is recommended that appropriate support be given to the service provider segment at the appropriate time to implement such services to the benefit of Canadian sub-scribers. It is not recommended that electronic information and transaction services into the home be a significant element of the national telecommunications strategy aimed at the international market.

8.4 Conclusions and Recommendations Relating to Enhanced Media Services at Home and at Work

Conclusions

- This is not a field that the cross section of universities interviewed are addressing. No inputs were received that could be validly considered under this heading.

- This field is being addressed by the same two manufacturers that are addressing the field of *Electronic Information and Transaction Services in the Home*. Indeed the same multi-media products are being developed for both technology thrusts. The areas of video digital compression and advanced digital TV are not being addressed in Canada, although there is significant interaction between the Canadian cable television industry and the Communications Research Centre on the one hand, and Medialab and Cable Television Laboratories in the United States on the other hand, for testing and assessing these technologies.

  It can thus be concluded that this technology is not one in which Canadian developers and manufactures are currently taking a major interest although once more there are niche products.

- Service providers are likely to carry out significant development of advanced media services over the next decade, starting immediately. These include systems carrying digitally compressed video services, at first in the current NTSC format and then in advanced television (high definition television) format. One of the prime thrusts will be to offer *near video-on-demand* services on cable television in response to the competition that will be offered by American direct broadcast satellite services.

  Virtually all of the new systems development taking place in this field will be based upon non-Canadian technology and will be driven by the acceptance by the U.S. regulatory body, of advanced television standards; acceptance

by the North American cable industry of digital video compression standards; and acceptance by the Canadian broadcasting industry of digital audio broadcasting standards. All of these standards, while in most cases having Canadian input, are the results of U.S. or European initiatives. Although most of the hardware for the implementation of these services will originate outside Canada, the development of the systems themselves is largely a Canadian initiative driven by Canada's major cable television companies, the CBC and in the case of digital audio broadcasting, also by the Canadian Association of Broadcasters.

Recommendation

- It is recommended that a watching brief on this technology be maintained jointly by the Department of Communications and industry. In addition, it is recommended that appropriate policy and regulatory support be given to the service provider segment of the industry at the appropriate time to impliment such services to the benefit of Canadian sub-scribers. It is not recommended that enhanced media services be a significant element of the national telecommunications strategy aimed at the international market.

8.5 Conclusions and Recommendations Relating to Intelligent Networks and Related Items

Conclusions

- This is a field where there is considerable interest in Canadian universities covering many of the advanced concepts at the current leading edge of intelligent network and network management technology.

- Canadian universities appear to be strong in all key areas and are addressing both software and hardware issues. As well as there being a number of well respected researchers working in this field in small university groups there are considerable linkages and synergy with centres of excellence and major organizations such as BNR, MPR Teltech and with Rogers Cable Systems.

- The majority of telecommunications developers and manufactures are active in one or a number of the elements of intelligent networks. This is field of both high Canadian interest and high Canadian capability. It can validly be said that Canada is world class in telecommunications network management and intelligent networks. Northern Telecom addresses the majority of the development of this key technology. In addition many other

companies have developed niche markets and a high reputation in this field. While Canada is considered world class, internationally there is very considerable competition and all companies in this field address considerable R&D effort to it.

- Intelligent networks is considered the key driving technology for all aspects of telecommunications in the future. Those companies concerned with the broader aspects telecommunications essentially see all other elements as subsets of intelligent networks. The technology, while being *real time software* based, has considerable hardware and other software peripherals associated with it. Conceptually it is distribution medium transparent so that it encompasses the fields of satellite communications, fibre optic communications, microwave communications, wireline communications etc. Much of the research and development currently being carried out addressed the transparent interface problems related to this concept.

- While the next decade is likely to be one of change in the use of intelligent networks by service providers, this change is likely to be evolutionary rather than revolutionary, building upon the changes of the last decade.

- Much of this evolution will be software driven, and will use distributed control of networks. Much of this hardware and software will be available from Canadian sources and the use of this by Canadian service providers and the federal government is likely to enhance Canada's position in the international market place.

- The next decade is likely to see further convergence of the telecommunications and cable television networks and the development of intelligent networks to serve them both.

- With the development of digital television and digital radio broadcasting there is significant possibility that these technologies would be implemented by the efficient use of small transmitters throughout a service area, linked together with an intelligent network. This is another path of convergence, and one where Canada could achieve world wide advantage in the development of an integrated architecture and delivery system for digital broadcasting. Such an intelligent network could use either cable television facilities or broadband telecommunications facilities. These alternatives could provide encouragement for competitive development of such intelligent networks.

Recommendations

- It is strongly recommended that intelligent networks and related activities form a major element of the overall R&D strategy. It is further recommended that consideration and support be given to the complete infrastructure concerned with intelligent networks and related activities, from the universities and centres of excellence, through the manufacturers to the service providers. In particular consideration should be given to applying resources to the small and medium entities (SME's) to ensure that they can play a maximum role in this fast moving technology

8.6 Conclusions and Recommendations Regarding Approaches Enhancing Canadian R&D

Conclusions

- The availability of telecommunications researchers and developers with high skill levels and high motivation is key to the continuing strength of Canadian telecommunications R&D. While traditionally the availability of such professionals has been considered a Canadian strength, this is now changing with many larger companies finding to difficult to attract the right level of competence. This is true despite the current economic situation, and while this problem does not seem to exist, or at least be significant, for smaller companies, the conclusion has been drawn that the problem will become essentially universal as the larger companies exert their economic strength to attract staff from smaller companies.The problem appears to be exacerbated by a significant outflow of qualified professional, particularly to the United States, where it is perceived that the cost of living is lower and the standard of living higher, although it is generally conceded that the quality of life is better in Canada.

- The Federal Government's prime R&D incentive program is the R&D tax credit program administered by Revenue Canada Taxation. While in general the R&D tax credit program is seen as a positive and useful approach to the encouragement of telecommunications R&D, a number of specific weaknesses are perceived. These include:

  - The fact that foreign and multinational companies headquartered in areas with less beneficial R&D encouragement programs carry out R&D in Canada and recieve credits. This R&D is designed to meet the needs and objectives of their foreign controllers, with the intellectual property going outside of the country. It can then be used to manufacturer

products outside of Canada which may compete with Canadian products. This is seen as not only counter productive, but a drain on scarce financial resources.

- The R&D tax credit program has as a specific objective the encouragement of R&D in small companies. Thus a small private Canadian company is permitted a refundable credit of 35% on it's eligible R&D as compared with a non-refundable 20% for large companies. A small company is defined as one with less than $ 2 million annual revenue or $200,000 profit. This definition has remained constant since 1985 and the figures are now so low that they tend to exclude any small telecommunications company with sufficient revenue to consider worthwhile company funded R&D .

- The R&D tax credit program is aimed primarily at scientific research and experimental development of products, particularly hardware. Canada's telecommunications R&D, whilst including products, has considerable orientation to the experimental development of systems and of software. While these activities are not excluded from eligibility, proof of such eligibility is considered to be difficult, expensive and time consuming. Thus a number of service providers and software developers perceive a *de facto* exclusion from the program.

- The fact that R&D tax credits are paid after R&D is carried out (frequently some considerable time after it is carried out) increases the cash flow problems, particularly of small companies. This would be alleviated if tax credits were paid against corporately authorized R&D funding, with suitable refunds or payments assessed after audit.

- Technology, particularly in the fields of intelligent networks and wireless personal communications is devloping at an ever increasing rate. Thus to enhance Canadian R&D it is more than ever important to ensure that mechanisms are in place to ensure rapid transfer of knowledge from concept, through the pre-competitive phases through to product development. Conversely linkages must be in place to ensure that the research community are aware of the developing market needs and of the technology research that may be required to meet these needs.

- Centres of Excellence are currently effective, but a review of the model for university-research centre-industry collaboration is required, to increase

collaboration, exchange of people and project in which all parties are involved.

- The reward system for university faculty involvement in industrial research and development is not conducive to any increase in either the amount or the effectiveness of current levels. more realistic models for collaboration and recognition of it's true value to academia and industry must be developed.
  More effective use of faculty strength and faculties could be made by "real" collaboration - exchange of personnel, active use of faculty and students - and a better understanding by industry of what strength the university faculty are and what they can do for the industry.

- Not all faculty are interested in direct collaboration with industry. Nor all should be. Some research must be conducted without specific applications in mind, bit their are a number of faculty across the country who are very concerned with direct and targeted research and who have the skills, personnel and facilities to conduct such research. This research, to be meaningful to both parties, must aim at a three to seven lead time. The major drawback to such research is that it is not specifically funded through the normal peer-evaluation research granting process, ie. NSERC grants, not is it recognized by most universities as academically acceptable.

- Small industries, which often need academic support the most, are usually unable to fund it out of profits. If government grants were available for industrial research; and not just matching-dollar shared-cost funding, with renewal on the basis of actual contribution to industry and the state of knowledge, perhaps evaluated as Scientific Research Tax Credits are, a much more active university/industry collaboration would be established.

Recommendations

- That DOC interface with Revenue Canada Taxation to increase the maximum revenue of a *small company* for the purposes of R&D tax credit to a level appropriate to the 1993 economy and that this figure be indexed to inflation

- It is further recommended that consideration be given to reducing or eliminating R&D tax benefits for companies in Canada whose R&D policies are decided by their offshore multi-national headquarters. Consideration should also be given to payment of R&D tax credits against corporately

authorized R&D funding, with suitable refunds or payments to be made after the R&D is carried out and after an appropriate audit. Finally further consideration should be given to expanding the eligibility criteria relating to R&D.

- Consideration should be given to tax breaks to keep suitably qualified staff in Canada, and to attract them here in the first place.

- The government convene a workshop to explore steps that can be taken to improve university/industry collaboration, aimed at reaching those faculty who are interested in and capable of aiding industry in obtaining their long-term goals through research and development. The topic of the workshop would be establishing means for achieving mutually beneficial rewards from collaboration. A key factor in this new approach would be a redefinition or re-examination of the means and criteria by which government would fund research in this category. Another key element of the workshop would be the establishment of mechanisms whereby specific faculty would be associated with specific industries.

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