TELECOMMUNICATIONS R&D IN CANADA

FINAL REPORT

D.A. FORD AND ASSOCIATES LTD.

and

E B SYSTEMS LIMITED

March 1992

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EXECUTIVE SUMMARY

INTRODUCTION

This report is the result of a major study conducted for the Department of Communications and Industry, Science and Technology Canada, the objectives of which included: updating and expanding existing DOC information on telecommunication R&D in Canada; documenting the decision-making process for R&D expenditures, spending instruments and mechanisms; examining the impact of the regulatory and fiscal environments on telecommunications R&D; assessing the appropriate role of governments in telecommunications R&D; examining how Canada's situation compares to selected countries using a common definition of R&D; analyzing organizational models which maximize the effectiveness of R&D resources; and developing options to encourage appropriate levels and mechanisms for Canadian telecommunications R&D by carriers, equipment manufacturers, universities and governments.

In examining telecommunications R&D in Canada, our focus has been on the end results of R&D. We believe that it is the eventual successful adoption and implementation of the positive results of telecommunications R&D activities in the form of products and services which will lead to desirable industrial and economic benefits for Canada.

FINDINGS OF THE STUDY

The findings of the study result primarily from the interviews with Canadian telecommunications service providers and telecommunications equipment manufacturers. They are also based on data received from many of those firms as well as data from published sources. While the findings are spread throughout the body of the main report in the discussion of the interview results, they are accumulated here for ease of reference.

The detailed analysis which followed the interviews and further research led to the overall findings and conclusions which are contained in the next section.

MANAGEMENT OF R&D

Our findings with respect to the decision-making process and other aspects of the management of R&D are:

SOMMAIRE POUR LA DIRECTION

INTRODUCTION

Le présent rapport est le résultat d'une vaste étude menée pour le compte du ministère des Communications (MDC) et d'Industrie, Sciences et Technologie Canada, qui poursuivait notamment les objectifs suivants : mettre à jour et accroître les renseignements existants du MDC sur la recherche et le développement (R&D) dans les télécommunications au Canada; consigner par écrit le processus de prise de décision relatif aux dépenses en R&D, aux mécanismes et aux instruments de dépense; examiner l'effet du cadre réglementaire et fiscal sur la R&D en télécommunication; évaluer le rôle convenant aux gouvernements en R&D dans les télécommunications; examiner la situation du Canada comparativement à des pays choisis à l'aide d'une définition commune de R&D; analyser les modèles organisationnels qui maximalisent l'efficacité des ressources en R&D; et présenter des solutions pour inciter les entreprises de télécommunications, les fabricants d'équipement, les universités et les gouvernements à fixer les mécanismes et les niveaux appropriés de R&D dans les télécommunications canadiennes.

Notre examen de la R&D dans les télécommunications au Canada s'est centré sur les résultats finals de la R&D. Nous croyons que le Canada obtiendra les avantages économiques et industriels désirés s'il réussit à adopter et à mettre en oeuvre les résultats positifs des activités de recherche et de développement en télécommunications sous la forme de produits et de services.

RÉSULTATS DE L'ÉTUDE

Les résultats de l'étude proviennent d'abord des entrevues menées avec des fournisseurs de services de télécommunications et des fabricants d'équipement de télécommunications canadiens. Ils sont également fondés sur les données transmises par nombre de ces entreprises ainsi que de données tirées de sources publiées. Même si les résultats sont divulgués tout au long du rapport principal dans le cadre de l'examen des résultats d'entrevue, ils sont concentrés dans le présent sommaire pour en faciliter la consultation.

L'analyse détaillée qui a suivi les entrevues et les recherches plus approfondies ont mené aux conclusions et aux résultats globaux qui sont présentés dans la partie suivante.

LA GESTION DE LA RECHERCHE ET DU DÉVELOPPEMENT

Voici les résultats concernant le processus prise de décision et d'autres aspects de la gestion de la recherche et du développement :

- Canadian telecommunications carriers spend in the range of 0.09% to 9.49% of revenues on R&D, although the amounts may well be understated due to the conservative approach used in defining R&D.

- Larger carriers tend to spend a greater percentage of revenue on R&D than smaller carriers, with most at around 2% of revenues.

- Canadian telecommunications manufacturers spend in the range of 4% to 20% of revenues on R&D, with the vast majority spending in the range of 10% to 12% of annual revenues.

- There is a difference of opinion as to whether a critical mass is necessary in order to obtain the optimal results from any R&D effort. The benefit of a critical mass depends on the characteristics of the project and its relationship to other R&D projects being conducted by the firm.

REGULATORY ENVIRONMENT

Our findings with respect to the impact of the regulatory environment on R&D are:

- The CRTC treats R&D expenses by applying to them a general test of reasonableness. This is the same general test of reasonableness the Commission applies to all other expenses made by the carriers under its jurisdiction. The basis for the test has not been further defined in legislation or by the Commission.

- There is a lack of certainty on the part of the carriers as to the level of R&D expenditures which the Commission believes is appropriate. At the same time, the carriers are opposed to the Commission setting any type of quota or target for R&D expenditures for the carriers under its jurisdiction.

- The method of assigning R&D expenses creates an opportunity for cross-subsidization among services in the same way as does the method of assigning other expenses. Given the nature of R&D expenses, however, a greater degree of regulatory scrutiny might be required in order to ensure that they are assigned to the appropriate service category.

- Les entreprises canadiennes de télécommunications affectent entre 0,09 et 9,49 p. 100 de leurs revenus à la R&D, bien que ces chiffres puissent être inférieurs à la réalité en raison de la façon traditionnelle de définir la recherche et le développement.

- Les entreprises de télécommunications plus grandes ont tendance à consacrer un plus fort pourcentage de leurs revenus à la recherche et au développement que les entreprises plus petites, la plupart des entreprises y consacrant environ 2 p. 100 de leurs revenus.

- Les fabricants canadiens de télécommunications consacrent entre 4 et 20 p. 100 de leurs revenus à la recherche et au développement, une bonne majorité y affectant entre 10 et 12 p. 100 de leurs revenus annuels.

- Les avis sont partagés quant à la nécessité d'atteindre une masse critique pour obtenir des résultats maximums d'un effort donné de R&D. L'avantage d'une masse critique dépend des caractéristiques du projet et de ses rapports avec les autres projets de R&D menés par l'entreprise.

LE CADRE RÉGLEMENTAIRE

Les résultats concernant les répercussions du cadre réglementaire sur la R&D sont les suivants :

- Le CRTC traite les dépenses en R&D en leur appliquant un critère général de caractère raisonnable. Il s'agit du même critère général de caractère raisonnable que le Conseil applique à toutes les autres dépenses effectuées par les entreprises de télécommunications relevant de sa compétence. Le fondement de ce critère n'est pas davantage défini dans la loi ou par le Conseil.

- Les entreprises de télécommunications n'ont pas de certitude absolue concernant le niveau de dépenses en R&D que le Conseil estime convenable. Par ailleurs, les entreprises de télécommunications s'opposent à l'établissement d'un contingent ou d'un objectif de dépenses en R&D par le Conseil applicable aux entreprises de télécommunications relevant de sa compétence.

- La méthode d'affectation des dépenses en R&D crée la possibilité de subventionner un service par un autre de la même façon que le permet la méthode d'affectation des autres dépenses. Étant donné la nature des dépenses en R&D toutefois, il peut être nécessaire d'assurer un examen réglementaire plus serré de façon à s'assurer que ces dépenses soient affectées à la catégorie de service approprié.

- The absence of specific guidelines from the CRTC regarding the treatment of R&D expenses appears to have given carriers the perception that the CRTC is not interested in or wants to constrain expenditures on R&D. This also creates confusion about CRTC requirements vis-a-vis R&D.

FINANCIAL (FISCAL) ENVIRONMENT

Our findings with respect to the impact of the fiscal environment on R&D which were common to both carriers and manufacturers are:

- Essentially all eligible interviewees, whether carriers or manufacturers, made some use of the federal government R&D tax credit program and, for those provinces which had provincial programs, these were made use of whenever the interviewees were aware of them.

- There is a comparatively low level of in-depth knowledge of the programs. To some extent, this can be explained by the relatively complex nature of this section of the Tax Act. However, since the R&D tax credits are part of an organization's income tax return, and since there appears to be little liaison between the accounting department and the R&D department in some organizations, this could account for the misunderstandings as well as the lack of full use of the tax credit programs in place.

- The majority of those responding believe that those aspects of market research required to specify and identify areas for R&D should be eligible for tax credits.

Additional findings which were unique to the carrier interviews are:

- Telecommunications carriers have the perception that federal R&D tax credits are product-oriented rather than being also applicable to the service industry. With the exception of the very major carriers, most of those interviewed did not have a good understanding of the eligibility of systems R&D activities.

- Only about one quarter of the carriers feel they are taking full advantage of the program, and few believe that its impact on their R&D activities was very significant.

- L'absence de lignes directrices particulières du CRTC concernant le traitement des dépenses en R&D semble laisser croire à des entreprises de télécommunications données que le CRTC n'est pas intéressé à limiter les dépenses en R&D ou ne le veut pas. Cette situation crée également de la confusion à l'égard des exigences du CRTC en matière de R&D.

CADRE FINANCIER (FISCAL)

Voici les résultats concernant l'effet du cadre fiscal sur la recherche et le développement commun aux entreprises et aux fabricants de télécommunications :

- Pratiquement toutes les personnes interrogées admissibles, porte-parole d'entreprises de télécommunications ou fabricants, tirent profit d'une certaine façon du programme fédéral de crédit fiscal en matière de R&D et de celui des provinces qui en offrent également un du genre, lorsqu'elles en connaissent l'existence.

- Il existe comparativement peu d'entreprises qui connaissent très bien ces programmes. Cette situation s'explique dans une certaine mesure par la nature relativement complexe de cet article de la Loi de l'impôt. Toutefois, comme les crédits d'impôt en R&D font partie de la déclaration d'impôt sur le revenu d'une organisation et comme il semble y avoir peu de liens entre le service de la comptabilité et celui de la recherche et du développement dans certaines organisations, cela pourrait expliquer l'absence de compréhension ainsi que la non-utilisation intégrale des programmes de crédits fiscaux en vigueur.

- La majorité des répondants croient que les aspects de la recherche de marché nécessaires pour préciser et cerner les domaines de recherche et de développement devraient être admissibles aux crédits d'impôt.

Voici d'autres résultats uniques aux entreprises de télécommunications :

- Les entreprises de télécommunications ont le sentiment que les crédits fiscaux fédéraux en matière de R&D visent davantage les produits que l'industrie des services. À l'exception des très grandes entreprises de télécommunications, la plupart de celles qui ont été interrogées ne comprennent pas très bien l'admissibilité des activités des R&D sur les systèmes.

- À peine le quart des entreprises de télécommunications estiment qu'elles tirent le maximum du programme et peu d'entreprises croient que son effet sur leurs activités de R&D soit très important.

- The lack of knowledge likely also accounts for the lack of consensus regarding the strengths and weaknesses of the federal and provincial tax incentive programs, and, with the exception of making market research eligible, what could be done to improve these programs.

One additional finding which was unique to the telecommunications manufacturer interviews is:

- The general level of knowledge of both the federal and the provincial tax programs was considerably higher in the case of the telecommunications manufacturers than in the case of the telecommunications carriers. However, there was still considerable misunderstanding with regard to areas of eligibility.

ROLE OF GOVERNMENT

Our findings with respect to the appropriate role of government regarding R&D are:

- There are few significant government policy barriers to R&D existing at present.

- The appropriate role of government in terms of R&D is one of encouraging or providing an incentive, but not to be too involved in the process.

QUANTITATIVE DATA ON R&D EXPENDITURES

For the service providers and equipment manufacturers which supplied data, total 1990 worldwide revenues were almost $22.5 billion, and employees of these firms numbered some 176,000 worldwide. Total 1990 worldwide R&D expenditures for these firms was $1.2 billion.

Adding to this data additional data from published sources on another eight firms (Mitel Corporation, NovAtel Communications Ltd., SR Telecom Inc., TIL Systems Limited, Positron Industries Inc., Glenayre Electronics Ltd., Alcatel Canada Wire Inc. and Prism Systems Inc.) provides a view of R&D expenditures on what we believe is over 95% of the Canadian telecommunications industry. With this additional data, 1990 worldwide industry revenues totalled $23.6 billion, employees numbered 183,700 worldwide and worldwide R&D expenditures were $1.3 billion.

- Le manque de connaissance explique probablement également l'absence de consensus concernant les forces et la faiblesses des programmes fédéraux et provinciaux de stimulants fiscaux et, à l'exception de l'admissibilité souhaitée de la recherche de marché, sur ce qui pourrait être fait pour améliorer ces programmes.

Un autre résultat s'applique uniquement aux fabricants de télécommunications :

- Le degré de connaissance des programmes fiscaux fédéral et provinciaux est beaucoup plus élevé dans le cas des fabricants de télécommunications que dans le cas des entreprises de télécommunications. Toutefois, l'incompréhension demeure grande concernant les domaines d'admissibilité.

LE RÔLE DU GOUVERNEMENT

Les résultats concernant le rôle qui conviendrait au gouvernement en matière de R&D sont les suivants :

- La politique gouvernementale présente actuellement peu de barrières importantes à la recherche et au développement.

- Le rôle qui conviendrait au gouvernement en matière de recherche et développement consiste à encourager ou à offrir un stimulant, mais à ne pas trop s'engager dans le processus.

DONNÉES QUANTITATIVES SUR LES DÉPENSES EN R&D

Dans le cas des fournisseurs de services et des fabricants d'équipement qui ont transmis des données, les recettes mondiales ont totalisé en 1990 près de 22,5 milliards de dollars, et l'effectif de ces entreprises se chiffrait à quelque 176 000 personnes à l'échelle mondiale. En 1990, ces sociétés ont consacré 1,2 milliard de dollars à l'échelle mondiale à la recherche et au développement.

Si l'on ajoute à ces chiffres des données tirées de sources publiées portant sur huit autres entreprises, (Mitel Corporation, NovAtel Communications Ltd., SR Telecom Inc., TIL Systems Limited, Positron Industries Inc., Glenayre Electronics Ltd., Alcatel Canada Wire Inc. et Prism Systems Inc.) on obtient un tableau des dépenses de R&D de ce qui, d'après nous, constitue près de 95 p. 100 du secteur canadien des télécommunications. En ajoutant ces données, les recettes mondiales du secteur ont totalisé en 1990, 23,6 milliards de dollars, l'effectif se chiffrait à 183 700 personnes à l'échelle mondiale et les dépenses mondiales en R&D se sont élevées à 1,3 milliard de dollars. On estime que les entreprises et les fabricants de

Of this $1.3 billion, an estimated $950 million was telecommunications R&D conducted in Canada by manufacturers and carriers.

Based on this data and forecasts provided by many of those interviewed, our estimate of current and future telecommunications R&D expenditures is provided in Table I below.

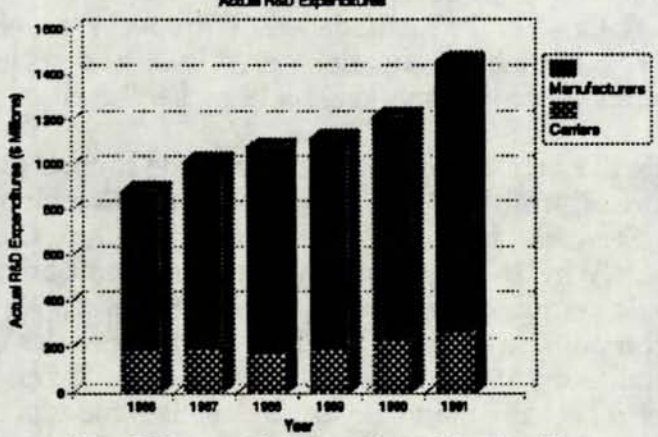
TABLE I: ESTIMATES OF TOTAL R&D EXPENDITURES FOR THE CANADIAN TELECOMMUNICATIONS INDUSTRY

Year	R&D Expenditures Worldwide $(millions)	R&D Expenditures in Canada $(millions)
1990	$1,300	$950
1994	$1,850	$1,225

Note: Figures are in constant 1990 Canadian dollars.
Source: Interview data and consultants' estimates.

Historical data on R&D expenditures was provided by 15 of the facilities-based and other telecommunications carriers interviewed, and by nine of the telecommunications equipment manufacturers interviewed. This data is presented in Figure I below.

Figure I
Actual R&D Expenditures



Note: All $ figures are in millions of current Canadian dollars.
Source: Interview data (15 carriers, 9 manufacturers).

télécommunications ont consacré 950 millions de dollars de cette somme à la recherche et au développement dans les télécommunications au Canada.

Le tableau I ci-dessous présente notre évaluation des dépenses actuelles et futures en R&D dans les télécommunications en s'appuyant sur ces données et les prévisions fournies par nombre des personnes interrogées.

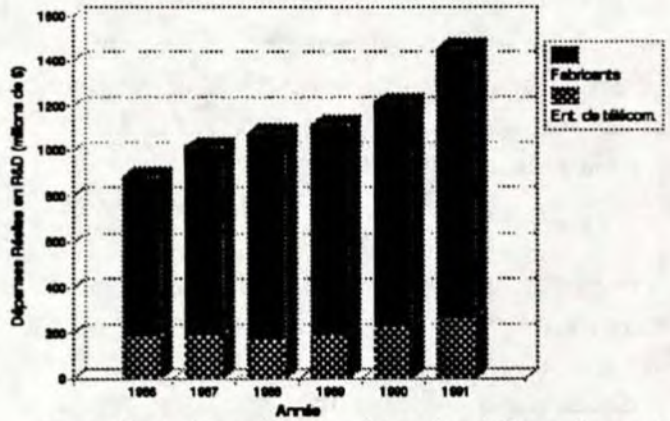
TABLEAU I: ÉVALUATION DES DÉPENSES TOTALES EN R&D DU SECTEUR CANADIEN DES TÉLÉCOMMUNICATIONS

Années	Dépenses mondiales en R&D (millions de $)	Dépenses en R&D au Canada (millions de $)
1990	1,300 $	950 $
1994	1,850 $	1,225 $

Remarque : Ces chiffres sont exprimés en dollars canadiens constants.
Source : Données tirées des entrevues et évaluation des experts-conseils.

Les données historiques sur les dépenses en R&D proviennent de 15 des entreprises de télécommunications comptant des installations et d'autres entreprises interrogées et de neuf des fabricants d'équipement de télécommunications interrogés. Ces données sont présentées à la figure I ci-dessous.

Figure I
Dépenses Réelles en R&D



Remarque : Tous les chiffres en dollars sont exprimés en millions de dollars canadiens courants.
Source : Données des entrevues (15 entreprises de télécommunications, 9 fabricants).

The analysis with respect to international comparisons, models for maximizing R&D effectiveness and alternatives for the government are contained in the conclusions section below.

CONCLUSIONS

Our overall findings and conclusions, in addition to those presented in the previous section, are:

- Canada ranks seventh among major OECD countries in terms of R&D expenditures by all industrial sectors in absolute terms. In terms of total per capita R&D for all industrial sectors and in terms of total R&D as a percentage of GDP, Canada ranks ninth among OECD countries. However, since Canadian telecommunications R&D accounts for a disproportionately large share of Canadian R&D (16%) compared to 10-13% for all developed countries, it is highly likely that Canadian telecommunications R&D expenditures compare much more favourably with other major OECD countries.

- The positive results of R&D in the telecommunications manufacturing sector are found in the conventional measures of industry success - increased employment, increased investment, increased domestic and export sales, and decreased imports.

- R&D in the telecommunications services industry does not often lead to the same direct economic benefits as are found in the telecommunications manufacturing sector. In this case, one must often look to the users of telecommunications services to determine the benefits of R&D. While the development and implementation of new services can result in increased investment and employment as well as assisting business users of the services to be more competitive, most of the economic benefits of those developments result in increased carrier efficiency and the lower rates which will accrue to users.

- With respect to maximizing the benefits of telecommunications R&D, the experience of most telecommunications equipment manufacturers is that development is a short term process and it is getting shorter, with development cycles in the range of 12 to 18 months now becoming the norm. Concurrent engineering (carrying out the last stages of development on the production line) is becoming increasingly common as manufacturers strive to be first to market with the latest products.

L'analyse concernant les comparaisons internationales, les modèles permettant de maximaliser l'efficacité de la R&D et les solutions de rechange qui s'offrent au gouvernement sont présentés dans la partie des conclusions qui suit.

CONCLUSIONS

Voici les autres résultats et conclusions globales :

- Le Canada se classe septième dans les principaux pays de l'OCDE au plan des dépenses en R&D par tous les secteurs industriels en termes absolus. Il se classe neuvième au sein des pays de l'OCDE pour ce qui est du total de R&D par habitant pour tous les secteurs industriels et pourcentage du PIB consacré à la recherche et au développement. Toutefois, comme les télécommunications canadiennes occupent une part disproportionnellement importante de la recherche et du développement au Canada (16 %), comparativement à 10 à 13 p. 100 pour tous les pays développés. Il est plus que probable que les dépenses de télécommunications canadiennes en R&D se comparent beaucoup plus favorablement avec les autres grands pays de l'OCDE.

- Les résultats positifs de la recherche et du développement dans le secteur de la fabrication des télécommunications se trouvent dans les mesures conventionnelles du succès d'un secteur - hausse de l'emploi, augmentation des investissements, accroissement des ventes intérieures et des exportations et diminution des importations.

- La recherche et le développement dans le secteur des services de télécommunications ne conduit pas souvent aux mêmes avantages économiques directs que l'on trouve dans le secteur de la fabrication des télécommunications. Dans ce cas, on doit souvent se tourner du côté des usagers des services de télécommunications pour déterminer les avantages de la recherche et du développement. Même si le développement et la mise en place de nouveau service peuvent se traduire par une hausse des investissements et de l'emploi et aider les usagers industriels des services à être plus compétitifs, la plupart des avantages économiques de ces développements se traduisent par une augmentation de l'efficience de l'entreprise de télécommunications et par une baisse des tarifs qui profitera aux usagers.

- Pour ce qui est de la maximalisation des avantages de la R&D dans les télécommunications, la plupart des fabricants d'équipement en télécommunications ont comme expérience un développement à court terme qui a tendance à se raccourcir, la norme s'établissant actuellement à des cycles de développement de l'ordre de 12 à 18 mois. Les fabricants s'attardent de plus en plus à l'ingénierie concourante (réalisation des dernières étapes sur la chaîne de production), car ils luttent pour être les premiers à commercialiser les plus récents produits.

- With the private sector focus on short term development, it is also apparent that the longer term research which forms the basis for such developments is not being conducted to a sufficient degree by industry. In order to be able to continue to develop new products, industry will require timely access to the results of the underlying basic research.

- The three industrial R&D models examined in this study - vertical integration, aggregation of carriers resources and pre-competitive collaboration - all have advantages and disadvantages. Each plays a different role in providing telecommunications carriers and equipment manufacturers with information about the technologies and the markets over and above what they can obtain through their own individual resources.

- Constraints on overall spending by government mean that direct funding of telecommunications R&D by government is likely to be limited in future. Other alternatives available to the government to promote and encourage R&D in telecommunications include encouraging Stentor to deal with smaller manufacturers on a long term basis; setting quotas for R&D expenditures; promoting increased understanding and use of the federal R&D tax credit program; assisting manufacturers to gain access to other markets; and promoting the world product mandate concept among Canadian subsidiaries of foreign-owned multinational corporations. Of these, all except the setting of quotas would be expected to yield positive results in terms of the quantity and quality of telecommunications R&D.

STRATEGIES

In developing R&D strategies for government, it has been kept in mind that the factors which are critical in promoting successful and effective R&D include:

- Market knowledge: Products which are not responsive to market needs are more likely to fail. For this reason, market research is an important input to the innovation process.

- Market access: Access to the markets for the sale of the product or service resulting from the R&D is a necessary condition for success.

- Le secteur privé se concentrant sur le développement à court terme, il apparaît donc qu'il n'entreprend plus à un degré suffisant la recherche à plus long terme qui constitue le fondement de ces développements. Pour être en mesure de continuer d'élaborer de nouveaux produits, le secteur devra accéder à temps aux résultats de la recherche fondamentale sous-jacente.

- Les trois modèles de R&D industriels examinés dans la présente étude - l'intégration verticale, la mise en commun des ressources des entreprises en télécommunications et la collaboration pré-concurrence - présentent tous des avantages et des inconvénients. Chaque modèle joue un rôle différent dans la transmission aux entreprises de télécommunications et aux fabricants d'équipement de renseignements sur les technologies et les marchés supérieurs en quantité et en qualité à ce qu'ils peuvent obtenir par leurs propres ressources.

- Les réductions des dépenses gouvernementales générales signifient que le financement public direct de la R&D dans les télécommunications sera probablement limité à l'avenir. Afin de favoriser et d'encourager la R&D dans les télécommunications, le gouvernement a notamment à sa disposition les solutions de rechange suivantes : inciter Stentor à traiter avec les fabricants de moindre envergure à long terme; fixer des contingents applicables aux dépenses en R&D; favoriser une plus grande compréhension et utilisation du programme fédéral de crédit fiscal en R&D; aider les fabricants à accéder à d'autres marchés; et pousser les succursales canadiennes de sociétés multinationales à propriété étrangère à se donner comme mandat de fabriquer un produit mondial. Toutes ces solutions, sauf l'établissement de contingents, devraient produire des résultats positifs aux plans quantitatif et qualitatif de la R&D dans les télécommunications.

STRATÉGIES

Au moment d'élaborer des stratégies en matière de R&D pour le compte du gouvernement, on a pris en compte les facteurs suivants qui sont essentiels pour favoriser de la R&D réussie et efficace :

- La connaissance du marché : Les produits qui ne répondent pas aux besoins du marché risquent davantage l'échec. Pour cette raison, la recherche de marché est un élément important du processus d'innovation.

- L'accès au marché : L'accès au marché permettant la vente du produit ou du service issu de la R&D est une condition nécessaire au succès.

Accordingly, in setting priorities and making decisions with respect to industrial R&D, it is important to involve all aspects of a company's operations, including marketing, sales and service, manufacturing, as well as to gather as much information on the market as possible from outside sources.

As one respondent noted during an interview for this project, it might be more efficient for a firm to conduct all its R&D in one location, but it is important to decentralize R&D and locate it close to major customers so that they will know what to do.

In developing strategies for government, it has also been kept in mind that due to the introduction of competition at the carrier and services level, by the year 2000 as much as 50% of telecommunications equipment will be purchased by non-carriers. Traditional manufacturers have acted to preserve their existing markets and to serve the new markets created by competition. At the same time, in the major areas of the telecommunications manufacturing sector, only the largest suppliers will survive. As a result, successful smaller firms will be those which concentrate on specialized niche markets.

RECOMMENDATIONS

Based on the research, interviews, data collected from public and proprietary sources and analysis conducted during this study, we have developed a few key recommendations for consideration by the government.

In developing these recommendations, we envisage three distinct roles for the government with respect to telecommunications R&D:

- The government as a performer of R&D;
- The government as the creator of an appropriate private sector R&D environment; and
- The government as a facilitator of the implementation of private sector developments.

In developing the specific recommendations under each heading, we have also been cognizant of the constraints on government spending which continue to reduce the government's ability to fund directly those initiatives which it believes are important.

Par conséquent, lorsqu'on établit des priorités et prend des décisions concernant la R&D industriels, il est important d'engager tous les aspects des opérations d'une société, y compris la mise en marché, les ventes et le service, la fabrication ainsi que de recueillir de sources extérieures le plus de renseignements possibles sur le marché.

Comme l'a fait remarquer l'un des répondants au cours d'une entrevue menée dans le cadre de ce projet, il serait plus efficient pour une entreprise de concentrer toute sa recherche et son développement en un seul lieu, mais il est important de décentraliser la R&D et de les situer près des principaux clients de façon à savoir ce qu'il faut faire.

Au moment de l'élaboration de stratégies pour le gouvernement, on a également pris en compte qu'en raison de l'arrivée de la concurrence dans le secteur des services et chez les entreprises de télécommunications, près de la moitié de l'équipement en télécommunications sera acheté d'ici l'an 2000 par d'autres sources que des entreprises de télécommunications. Les fabricants traditionnels ont agi de manière à préserver leurs marchés existants et à desservir les nouveaux marchés créés par la concurrence. Par ailleurs, dans les grands domaines du secteur de la fabrication de télécommunications, seuls les plus gros fournisseurs survivront. Par conséquent, les entreprises plus petites qui réussiront seront celles qui se concentreront dans des niches spécialisées du marché.

RECOMMANDATIONS

En s'appuyant sur la recherche, les entrevues, les données recueillies du public et de sources privées et les analyses menées au cours de la présente étude, on a élaboré quelques recommandations clés qui sont présentées au gouvernement pour fins d'examen.

En élaborant ces recommandations, on a attribué trois rôles distincts au gouvernement concernant la R&D dans les télécommunications :

- le gouvernement dans le rôle d'exécutant de la R&D;
- le gouvernement dans le rôle de créateur d'un climat favorable à la R&D dans le secteur privé; et
- le gouvernement dans un rôle d'intermédiaire pour faciliter la mise en oeuvre des développements du secteur privé.

En formulant les recommandations particulières à chaque titre, on a également pris en compte les contraintes imposées aux dépenses gouvernementales qui continuent de limiter les capacités du gouvernement de financer directement les initiatives qu'il croit importantes.

THE GOVERNMENT AS A PERFORMER OF R&D

Given that the focus of the private sector is on short term development, but that it requires timely access to the results of basic research in order to have a continuing basis for such developments, the most appropriate role for the government is as a performer or funding agency for more basic, longer term types of research. Whether such research is conducted directly by government or is conducted by universities with government support, it is apparent that the most appropriate research role for the government is in such long term projects where the risk is higher and the returns are less certain.

With their focus on the market, private sector firms can then avail themselves of the results of such research which have promising applications. Appropriate cost recovery approaches should be developed to recoup a portion of the costs of the research while still promoting the transfer of successful technologies to industry.

Given the constraints on government funds for R&D, we believe that the direct support of longer term research is the most appropriate direct funding role for government.

THE GOVERNMENT AS THE CREATOR OF AN APPROPRIATE R&D ENVIRONMENT

Recognizing that market knowledge and market access are the keys to attaining successful results of R&D, the most important role of government is to create an appropriate environment for R&D in Canada. The major aspects of the appropriate environment include the tax and regulatory environments. The government should also encourage R&D by recognizing and promoting R&D successes.

It is apparent from our interviews that the R&D tax credit program is a source of frustration for many of the smaller manufacturers. The most recent federal budget announced that changes would be proposed to some of the regulations regarding overhead expenses and shared facilities and equipment. However, there still remains an opportunity for the government to assist industry by increasing the level of understanding of the program.

One general misunderstanding of the tax credit program that should be corrected is that a company must be profitable to benefit from tax credits. The program provides for payments as opposed to credits where a company has no profits against which to apply the credits. This is of assistance to companies which are in a start-up phase.

LE GOUVERNEMENT DANS LE RÔLE D'EXÉCUTANT DE LA R&D

Comme le secteur privé se concentre sur le développement à court terme, mais qu'il a besoin d'un accès opportun aux résultats de la recherche fondamentale de manière à pouvoir s'appuyer sur un fondement permanent à ces développements, le rôle qui conviendrait le mieux au gouvernement serait celui d'exécutant ou d'organisme de financement de la recherche plus fondamentale, du genre à plus long terme. Que cette recherche soit menée directement par le gouvernement ou par des universités grâce au financement gouvernemental, il semble que le rôle qui conviendrait le mieux au gouvernement en matière de recherche consisterait à s'engager dans des projets à long terme où le risque est plus élevé et le profit moins que certain.

Tout en se concentrant sur le marché, les entreprises du secteur privé peuvent alors tirer profit des résultats des recherches qui offrent des applications prometteuses. On pourrait mettre en place des mécanismes de recouvrement des coûts convenables de façon à rembourser une partie des frais de la recherche tout en favorisant le transfert à l'industrie des technologies couronnées de succès.

Compte tenu des fonds limités que peut affecter le gouvernement à la R&D, on croit que le financement direct de la recherche à plus long terme constitue le rôle de financement le plus convenable au gouvernement.

LE GOUVERNEMENT DANS LE RÔLE DE CRÉATEUR D'UN CLIMAT FAVORABLE À LA R&D

Comme l'on sait que la connaissance du marché et l'accès au marché sont des éléments clés pour obtenir des résultats positifs de la R&D, le gouvernement a comme rôle très important de créer un climat favorable à la R&D au Canada. Les principaux aspects de ce climat favorable comprennent le cadre fiscal et le cadre de réglementation. Le gouvernement pourrait également encourager la recherche et le développement en reconnaissant les succès de la R&D et en faisant la promotion.

Nos entrevues laissent apparaître que de nombreux fabricants de plus petite taille sont frustrés par le programme de crédit fiscal en matière de R&D. Le tout dernier budget fédéral a annoncé que des modifications seraient proposées à la réglementation concernant les frais généraux et le partage des installations et de l'équipement. Toutefois, le gouvernement a toujours la possibilité d'aider le secteur en faisant mieux comprendre le programme.

Un des malentendu courant entourant le programme de crédit fiscal et qui devrait être dissipé consiste à croire qu'une entreprise doit être rentable pour tirer avantage des crédits fiscaux. Le programme prévoit des versements par opposition à des crédits lorsqu'une société n'a pas de profit pour lui permettre de demander des crédits. Il s'agit d'une assistance aux entreprises qui sont en phase de démarrage.

The government should also work with the CRTC to develop a better understanding on the part of regulated companies of the approach and attitude of the Commission to R&D expenses. It is apparent that there are some misunderstandings of the Commission's intent in this regard, in spite of decisions which quite clearly state the Commission's position.

The government should increase its efforts to recognize and publicize the successful development and implementation of R&D.

THE GOVERNMENT AS THE FACILITATOR OF R&D IMPLEMENTATION

The government should promote collaboration among smaller manufacturers through active brokering. A forum for the collaboration of the pre-competitive development efforts of a number of smaller manufacturers would assist these companies with market knowledge and market access. The government should assist smaller manufacturers to acquire information on the markets and technologies in this way.

The creation of Stentor Resource Centre Inc. will consolidate the marketing, national standards setting and research and development activities for all the former Telecom Canada members. It is recommended that the government work with Stentor to develop mechanisms for effective and collective cooperation between the carriers and Canadian equipment manufacturers, with a view to extending to the smaller firms some of the benefits which have contributed to Northern's success.

One way to implement this initiative would be to form a Stentor-Government-Industry Steering Committee. This group would be charged with the responsibility of reviewing potential R&D opportunities and facilitating arrangements between Stentor and one or more equipment manufacturers. The Committee would subsequently monitor progress on each undertaking.

As a major user of telecommunications services the government could also serve as a test bed and initial market for new equipment and services resulting from carrier/industry cooperative ventures.

Le gouvernement devrait également travailler de concert avec le CRTC pour mieux faire comprendre aux sociétés réglementées la démarche et l'attitude du Conseil à l'égard des dépenses en R&D. Il semble qu'il existe certains malentendus quant aux intentions du Conseil à cet égard, malgré des décisions qui exposent assez clairement la position du Conseil.

Le gouvernement devrait accroître ses efforts pour reconnaître et publiciser le développement et la mise en oeuvre réussis de la R&D.

LE GOUVERNEMENT DANS LE RÔLE D'INTERMÉDIAIRE POUR FACILITER LA MISE EN OEUVRE DE LA R&D

Le gouvernement devrait favoriser la collaboration entre les fabricants de plus petite taille en agissant activement comme courtier. La création d'un forum permettant la mise en commun des efforts de développement pré-concurrentiels d'un certain nombre de fabricants de plus petite taille aiderait ces entreprises à obtenir une connaissance du marché et un accès au marché. Le gouvernement pourrait aider de cette façon les plus petits fabricants à acquérir des renseignements sur les marchés et les technologies.

La création de Stentor Resource Centre Inc. consolidera la commercialisation, la mise au point de normes nationales et les activités de recherche et de développement de tous les membres de l'ancien Telecom Canada. Il est recommandé que le gouvernement cherche avec Stentor à élaborer des mécanismes pour assurer une collaboration efficace et collective entre les entreprises de télécommunications et les fabricants canadiens d'équipement en vue d'étendre aux entreprises plus petites certains des avantages qui ont contribué au succès de Northern.

La mise sur pied d'un comité d'organisation Stentor-gouvernement-industrie sera l'une des façons de mettre en oeuvre cette initiative. Ce groupe serait chargé d'examiner les possibilités de R&D et de faciliter les accords entre Stentor et un ou plusieurs fabricants d'équipement. Le Comité pourrait par la suite surveiller l'état d'avancement de chacun des projets.

À titre d'utilisateur important de services de télécommunications, le gouvernement pourrait également servir de banc d'essai et de marché initial pour le nouvel équipement et les nouveaux services issus des projets de collaboration entre l'industrie et les entreprise de télécommunications.

1. INTRODUCTION

This report is the result of a major study conducted for the Department of Communications and Industry, Science and Technology Canada, the objectives of which can be summarized in the following terms:

- To update the information already obtained by the DOC on telecommunication R&D in Canada, and extend it, with a focus on the telecommunications equipment carriers and equipment manufacturers as the major participants in R&D;

- To document expenditures, spending instruments and mechanisms as well as the ratio between long-term and short term R&D;

- To examine the impact of the regulatory and fiscal environments on telecommunications R&D, and to assess the appropriate role of governments in telecommunications R&D;

- To examine how Canada's situation compares to selected countries using a common definition of R&D;

- To analyze organizational models which maximize the effectiveness of R&D resources, such as vertical integration, the aggregation of R&D resources, the formation of alliances and the targeting of resources into specific areas; and

- To develop options to encourage appropriate levels and mechanisms for Canadian telecommunications R&D by carriers, equipment manufacturers, universities and governments.

In conducting this study, the starting point was the assumption that R&D is a means to an end, not an end in itself. The desirable end results of a successful R&D policy for the Canadian telecommunications carrier and manufacturing industries, and for the Canadian economy as a whole, are increased direct and indirect employment, increased direct and indirect investment, increased utilization of services and sales of products in Canada, increased exports of both products and services, decreased imports of both products and services (the latter two together representing an improvement in the balance of trade), improved efficiency for both service provision and manufacturing, and improved competitiveness of Canadian industry.

Given that telecommunications services are becoming increasingly important to the operations of both government and industry, the spin-off benefits from the desirable end results listed above permeate rapidly through the economy. These benefits can further improve the efficiency and competitiveness of all industrial sectors for which telecommunications is an important input.

Accordingly, in examining telecommunications R&D in Canada, it has been our thesis that it is the eventual successful adoption and implementation of the positive results of telecommunications R&D activities in the form of products and services which lead to the desirable industrial and economic benefits for Canada.

TERMS OF REFERENCE

The terms of reference for this study took the form of a Statement of Work. The "Requirement" section of that Statement of Work read as follows:

> " To carry out a study on telecommunications R&D in Canada. The study is to develop a thorough understanding of telecommunications R&D in Canada, the competitive environment which Canadians face, the regulatory, financial, policy and institutional factors affecting telecommunications R&D, and constraints to undertaking R&D."

The complete Statement of Work along with a description of the Approach and Methodology used in conducting the study are contained in Appendix A.

TELECOMMUNICATIONS R&D: THE PLAYERS

As used in this study, the term telecommunications is defined broadly to include services provided by facilities-based carriers, resellers, cellular carriers and other network service providers, and the telecommunications equipment used by these carriers as well as the telecommunications equipment used by the customers of these carriers. It does not include the broadcasting or cable television industries, although network services of cable firms are included.

Telecommunications R&D in Canada is carried out by telecommunications equipment manufacturers, telecommunications carriers, government agencies and universities.

Each of these four groups is described below.

THE TELECOMMUNICATIONS CARRIERS

These companies are the providers of telecommunications services. In Canada, the carriers encompass federally and provincially regulated telephone companies. They include Telecom Canada members[1], independent telephone companies, other common carriers such as Unitel, Telesat and Teleglobe, the cellular carriers, and the radio common carriers.

Table 1 below provides an estimate of revenues from the major players in this sector in 1990.

TABLE 1 - ESTIMATED TELECOMMUNICATIONS CARRIER REVENUES - 1990

	$ Millions	% of Total
Telecom Canada (terrestrial carriers)	12,849	83.3
Other telcos	906	5.9
Unitel	362	2.3
Teleglobe	226	1.5
Telesat	178	1.2
Cellular & RCCs	906	5.9
Total	15,427	100.0

Note: All $ figures are in current Canadian dollars.
Source: Annual Reports, Statistics Canada.

[1] During the time this study was underway, the member companies of Telecom Canada announced a reorganization under the name Stentor. The announcement included a revised mandate for Telecom Canada which is now called Stentor Canadian Network Management and the creation of two jointly held companies - Stentor Resource Centre Inc. and Stentor Telecom Policy Inc.

In the remainder of this report, all references are to Stentor rather than Telecom Canada. Where appropriate, references are made more specific by including the full name of the Stentor organization.

THE TELECOMMUNICATIONS EQUIPMENT MANUFACTURERS

The telecommunications equipment manufacturers in Canada produce a wide range of equipment for use by terrestrial and satellite telecommunications carriers, or for use by users in conjunction with a telecommunications carrier's facilities. Equipment manufactured includes Central Office (CO) based equipment such as digital switches, cable of all types including fibre optic cable, transmission equipment, satellite and satellite earth station equipment, multiplexing equipment, modems, PBXs and other terminal equipment. Unfortunately, detailed statistics for this industry are not readily available from public sources since they are aggregated within broader industrial classifications for reporting purposes. Information collected during the study and presented in a later chapter of this report indicates that telecommunications equipment manufacturing sector revenues in 1990 were in excess of $10 billion. This figure includes worldwide sales for the Canadian industry. While the carriers represent an important market for this sector, many of the smaller manufacturers address niche markets outside the core telephone carrier environment.

THE GOVERNMENT, UNIVERSITY AND NON-PROFIT SECTOR

The government sector includes departments and agencies belonging to both the federal and provincial governments. In Canada, governments are involved in basic research, applied research and development. For example, research relating to satellite communication carried out by or for the federal government involves all three elements - basic and applied research as well as development. Public funds also support the activities of the Communications Research Centre, whose activities have resulted in the development of a number of important technologies and have influenced the creation of a number of Canadian telecommunications manufacturing companies.

A number of federal government programs provide direct and indirect support for R&D, and to some extent these programs are available to the telecommunications industry. Examples of programs administered by ISTC include the Microelectronics and Systems Development Program (MSDP), which supports the development of advanced microelectronics and information technologies systems; the Defence Industry Productivity (DIP) Program, which provides assistance to a wide variety of developmental activities which have potential military applications or customers; and the Strategic Technologies Program (STP), which promotes the formation of precompetitive alliances in information technologies. MSDP and STP together have committed some $18 million in funding to telecommunications manufacturers over the past five years, while authorized conditionally repayable

contributions for telecommunications projects under the DIP Program over the same period have been in excess of $50 million.

R&D funding is also available from the Department of Western Economic Development (WED) and the Atlantic Canada Opportunities Agency (ACOA) for firms in those respective regions.

Canada has major federal government sponsored "Centres of Excellence" that carry out research. Those relating to telecommunications include the Canadian Institute for Telecommunications Research (CITR), the Microelectronic Devices, Circuits and Systems for Ultra Large Scale Integration (ULSI), the Canadian Network for Space Research, and the Institute for Robotics and Intelligent Systems.

Two federal research and applications centres which have a telecommunications orientation include the National Wireless Communications Research Foundation in Vancouver and the Canadian Centre for Marine Communications in St. John's, Newfoundland. The objective of these organizations is to act as a bridge between the universities and industry in order to bring basic research to the point where it is marketable to industry.

The provincial governments, sometimes jointly with industry, are involved in supporting telecommunications R&D. One such example is TR Labs, a non-profit research institute established in 1986 with three charter sponsors: the University of Alberta, the Government of Alberta and Bell-Northern Research Ltd. The Government of Alberta, AGT, the universities in Calgary and Edmonton, the Government of Saskatchewan, SaskTel and the universities in Regina and Saskatoon are all committed to making TR Labs the focus of their R&D endeavours.

Another example of a telecommunications research facility supported by a provincial government is the Telecommunications Research Institute of Ontario (TRIO), which is funded under the Ontario Premier's Technology fund.[2]

For the most part, universities receive R&D grants from the government or from private companies. As noted earlier, universities are also often involved with government and industry in joint undertakings. CITR, funded to the extent of $14.7 million under the National Sciences and Engineering Council of Canada, includes Carleton, Concordia, Laval, McGill, McMaster, Queen's, British Columbia, Montreal,

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[2] NGL Consulting Ltd., A Proposal Towards a Strategic Plan for the Canadian Telecommunications Equipment Industry (Ottawa: NGL Consulting Ltd., October 1990), 35.

Ottawa, Toronto, Victoria and Waterloo. Other participants include TR Labs and INRS-Telecommunications.

INTERVIEWS CONDUCTED DURING THIS STUDY

The telecommunications carriers, telecommunications equipment manufacturers, provincial governments, regulators, international agencies and foreign government agencies interviewed during the data collection phase of the study were as follows:

CARRIERS AND RESELLERS

- AGT Limited
- Bell Canada
- British Columbia Telephone Company (B.C. Tel)
- Call-net Telecommunications Ltd.
- ED TEL
- fONOROLA
- Island Tel
- Manitoba Telephone System (MTS)
- Maritime Telegraph and Telephone (MT&T)
- New Brunswick Telephone (NB Tel)
- Newfoundland Telephone (Nfld Tel)
- Québec Téléphone
- Rogers Cantel Inc.
- Rogers Network Services
- Saskatchewan Telecommunications (SaskTel)
- Teleglobe Canada
- Telesat Canada
- Telesat Mobile Inc. (TMI)
- Unitel Communications Inc.

MANUFACTURERS

- Canstar Communications
- Develcon Electronics Ltd.
- Eicon Technology Corporation
- Gandalf Data Limited
- Glenayre Electronics Ltd.
- Harris-Farinon Canada Inc.
- Motorola Canada Ltd.
- MPR Teltech Limited
- MUX LAB Inc.
- Nexus Group of Companies
- Newbridge Networks Corporation
- Northern Telecom (through Bell-Northern Research Ltd.)
- Positron, Inc.
- Spar Aerospace Ltd.
- SR Telecom Inc.
- Teleglobe Inc.
- TIE/Communications Canada Inc.
- TIL Systems Ltd.
- TR Labs

PROVINCIAL GOVERNMENTS

- Alberta
- British Columbia
- Manitoba
- New Brunswick
- Newfoundland
- Nova Scotia
- Ontario
- Prince Edward Island
- Québec
- Saskatchewan

REGULATORS

- Canadian Radio-television and Telecommunications Commission

INTERNATIONAL AGENCIES

- Organization for Economic Cooperation and Development (OECD)
  (Telecommunications and Information Services)

FOREIGN GOVERNMENT AGENCIES

- Commission of the Economic Communities
  (Directorate General, Telecommunications, Information Industries and Innovation)

- United States
  (Federal Communications Commission, National Telecommunications and Information Administration, International Trade Administration, House Sub-committee on Technology and Competitiveness)

2. BACKGROUND TO THE STUDY

This chapter sets the stage for the study. It identifies the key issues associated with R&D, examines the structure of the telecommunications industry and highlights the major global trends. The chapter also carries out an examination of R&D definitional issues and their implications for international comparisons.

INDUSTRY STRUCTURE IN THE DEVELOPED WORLD

In this section of the report, we outline the evolution of the telecommunications industry in Canada and the world and discuss how the structure of the telecommunications industry has influenced research and development in the sector.

The telecommunications industry is more than 100 years old and has been distinguished throughout its history by evolutionary change and improvements. In recent years, the pace of technological change has accelerated, causing many governments to introduce policies to modify the structure of the industry. These changes have affected manufacturers of telecommunications equipment and telecommunications carriers; however, many of the underlying principles of the relationship between manufacturers and carriers are still in place and continue to dominate R&D priorities.

The telephone was invented in 1876. Within twenty years, an industry structure emerged that remains more or less intact to the present day. From the very beginning, the telephone company founded by Alexander Graham Bell and his financial backers recognized that maximum exploitation of the invention could best be achieved by the rapid expansion of telephone service and the manufacture of equipment. Accordingly, and to ensure that it would have a secure source of equipment supply, the telephone company established a manufacturing subsidiary (Western Electric), thus establishing vertical integration as the industry structure in North America.

Over the next few years the two companies filed a large number of telephone patents. Through the vigourous legal defence of its patents and by the takeover of the thousands of small telephone companies that had sprung up all over the United States, the Bell System soon emerged as the dominant force in the provision of telephone services, and Western Electric emerged as the dominant manufacturer.

By 1880 the International Bell Telephone Company (IBTC) had obtained franchises to provide telephone services in a number of European cities, including Stockholm, Moscow, St. Petersburg, Amsterdam, Brussels, and Copenhagen. In all

of these cities, and in a number of other European countries such as Britain, France, the German Empire, Finland, Hungary, and Austria, Western Electric was the principal supplier of the switchboards and telephone instruments used. Later, Western established manufacturing operations in Europe.

By 1895, the European franchises granted to the IBTC had been withdrawn in favour of state ownership, under the auspices of the Posts, Telegraphs, and Telephone Departments, the PTTs. By this time a number of European firms, notably L M Ericsson, were engaged in the manufacture of telephone equipment. Motivated by the same security of supply considerations that created Western Electric, and for nationalistic reasons, the PTTs were quick to encourage the expansion of domestic manufacturers. Soon the major industrial powers each supported several indigenous suppliers and the "buy domestic" policy combined with the purchasing power of the PTTs began to dictate the design and development of new equipment.

By 1900, the American and European industry structures were firmly in place. In the U.S., the model that emerged was that of an investor-owned, regulated monopoly providing telephone service, vertically integrated with manufacturing operations. In Europe, the PTT model was adopted, whereby state-owned monopolies provided telephone service, purchasing their equipment needs from domestic manufacturers. In both systems, the carriers provided R&D funding, directly or indirectly, and effectively controlled the rate of innovation by funding R&D and through purchasing policies.

By the late 1960s, the North American telecommunications system was far in advance of that of any other country by almost any measure. Beginning in the early 1970s, the U.S. government and its regulatory agency initiated a series of policy changes to introduce competition into the provision of telecommunications services. The culmination of these efforts came in 1984 when the U.S. Department of Justice forced the breakup of the Bell System, thus opening up the huge domestic market for telecommunications equipment to alternative suppliers.

The dynamic forces unleashed by the U.S. initiative would have had the effect of leaving most European countries even further behind in telecommunications development, and were the major spur to the policy changes initiated first by Britain and on a lesser scale by other European powers. Seen in this light, the changes in Europe to introduce limited competition at the services level reflect a belated recognition of the superiority of the American free enterprise system rather than a desire to create a brand new industry model. At the manufacturing level, the mergers and consolidations recognize that no single European country can support several major manufacturers.

INDUSTRY STRUCTURE IN CANADA

In general, telecommunications in Canada is organized along the lines of the pre-divestiture American model, whereby the largest telephone company, Bell Canada, is affiliated with the major equipment manufacturer, Northern Telecom. However, there are important differences in the structure of the industry in the two countries. These differences are related to history and market size, which present both challenges and opportunities in the development of R&D strategies for Canada.

Canada is often described as a "world leader" in telecommunications. Its modern telecommunications infrastructure, most of which is "made in Canada", is the envy of many larger countries. On the face of it, telecommunications in Canada is an outstanding success story, and Northern Telecom is a true, world-class manufacturer. Within Canada, Northern is in a class by itself. Unfortunately, many of the factors which enabled its early growth have stunted the development of smaller Canadian manufacturers. It is therefore useful to review briefly Northern's history, not only to pinpoint some of the reasons for its success, but also to identify some of the factors which account for the poor domestic market performance of smaller Canadian companies.

The manufacture of telephone equipment in Canada began in Brantford, Ontario in 1878. Bell Canada was granted its charter in 1880, and its Mechanical Department took over the manufacture of telephones in 1882. The Mechanical Department was reorganized as Northern Electric in 1895, with Bell Canada owning 56% and Western Electric 44%. All equipment was manufactured to Western Electric designs. Thus Northern was a branch plant in the classic Canadian tradition.

Northern's links with Western allowed free and unrestricted access to leading edge technology developed by the world's largest telecommunications equipment manufacturer, including manufacturing information and processes, documentation, and product support. This situation endured for more than 60 years and provided the basis for the excellent standard of telephone service we enjoy today. Northern also enjoyed a secure market for its products by virtue of its relationship with Bell Canada.

Bell Canada was originally granted a franchise for all of Canada, but it soon abandoned or sold off many of its interests in order to concentrate its limited capital and resources on serving the Ontario and Québec markets. This led to the creation of separate telephone companies in each of the other provinces. Later, European based manufacturers such as Siemens and ITT established branch plants in some provinces with the objective of supplying provincial telephone company needs. With

the virtual continent-wide standardization on the Western Electric products manufactured by Northern and on GTE products in the case of B.C. Tel, the foreign companies never achieved any significant penetration of the Canadian market for major systems.

The effect of Northern's dominance of the domestic market together with the presence of foreign manufacturers in Canada was to inhibit the growth of small Canadian firms. Western Electric was a one-stop supplier of telecommunications equipment, thus enabling Northern to furnish just about every item of equipment used by telephone companies except vehicles and office equipment. Most of the large foreign firms also carried a complete portfolio of telecommunications products, and while unable to penetrate the market for major systems, were able to eke out a living in Canada by serving so-called niche markets.

The overall result was that up until the year 1956, Northern Electric, a virtual branch plant of Western Electric, was the principal supplier to the Canadian telecommunications carriers, with the exception of B.C. Tel. The foreign manufacturers competed with each other and with the few small independent Canadian suppliers for what remained of the market.

The history of Northern's transformation from a branch plant captive supplier to a world competitor is a story yet to be written. According to a 1972 speech delivered by the then President of Northern, Mr. V.O. Marquez:

> " (In 1956) the roof fell in on Northern Electric... A dispute between the U.S. Department of Justice and AT&T effectively throttled the flow of product design, of process technology, of manufacturing know-how, of purchased apparatus and components from Western Electric to Northern. At the time, Northern had no design capability of its own, employed no scientists engaged in product or process development, and had never been interested in markets outside of Canada."

However, it should also be noted that the "roof" fell in rather gradually, and did not create market opportunities for other Canadian suppliers. At that time, Canadian telecommunications carriers were standardized on equipment manufactured by Northern, especially the mature products such as No. 5 Crossbar. Northern was able to continue to manufacture all existing Western designs and could access later technology on a fee basis. As a result, up until 1972, approximately two-thirds of the products in Northern's portfolio were still of Western design. The cushioning effect arising from Northern's dominance of the market also provided the company with the opportunity to work out its own salvation.

As Mr. Marquez noted in his speech, up until 1956 there was no measurable telecommunications R&D spending in Canada. In 1958, Northern created an R&D laboratory which was reorganized in 1971 as a separate company, Bell Northern Research (BNR). BNR is now Canada's leading privately-owned R&D facility. Northern is BNR's largest customer. BNR also does contract R&D work for Bell and, to an extent, for the Stentor members collectively, and for other firms.

Historically, a similar arrangement existed among B.C. Tel, Microtel and Microtel Pacific Research. This arrangement continues in part in that MPR Teltech does work for B.C. Tel, the Stentor members collectively, and other firms, on a contract basis.

From the preceding paragraphs it might be inferred that telephone companies other than Bell are not paying an appropriate share of R&D expenditures, except for that done by the Stentor members jointly. However, it can be argued that the cost of R&D is included in the price of equipment these firms purchase from major manufacturers like Northern. In general non-Bell companies have preferred to encourage smaller manufacturers located within their provinces, somewhat akin to the PTT model.

However, the efforts of provincial telephone companies to support R&D and manufacturers in their own provinces have not encouraged the growth of small Canadian manufacturers for a number of reasons. As described earlier, major equipment items such as switches, which account for the bulk of expenditures, can only be purchased from Northern or other very large suppliers. Moreover, for smaller companies, the costs of entry into the design, development and manufacture of such systems is prohibitive. In fact, major and long-established manufacturers throughout the world are consolidating and combining their efforts in order to stay in business. As a result of these realities, smaller suppliers are left with only the so-called "niche" markets. When we also consider that "buy provincial" policies often function as de facto inter-provincial trade barriers so as to confine the niche supplier to a single small provincial market, it is no wonder that there is a dearth of small to medium sized telecommunications equipment manufacturers in Canada.

In summary, the real problem facing the smaller Canadian telephone companies in attempting to support R&D by smaller firms is that any worthwhile project must have significant market potential, in most cases beyond that which a single telephone company can provide. Moreover, projects of significant potential, almost by definition, might already be under consideration by Northern, or beyond the capability of other potential Canadian manufacturers.

THE CHANGING INTERNATIONAL TELECOMMUNICATIONS ENVIRONMENT

This section begins with an examination of the trends in the telecommunications environment, both internationally and in Canada, including:

- Technology push and market pull
- Liberalization, privatization, structural changes and globalization
- Canada's situation within the global telecommunications market

As described above, the research and development programs of most industrialized countries evolved historically in isolation, with little interaction with R&D programs in other countries. Consequently, each R&D program developed its own unique structure. However, several factors are putting pressure on these programs. These factors stem primarily from market demands and technological developments as well as from the changing telecommunications environment and the globalization of the marketplace and are a consequence of the interaction of consumer needs, the availability of technology, and regulatory liberalization. The following are some of the trends that are shaping the global marketplace.

TECHNOLOGY PUSH AND MARKET PULL

Two parallel forces that have had an impact on the telecommunications environment are technology push and market pull. In parallel, technological developments have created market opportunities, and market demands have propelled the emergence of new technologies.

The most significant technological milestones are the development of digital technologies and fibre optic systems. These developments, coupled with advances in computer hardware and software, are transforming telecommunications systems into higher bandwidth, intelligent systems. There is now greater integration of voice, data, image and video. Customer premises equipment (CPE) is "smarter", and broadband technologies based on cell-relay are on the horizon. Developments in cellular and cordless technologies are merging to produce personal communications networks which are essentially wireless systems based on micro-cellular architecture.

On the demand side, business users require higher speeds and greater bandwidth, and are demanding more functionality from equipment and more specialized services from service providers.

Arthur H. Solomon's study on R&D spending trends in the telecommunication industry points to some converging trends in an increasingly competitive milieu.[3] As the Solomon study points out, the effects of this market reshaping are faster technological innovations, the development of a broader range of technologies and greater risk-taking by innovators as many different technological approaches compete for market acceptance. As end-users become more discriminating and demanding, telecommunications equipment suppliers, in order to maintain or increase market share, must offer a steady stream of new and improved products and services that reflect the latest technologies.

A rapidly expanding industry stimulates increased demand for intermediate components and materials.[4] This produces rapid technical change in supplier industries. The rapid growth in the demand for telecommunications services, for instance, has given manufacturers incentives to make substantial investments in digital switches. To spread development costs and to realize economies of scale in R&D, switch manufacturers are expanding their geographic coverage by adapting switches to new markets.

The organization of R&D has assumed added significance due to higher development costs, in combination with shorter life cycles. Rapid technological change in telecommunications has substantially increased the risk of investing in long-lived plant and equipment.[5] As product life-cycles shorten, the risk is further intensified, since the precise timing of the commitment of large amounts of resources to the development process becomes even more critical.

LIBERALIZATION, PRIVATIZATION, STRUCTURAL CHANGES AND GLOBALIZATION

The traditional regulatory regime was based on the premise that telecommunications was a natural monopoly which needed to be regulated to ensure that

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[3] Solomon, Arthur H., "R&D Spending Trends in the Telecommunications Industry", Spectrum, June 1989, 1-31/1-32; quoted in "R&D Strategy for the Telecommunications Industry," Discussion paper (draft), (Ottawa: Department of Communication, Government of Canada), 3.

[4] Robert G. Harris, "Divestiture and Regulatory Policies: Implications for Research, Development and Innovation," Telecommunications Policy, April 1990, 118.

[5] Ibid., 119.

service would be available on a non-discriminatory basis at just and reasonable rates. In recent years, new technology has eroded the natural monopoly approach, enabling governments to introduce a degree of competition in the provision of telecommunications services. This trend is well established and appears certain to continue. The emergence of competition also weakens the case for state ownership, and many countries are now privatizing their public utility operations in the belief that deregulation and privatization will not pose a threat to universal service.

The process of deregulation began in the United States and the process of privatization got underway in the United Kingdom. Both trends are gradually spreading to other parts of the world. Many European countries as well as Australia and New Zealand have taken far-reaching measures in this regard. In most cases, the competition ensuing from liberalization and privatization measures has helped meet the demand for new products and services.

The telecommunications services sector is most affected by the policy and regulatory initiatives and is undergoing radical and irreversible changes. Within developed countries, the concept of a single monopoly end-to-end supplier of all services is rapidly giving way to a multi-layered industry structure consisting of the conventional telephone companies like Bell and MTS, competing carriers such as Unitel and Telesat, cellular/wireless based carriers like Rogers Cantel and B.C. Cellular, terminal equipment suppliers like Mitel and Northern, and a range of manufacturers of sophisticated voice and data communications equipment like Newbridge and Gandalf. Globally, new international alliances are being forged to supplement and compete with the traditional telephone company arrangements.

The developments in the services sector provide both challenges and opportunities for telecommunications equipment manufacturers. The traditional suppliers can no longer depend on an ongoing relationship with one or two major customers, and in any event it is recognized that the ever-increasing costs of developing the technology for new products can no longer be recovered from domestic markets. Moreover, most developed countries recognize the strategic importance of telecommunications, and continue to protect domestic markets. Accordingly, major manufacturers are seeking international alliances both to extend their markets and to share and spread R&D expenditures over a larger base. This is leading to consolidations and shakeouts in the telecommunications manufacturing industry.

According to the Science Council of Canada, these consolidations and shake-outs could leave as few as five world class manufacturers by the year 2000.[6] Recent activities in the United States, for instance, have removed companies such as Automatic Electric and TRW from the industry. Recent years have seen several major acquisitions and agreements among major players in the telecommunications industry. Some of the large-scale consolidations include the formation of Alcatel as a result of the merger of France's CGE and ITT; the Siemens/GEC acquisition of Plessey; Siemens' purchase of IBM's Rolm manufacturing and development operations; and Northern Telecom's purchase of STC.

Service providers are also taking a global view of the telecommunications services market. As multi-national customers demand more specialized services, global consortia of service providers are forming to provide world-wide private networks and virtual private network services to meet those needs. Some carriers view these global consortia as a threat in their domestic markets.

CANADA'S SITUATION WITHIN THE GLOBAL TELECOMMUNICATIONS MARKET

The foregoing developments mean both opportunities and risks for Canadian firms. To continue to compete internationally and maintain their viable presence in the domestic market, Canadian manufacturers and service providers will have to expand and diversify their product and service offerings.

In its reorganization to form Stentor, and in particular the creation of Stentor Resource Centre Inc. which will begin operation on January 1, 1993, the major Canadian carriers are acknowledging the global nature of the marketplace. For example, the news release announcing the reorganization of Telecom Canada stated:

> "Stentor Resource Centre will develop and deliver national telecommunications products and services, will develop national technology standards, will conduct or sub-contract research and development

[6] Science Council of Canada, "The Canadian Telecommunications Sector," Sectoral Technology Series No. 1 (Ottawa: Science Council of Canada, 1992), 11.

projects for the telephone companies, and will establish international alliances with other telecommunications organizations."[7]

It is universally accepted that Canadians enjoy a very high standard of telecommunications services, and that Canada is home to a world class equipment manufacturer and a number of smaller firms serving domestic and export markets. During the 1971 to 1985 period, both the carrier and manufacturing sub-sectors of the Canadian telecommunications industry recorded rates of growth in output well above the national average, as measured by the Gross Domestic Product. The industry also accounts for the largest share of private spending on R&D. Maintaining Canada's position as a leader in telecommunications and ensuring continued growth of the sector will require an even greater concentration on effective R&D for the foreseeable future.

R&D SPENDING IN CANADA

Statistics Canada reported that total Canadian R&D expenditure intentions for 1991 were $9.7 billion.[8] In 1991, the business sector planned to perform 54% of the total R&D and the federal government 16%. The corresponding figures for funding of R&D are 42% and 29%. At 1.36% of gross domestic product in 1990, Canada's planned R&D effort was similar to the percentage recorded in 1989. The ratio was lower than that of most industrialized OECD countries.

R&D expenditures planned by Canadian industry (54% of total Canadian R&D expenditures) were expected to exceed $5.2 billion in 1991, an increase of 5.9% over 1990.[9] Industry spending intentions for 1991 were expected to be twice the amount spent by industry on intramural R&D in 1983. Provincial research organizations account for only 2% of the estimated expenditures for R&D in 1989.[10] According to Statistics Canada, it would be a mistake to measure their importance

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[7] Stentor Canadian Network Management, "Canadian Telephone Companies Introduce Stentor: The Power of Telecommunications", news release, (Ottawa: Stentor Canadian Network Management, January 29, 1992), 1.

[8] Statistics Canada, "Total Spending on Research and Development in Canada, 1971 to 1991," Science Statistics (Ottawa: Statistics Canada, July 1991), 4.

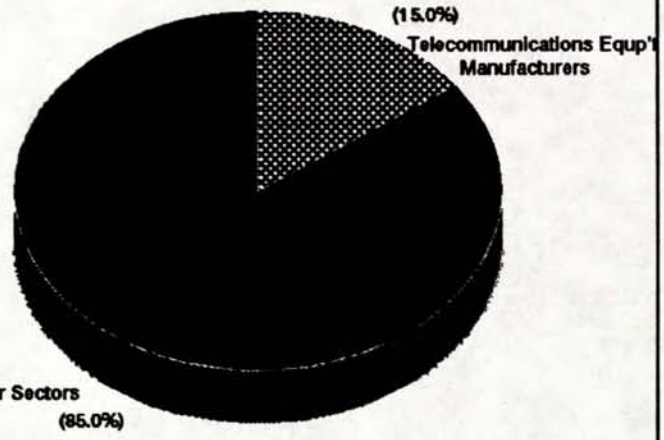
[9] Ibid.

[10] Statistics Canada, "The Provincial Research Organizations, 1989," Science Statistics, (Ottawa: Statistics Canada, December 1990), 1-2.

only in monetary terms.[11] These organizations play a significant role in the transfer of technology from laboratory to production unit, acting as an interface between science and business.

As Figure 1 shows, the telecommunications equipment industry is the most R&D intensive industrial sector in Canada. It accounted for 15% of R&D expenditures by all industry sectors in 1989. Foreign R&D funding was also highest in the telecommunications sector, amounting to $322 million in 1989.

Figure 1
Industrial R&D Expenditures in Canada - 1989



Source: Statistics Canada Catalogue No. 88-202 (December 1991).

In 1989, about 57% of all industrial R&D in Canada was performed in Ontario. 77% of the industrial R&D performed in the electrical and electronic industries took place in Ontario. Among provinces, Ontario-based firms are the highest spenders on telecommunications R&D. Ontario-based firms accounted for 87% of Canadian telecommunications R&D in 1989. This amount was the highest among all the industries in the province. Ontario also employed the highest number of telecommunications R&D personnel as compared to other provinces. These statistics should be viewed with some caution, however, since such statistics are often attributed on the basis of the province in which the head office of the organization is situated. With BNR's head office located in Ontario, it is likely that all data relating to BNR is attributed to Ontario.

In 1989, software R&D expenditures totalled $1.1 billion, an increase of 11% over the previous year.[12] The telecommunications equipment industry accounted for 38% of total Canadian software R&D. These expenditures are reported by the industry as part of their total R&D expenditures.

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[11] Ibid.

[12] Statistics Canada, "Software Research and Development in Canadian Industry, 1989," Science Statistics (Ottawa: Statistics Canada, September 1991), 1.

3. THE CANADIAN ENVIRONMENT FOR TELECOMMUNICATIONS R&D

This chapter presents the results of the interviews with telecommunications service providers, telecommunications equipment manufacturers, provincial government representatives and federal government representatives with respect to a broad range of issues regarding telecommunications R&D in Canada. It is presented in five main sections, as follows:

- The management of R&D, including the decision-making process;
- The regulatory environment;
- The financial environment, including the income tax environment and government programs;
- The role of government in telecommunications R&D; and
- Maximizing the benefits of telecommunications R&D.

Each section contains a report on the views of those individuals interviewed during the course of the study, a discussion of those views, and a number of findings made by the consultants as a result of the research conducted during the study, the analysis of the interviews and the review of other background material.

THE MANAGEMENT OF R&D

Included in the topics for discussion during the interviews was the decision-making process within each organization for setting annual R&D expenditure levels and determining R&D priorities, for determining the appropriate level of R&D expenditures in terms of revenues, if any, and the roles of various groups within the organization, such as marketing, engineering and finance, in the decision-making process. The optimum level of R&D expenditures and the importance of having a critical mass in terms of R&D effort or expenditures were also discussed.

RESULTS OF THE INTERVIEWS

In most cases, decisions with respect to overall R&D expenditure levels are determined on the basis of current revenues or short term future revenue projections. Many companies use a top down and bottom up approach, with final budgets representing a compromise between the initial top down overall expenditure limit and the bottom up detailed wish list of projects for the year. Historical experience and sensitivity to the market were also mentioned by some respondents. Some carriers tended to use historical levels as the primary determinant.

Comparisons with other carriers outside Canada are also used as a guideline by some of the larger carriers.

While telecommunications manufacturers and the larger telecommunications carriers generally have a well-documented approach to the decision-making process for R&D levels, many of the smaller carriers do not have a fixed budget for R&D, nor are they concerned with the distinction between R&D and engineering except for tax purposes. Several of the smaller carriers stated that they do what has to be done to meet the needs of their customers, then determine at year end whether or not any given project qualifies as R&D for tax purposes. If it does, it is then reported as R&D in the financial statements as well.

With respect to the criteria used to determine priorities within overall expenditure limits and to approve individual projects, a wide range of responses was received. Some carriers spread the R&D budget widely among a broad range of commitments and activities inside and outside the company. Stentor members assume a share of the overall Stentor R&D budget. A few carriers use a formal return on investment (ROI) or net present value (NPV) estimate to try and pick winners, while others indicate they should do so, but to date have not. Some tie these decisions to marketing and sales objectives or national product plans, while others have an inter-departmental priorities committee to set priorities. A number emphasized that R&D expenditures were treated the same as any other planned expense by the company. One mentioned an "R&D venture capital fund" which could be used to take a few promising projects to the point where they could be fully evaluated.

The telecommunications manufacturers, on average, appeared to have a more formalized approach to the setting of priorities, with many of those interviewed using an ROI or business case approach to setting priorities and selecting individual projects. Where a formal approach is not used, expected revenues or sales volumes are still taken into account. Market trends and the competitive environment also play a large part in the decision-making process of most manufacturers.

One manufacturer stated it had specific targets such that 85% of R&D expenditures were on product development and 15% of R&D expenditures were on basic technology development. Another indicated that different decision-making approaches were used for new product development and product upgrades. However, in almost all cases, the decisions are market-driven.

In terms of the roles of the different departments or functions within the company - marketing, engineering and finance - in the R&D decision-making process, almost all companies interviewed indicated that marketing (or business

development or sales) and engineering were always involved in decisions. In most cases, marketing or sales was the starting point, and had the most influence in the process, although the engineering departments initiate projects in a few cases. In a few cases with larger companies, there was wide consultation within the organization, including operations. Finance is often involved in the decision in most organizations, but from a control rather than a decision-making perspective.

With regard to whether or not there is an optimum level of R&D, most agreed that there was an optimum level for manufacturers, although the level would be unique to each organization. It was often pointed out that new companies or new product lines require a substantial initial R&D investment, and in most cases the expenditures level off as the company or product matures. With respect to the experience of manufacturers, R&D expenditures as a percentage of sales ranged from a low of 2-2.5% of sales in certain product lines to as high as 20% of sales in others. The vast majority of the telecommunications manufacturers indicated they spent between 10% and 12% of annual sales on R&D.

A number of carriers indicated that there was an optimum level of R&D for manufacturers, but not for carriers. One carrier indicated that the optimum level of R&D as a percentage of revenue should be 0.25% and another indicated it should be 4%, with the majority of those citing a specific figure suggesting a figure close to 2%.

Actual data on expenditures from public sources is provided in the next section, and aggregated data received during the data collection phase of this project is provided in the next chapter. However, as further discussed in the next section of this report, many carriers specifically opposed the setting of a prescribed level of R&D expenditures for regulatory purposes.

With respect to whether or not a minimum critical mass is necessary for the optimal conduct of telecommunications R&D, the responses varied widely. Larger carriers and manufacturers generally indicated that a critical mass is necessary for at least some projects, particularly those involving technology, and is less necessary for short term projects. Most small companies, on the other hand, did not believe it was necessary, noting that most major product breakthroughs in the past decade had come from small companies or small groups within large companies. One carrier pointed out that there were "islands of critical mass", and stated it was necessary to decide which islands an organization would play on. Others pointed out that the critical mass should be measured in terms of activities and the inter-relationship among the R&D activities, not total dollar expenditures. One manufacturer indicated that the critical mass could be measured in terms of capital investment in R&D facilities and test equipment.

DISCUSSION AND FINDINGS

Each organization approaches decision-making with respect to R&D in its own way, with the manufacturers generally making R&D expenditure decisions with a greater degree of formality than the carriers. This is not surprising in view of the larger percentage of annual revenues invested in R&D by the manufacturers. However, it is interesting to note that many smaller carriers are not concerned with whether or not a project is even R&D until after the decision has been made.

Based on all of the above, we have made the following findings:

1. Canadian telecommunications carriers spend in the range of 0.09% to 9.49% of revenues on R&D, although the amounts may well be understated due to the conservative approach used in defining R&D.

2. Larger carriers tend to spend a greater percentage of revenue on R&D than smaller carriers, with most at around 2% of revenues.

3. Canadian telecommunications manufacturers spend in the range of 4% to 20% of revenues on R&D, with the vast majority spending in the range of 10% to 12% of annual revenues.

4. There is a difference of opinion as to whether a critical mass is necessary in order to obtain the optimal results from any R&D effort. The benefit of a critical mass depends on the characteristics of the project and its relationship to other R&D projects being conducted by the firm.

THE REGULATORY ENVIRONMENT

This section describes the approaches used by the CRTC in its regulation of the level and allocation of R&D expenditures by facilities-based carriers under its jurisdiction. Recent decisions of the Commission are examined, the views of carriers and manufacturers are presented and discussed, and conclusions are drawn with respect to the impact of the CRTC on the levels of R&D conducted by the telecommunications carrier industry.

RECENT DECISIONS OF THE COMMISSION

The matter of R&D expenses is always subject to the Commission's purview, as is any other operating or capital expense item incurred or proposed to be incurred by a regulated telecommunications carrier which is subject to the Commission's jurisdiction. Recent decisions of the Commission have dealt with both the level of R&D expenditures and the allocation of those expenditures to categories of service.

THE LEVEL OF R&D EXPENDITURES

Two recent decisions of the Commission are helpful in understanding the Commission's approach to considering the level of R&D expenditures. In Telecom Decision CRTC 88-21[13], the Commission disallowed some $6.6 million in R&D expenditures proposed by B.C. Tel for 1989. The Commission noted that B.C. Tel had failed to provide details of the proposed R&D projects, and it therefore disallowed the proposed increase in annual R&D expenditures from $22.3 million in 1988 to $30 million in 1989, instead allowing the company to increase its R&D expenditures in 1989 by 5% over the 1988 level. In explaining its decision, the Commission stated:

> "The Commission considers that R&D activities comprise an important and necessary part of a telephone company's operation. The Commission is fully supportive of a responsible and effectively managed R&D program. At the same time, the Commission must satisfy itself that program expenditures are justified. For this reason, the Commission considers it incumbent upon the company to provide the necessary project details."[14]

While B.C. Tel had proposed to spend about 2% of its operating revenues on R&D, and while Bell Canada has traditionally spent a percentage of its annual operating revenues in the range of 1.9% to 2.1% on R&D, the Commission noted in Telecom Decision CRTC 91-21 regarding Teleglobe Canada Inc.[15] that Teleglobe

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[13] Telecom Decision CRTC 88-21, BRITISH COLUMBIA TELEPHONE COMPANY - REVENUE REQUIREMENT FOR THE YEARS 1988 AND 1989 AND REVISED CRITERIA FOR EXTENDED AREA SERVICE, December 19, 1988.

[14] Ibid., 53.

[15] Telecom Decision CRTC 92-21, TELEGLOBE CANADA INC., REGULATION AFTER THE TRANSITIONAL PERIOD, December 19, 1991.

Canada's expenditures on R&D amounted of 1.8% of its revenues in 1988, 3.5% in 1989 and 2.0% in 1990[16]. In an interrogatory response during the proceeding leading to Telecom Decision CRTC 91-21, Teleglobe Canada forecast 1992 capital expenditures on R&D of $11.5 million and 1992 operating expenditures on R&D of $3.7 million[17]. This total R&D expenditure of $15.2 million represents some 5% of forecast 1992 operating revenue after the estimated impact of the rate reductions ordered by the Commission in Telecom Decision CRTC 88-21 are taken into account. The Commission implicitly approved the proposed R&D operating expenditures, and stated it found reasonable Teleglobe Canada's proposal to devote 6% of its five-year capital plan to identified R&D projects[18].

Discussions with Commission staff members indicated that the Commission does not tend to be overly concerned with the definition of R&D used by the carriers under its jurisdiction. The Commission tends to apply the same test of reasonableness to proposed R&D expenditure levels as it applies to all other proposed expenses. However, as noted in the excerpt from Telecom Decision CRTC 88-21 above, the Commission requires project details in order to make its determination of the reasonableness of proposed levels of expenditure on R&D.

The basis on which the Commission generally makes its tests of reasonableness with respect to carrier expenditures is not defined. Accordingly, there is no indication of the basis on which the Commission makes its decisions with respect to the reasonableness of proposed R&D expenditures. The most definitive statement by the Commission on R&D expenses which our research found is that quoted above from Telecom Decision CRTC 88-21.

THE ASSIGNMENT OF R&D EXPENDITURES

The assignment of R&D expenses is also a matter which is subject to consideration by the Commission. Whereas the Commission might find that a carrier's overall proposed rate of expenditure on R&D is reasonable, it must also be concerned with the assignment of those expenses to various categories of services

[16] Ibid., 95.

[17] Teleglobe(CRTC)25Apr91-1611A, page 1 of 1.

[18] Telecom Decision CRTC 91-21, 95.

(known as Broad Service Categories or BSCs) for rate-making purposes.[19] The assignment of R&D expenses to BSCs is an issue which is covered in the Phase III Costing Manuals of the various carriers. These manuals are highly technical in nature and provide detailed methodologies for assigning classes of costs to the various BSCs.

Telecom Decision CRTC 88-7[20] dealt with the majority of the costing issues for Bell and B.C. Tel, although some items were subject to further review. One of those items was the matter of the assignment of R&D expenses by B.C. Tel. While Bell assigned the majority of R&D expenses to BSCs other than Common, B.C. Tel assigned R&D expenses directly to Common. In Telecom Letter Decision CRTC 90-11[21], the Commission directed B.C. Tel to submit a method for assigning research costs to BSCs, specifying that projects which relate to general or fundamental research should be assigned to the Common category. The result of this decision is that in determining whether or not the rates for services within any BSC, as a group, are compensatory (i.e., whether the total revenues generated by the services within, say, the Competitive Network (CN) Category are sufficient to cover the costs assigned to the CN Category and make a contribution towards Common Category costs), the costs of R&D which are related to that BSC will be included in the category costs.

In the case of Telesat, since there are only two BSCs, the space segment and the earth segment, the issue is whether expenses should be assigned to the space segment or the earth segment. A recent Commission decision dealt with this issue[22].

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[19] The BSCs for the telephone companies are Access, Monopoly Local, Monopoly Toll, Competitive Network, Competitive Terminal - Multiline & Data, Competitive Terminal - Other, Other and Common.

[20] Telecom Decision CRTC 88-7, BELL CANADA AND BRITISH COLUMBIA TELEPHONE COMPANY - PHASE III MANUALS : COMPLIANCE WITH CRTC TELECOM PUBLIC NOTICE 1986-54 AND TELECOM ORDER CRTC 86-516, July 6, 1988.

[21] Telecom Letter Decision 90-11, Re: British Columbia Telephone Company - Phase III Manual Review: Outstanding Issues, July 6, 1990.

[22] Telecom Decision CRTC 90-28, TELESAT CANADA - GENERAL RATE INCREASE FOR 6/4 GHz AND 14/12 GHz SPACE SEGMENT SERVICES, PHASE III COSTING MANUAL, December 18, 1990.

In its evidence in the proceeding leading to Telecom Decision 90-28, Telesat included $1 million in capitalized R&D costs associated with high definition television (HDTV) related to the space segment. Cancom and CBC, both interveners in the proceeding, objected to including this as a space segment expense. The Commission could find no justification for including these costs[23], and therefore adjusted the revenue requirement for the space segment downwards by this amount.

RESULTS OF THE INTERVIEWS

None of the carriers interviewed expressed any specific concerns about the decisions rendered by the CRTC with respect to proposed levels of R&D expenditures by carriers under its jurisdiction. One carrier and officials of several provincial governments expressed the view that a dichotomy existed between the DOC's strategy thrusts to stimulate product and service development and the CRTC's classical role as the protector of subscriber rates against undue cost burdens. One of the manufacturers expressed the opinion that the Commission's objective of keeping local rates affordable meant that depreciation rates for in-place facilities were kept lower than they should be, and this is turn meant that the carriers could not update their equipment as quickly as they would like. In this manufacturer's view, users of telecommunications services were the losers in the long term.

Three carriers subject to the Commission's jurisdiction had some concerns about the process used by the Commission to examine proposed R&D expenses. These carriers expressed the general view that the regulatory process tended to act as a damper on R&D expenditures. One noted that the regulatory process is a legalistic, public process which does not lend itself to an evaluation of R&D projects. This carrier also noted that competitors are often involved as interveners in these public processes, and the regulatory process provides these competitors with information on a carrier's R&D plans. Another carrier said that the regulatory process, while time-consuming, led to reasonable results. This carrier also said there was a feeling that you have to apologize to the CRTC for doing R&D, although it admitted that this feeling was not based on a decision of the Commission, but was an impression gained during a rate proceeding. A third carrier expressed the view that the regulatory process discourages a company from doing something different.

Regarding the assignment of R&D expenses to service categories, two regulated carriers and one unregulated carrier expressed concerns with respect to the potential impact of Commission decisions in this area. All three were concerned that too much of the R&D was allocated to monopoly rather than competitive

[23] Ibid., 66.

services. One indicated that the tendency of the Commission to do this was in conflict with DOC initiatives which tend to support developments in the competitive areas. The second indicated that R&D funded by monopoly services was used to fund R&D in support of competitive services, which amounted to a hidden subsidy, and recommended an audit process regarding the allocation of R&D expenses. The third was concerned that allocating too great a proportion of R&D expenses to the local category increases the revenue shortfall in this category and increases the contribution required of resellers.

With respect to a role for the Commission in terms of stimulating R&D, most carriers interviewed expressed the view that this would be an inappropriate role for the Commission. In particular, they were opposed to any type of quota or target for R&D expenses as a proportion of operating revenues. One carrier indicated that if quotas were set by the Commission, the focus on worthwhile and justifiable projects could be lost, with funds being spent just for the sake of meeting an objective.

One example of a regulatory quota for R&D is found in a decision of the Québec Régie des Télécommunications which ordered Québec Téléphone to spend $10 million in excess revenues on R&D instead of making a refund to subscribers. Québec Téléphone used a large portion of the $10 million to participate in Consortel, a joint venture with CVDS and Cogeco to develop a capability to deliver 32 video channels and 2 voice channels to the home on fibre optic cable. The Consortel project was suspended at the end of 1990. This decision of the Régie was raised by three parties interviewed, including two provincial government representatives, in response to a question with respect to whether or not the CRTC should be attempting to stimulate R&D. Neither of the provincial government representatives supported this decision of the Régie. One government representative commented that the reason why the Consortel project failed was that the initiative came from the Régie, and that it was not part of Québec Téléphone's own plans.

DISCUSSION AND FINDINGS

The CRTC's approach to the regulation of R&D expenditures by the carriers under its jurisdiction appears to be consistent in all respects with its approach to the regulation of all other expenditures by these carriers. Contrary to the concerns expressed by some carriers, we found no evidence to suggest that any of the Commission's decisions intended to place constraints on the level of R&D expenditures other than the general regulatory test of reasonableness. At the same time, it is acknowledged that there are perceptions among members of the telecommunications carrier industry that the Commission intended to curtail such expenditures.

Based on all of the above, we have made the following findings with respect to the regulatory environment as it affects R&D:

1. The CRTC treats R&D expenses by applying to them a general test of reasonableness. This is the same general test of reasonableness the Commission applies to all other expenses made by the carriers under its jurisdiction. The basis for the test has not been further defined in legislation or by the Commission.

2. There is a lack of certainty on the part of the carriers as to the level of R&D expenditures which the Commission believes is appropriate. At the same time, the carriers are opposed to the Commission setting any type of quota or target for R&D expenditures for the carriers under its jurisdiction.

3. The method of assigning R&D expenses creates an opportunity for cross-subsidization among services in the same way as does the method of assigning other expenses. Given the nature of R&D expenses, however, a greater degree of regulatory scrutiny might be required in order to ensure that they are assigned to the appropriate service category.

4. The absence of specific guidelines from the CRTC regarding the treatment of R&D expenses appears to have given carriers the perception that the CRTC is not interested in or wants to constrain expenditures on R&D. This also creates confusion about CRTC requirements vis-a-vis R&D.

THE FINANCIAL ENVIRONMENT

This section of the report begins with a discussion of the definition of R&D. It then provides a review of current federal, provincial and foreign R&D income tax incentive programs. Next it presents the results of the interviews with respect to the definitions of R&D used in these programs and the impact of these programs on the R&D expenditures of telecommunications carriers and manufacturers. It ends with a series of findings in respect of these issues.

R&D Definitional Issues

As a starting point in discussing R&D definitional issues, we consider the two definitions of R&D which are used in Canada. These definitions are:

- The Frascati Definition
- The Revenue Canada Definition

The Frascati Definition

Both UNESCO and the OECD have adopted a common definition of R&D which is commonly known as the Frascati definition. The current definition as contained in the Frascati Manual is as follows:

> "Research and experimental development comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society and the use of this stock of knowledge to devise new applications."[24]

In order to be classified as R&D, an activity has to have an "appreciable element of novelty."[25] The construction of prototypes and pilot plants is to be included in the definition, as is design and building work, only to the extent that they are required for the R&D phase and not for the production process.

A full discussion of the Frascati definition is contained in Appendix C to this report.

The Revenue Canada Definition

In a broad sense, scientific research and experimental development is defined by the Income Tax Act as the systematic investigation or search carried out in a field

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[24] Thomas Schnöring, Research and Development in Telecommunications: An International Comparison, (Bad Honnef: Wissenchaftliches Institut für Kommunikationsdienste, December 1989), presented at the 8th International Telecommunications Society Conference, Venice, Italy, March 18-21, 1990, 7.

[25] Statistics Canada, A Framework for Measuring Research and Development Expenditures in Canada (Ottawa: Statistics Canada, March 1984), 7-8.

of science or technology by means of experiment or analysis. This is then broken down into three classifications as follows:

- Basic Research: Research undertaken to advance scientific knowledge without a specific practical application in view.

- Applied Research: Research undertaken to provide possible uses for results of basic research or methods of achieving specific and pre-determined objectives.

- Experimental Development: Use of basic or applied research to create new, or improve existing materials, devices, products and processes.

While there are a considerable number of qualifying criteria, the key criteria used by Revenue Canada to ascertain whether the activity claimed is scientific research or experimental development are that the activity must:

- use a scientific method;
- be carried out with the intent of achieving an advance of knowledge in the field;
- involve scientific or technological uncertainty;
- be carried out by qualified personnel;
- be in an eligible field; and
- be carried out in Canada.

Further details on the Revenue Canada definition of R&D are provided in Appendix D.

REVIEW OF FEDERAL, PROVINCIAL AND FOREIGN R&D TAX INCENTIVE PROGRAMS

This section examines the Canadian federal and provincial R&D tax incentive programs along with the tax incentive programs in the United States, Australia, Japan, and the United Kingdom.

FEDERAL R&D TAX INCENTIVE PROGRAMS

The Canadian federal government encourages research and development in Canada primarily by means of its scientific research and experimental development tax credit program. The implementing authority for this research and development incentive program is Revenue Canada - Taxation.

In addition to this specific program, the federal corporate income tax system provides a number of other tax incentives for R&D. Currently it allows 100% deductions for current R&D expenditures, as well as capital expenditures made on R&D machinery and equipment. Buildings for R&D purposes are depreciated on an ordinary basis, but dedicated R&D facilities can be claimed as R&D expenditures.

The Scientific Research and Experimental Development Tax Credit program is directed at all Canadian entities carrying out eligible scientific research or experimental development in Canada. For Canadian-controlled private corporations, classified as small businesses (with annual revenues not greater than $2,000,000 or annual profits of $200,000), the credit is 35 per cent of valid expenditures. For all other Canadian entities the tax credit is 20 per cent of valid expenditures. For small businesses the tax credit is refundable. That is for companies paying income tax, the credit is deducted from the tax due. If, however, the credits exceed the tax due, the difference is refundable in cash. For small *for profit* companies not paying income tax, the credit is 100 per cent refundable in cash.

The objective of the federal Scientific Research and Experimental Development incentive program is to foster technologically new and improved systems, products and processes while contributing to the market expansion and cost competitiveness of Canadian companies. It is designed to assist both privately and publicly owned private companies, partnerships and individuals.

Claims for R&D tax credits must be made on a project-by-project basis, and included with the corporate (or personal) tax return. To obtain the tax credit, an entity is required to not only submit the appropriate tax forms and financial information, but to provide a detailed technical description of the project for which the tax credit is claimed. This description of the project is, to a large extent, the key to the acceptance by Revenue Canada of the eligibility for tax credits.

The original Research and Development Tax Credit program was inaugurated in the early 1980's, was comparatively ill-defined, and was subject to considerable abuses. This resulted in 1985 in a revision of policies aimed at eliminating the abuse. While keeping the basic concept, the new policy, which is in effect today, calls for both financial and technical audits of each claim. The technical description of the project mentioned above, together with supporting documentation, forms the basis for the technical audit, and thus the decision on eligibility.

Eligibility assessments are based on whether or not the work falls within the definition of R&D given in the Income Tax Act, its supporting regulations, and various interpretation documents developed by Revenue Canada - Taxation. In

addition, the work must meet a number of criteria aimed at ensuring that it meets the Government's objectives for the program.

Many telecommunications organizations, including telecommunications common carriers, carry out the development of new systems and networks under a complex integrated plan. Under these circumstances, it is frequently difficult and complex to evaluate the eligibility of such work against these specific criteria, and within the confines of a project-by-project approach as required by Revenue Canada - Taxation.

ONTARIO R&D TAX INCENTIVE PROGRAM

The 1988 Ontario budget introduced a new R&D superallowance. Expenditures eligible for the federal R&D investment tax credit qualify. The superallowance is based on the amount of qualifying expenditures incurred less the federal investment tax credit claimable. All corporations performing R&D in Ontario are eligible for an R&D superallowance deductible from income equal to 25 per cent of qualifying expenditures.

QUÉBEC R&D TAX INCENTIVE PROGRAM

The 1988 Québec budget enacted a number of tax relief measures for R&D conducted in the province. These measures were further expanded in the 1989 Québec budget. However, many of the incentives apply only to small companies and to extramural R&D expenditures. The province makes available a refundable tax credit of 20% of wages paid in Québec for carrying out R&D. Finally, the federal R&D investment tax credit is not taxable for Québec corporate income tax purposes, which is the opposite of the Ontario tax treatment of the federal R&D tax credit.

NOVA SCOTIA R&D TAX INCENTIVE PROGRAM

Corporations having a permanent establishment in Nova Scotia are eligible for a tax credit equal to 10% of R&D expenditures made in the province. The credit is applied against the corporation's Nova Scotia income tax liability. The qualified R&D expenditures conform to expenditures eligible for a federal R&D tax credit.

OTHER PROVINCIAL R&D TAX INCENTIVE PROGRAMS

At this time, no other Canadian Provincial R&D Incentive Programs have been identified.

UNITED STATES R&D TAX INCENTIVES

In the U.S., current R&D expenditures are 100% 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% 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 per cent 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 per cent of its value.

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% 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%, but over three years on a straight-line basis. Capital expenditures on buildings are 100% deductible, but are written off over three years on a straight-line basis.

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 per cent 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.

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.

RESULTS OF THE INTERVIEWS

While the following report of the interviews reflects the responses given regarding federal and provincial tax incentives, many of the answers reflect a lack of knowledge of both federal and provincial tax incentive programs. At the same time, it should be noted that in many cases where the level of knowledge of the federal and provincial tax incentive programs was not high, there were people in the organizations who were fully familiar with the programs, but they were not present for the interviews.

TELECOMMUNICATIONS CARRIERS

The majority of the telecommunications carriers use the Revenue Canada Taxation (RC-T) definition of research and development for all activities. A small number use it only for tax purposes, using a company definition for other purposes, and several noted that the definitions appeared to be product rather than system-oriented.

With respect to whether the RC-T's classifications were appropriate or understandable, half of those responding believed that the classifications were reasonable and appropriate, and the other half felt that they were too restrictive or too product-oriented.

With respect to the definition best fitting the work carried out by their organization, most of those who responded felt that their work was primarily experimental development, while two felt that their work was applied research, and one felt that their work was split between basic research and experimental development.

With regard to the activities which RC-T does not consider eligible for R&D tax claims, more than half of those responding expressed the opinion that market research should be eligible, although several qualified their definitions of market research to the inputs required to carry out the required experimental development.

Concerns were also expressed that the software related aspects of the program were overly restrictive and should be expanded.

With regard to knowledge of the federal tax incentive programs for R&D, only one third of those responding rated their knowledge as very good, another third rated their knowledge as average, with the rest as good or very poor. A similar distribution occurred for the provincial programs.

Half of those carriers responding indicated that their companies were taking full advantage of the tax incentive programs, while one third stated that they were taking partial advantage of the program, and the remainder indicated that, while eligible, for one reason or another as explained in the discussion of strengths and weaknesses below, they did not use the programs.

With respect to the impact of the tax incentive programs on the level and quality of their company's R&D activities, more than one half of those responding indicated the tax credit programs had little or no impact. Another third indicated the impact was significant, with a minority stating it was very significant or had some impact. Only one carrier differentiated between federal and provincial programs, and in this case, it was felt that the provincial program had no impact.

Given these responses, it is not surprising that only two carriers indicated that they currently take into account the potential impact of R&D incentive programs when selecting R&D projects for corporate approval and funding. However, three others (perhaps with this study acting as a catalyst) plan to do so in the future.

Regarding the major strengths and weaknesses of the federal and provincial tax incentive programs, there was no consensus among the responses. One third stated that the current federal program was acceptable, and there were single responses that the definitions were not broad enough, that the program was too product-oriented, that the strength was purely financial and that the weakness was not in the rules, but in their application. One respondent stated that there were better ways to go, one respondent stated that the administrative burden was too high for small companies, while several carriers stated that RC-T delayed its audits far too long.

With regard to suggested improvements, most respondents felt that the definitions should be broadened and clarified, with one stating that current tax rulings were written for lawyers and accountants rather than engineers and scientists. Other suggestions for improvement included encouraging market research, combining the federal and provincial programs, following through on

results of R&D (rewarding results rather than effort), increasing the credits permitted, overcoming the perceived product-orientation of the programs, simplifying the administrative burden, and including information systems.

It should also be noted that two of the carriers interviewed, SaskTel and Manitoba Telephone System, are provincial crown corporations, and a third carrier interviewed, ED TEL, is a public utility owned by the City of Edmonton. As such, these carriers are not subject to the *Income Tax Act*. Research and development tax incentives designed for taxable Canadian corporations do not, therefore, provide any incentive to these three carriers. Incentives suggested in lieu of tax incentives included the use of a rebate on radio licence fees to encourage R&D, and the use of the CEIC "Insert" program to subsidize R&D salaries for non-taxable corporations.

TELECOMMUNICATIONS MANUFACTURERS

Of the telecommunications manufacturers responding, only one quarter used the RC-T definition for all of their R&D activities. Other respondents used the RC-T definition for both tax and internal use, using other definitions as appropriate for other purposes, or used the RC-T definition for tax purposes and market-driven definitions for other purposes. A few use a breakdown of the definition into products and systems.

Almost half of the respondents expressed the opinion that RC-T's classifications were appropriate and understandable. One felt that while the spirit was correct, the wording of the definitions was different from those used in the private sector. Another organization felt that the definitions were open to interpretation, and yet another felt that they were not applicable to rapidly changing situations.

Regarding the headings the organization felt their work fell under, only two of those responding believed that they were doing any basic research, and most respondents believed that much of their work was experimental development. Most felt that they also carried out routine development and routine engineering. Generally the responses reflected a good understanding of the RC-T classifications.

With respect to ineligible activities, all except two of the respondents felt that market research should be eligible, although most recognized that to be eligible, these activities should be related to eligible R&D core activities.

Regarding knowledge of the federal tax incentive program, half of those responding rated their knowledge as good or very good. In general terms, the responses to all questions reflected to some extent, these evaluations.

With regard to knowledge of the provincial tax incentive programs, the distribution was very similar to that for the federal program. The comparatively high level of companies which felt their knowledge was very good generally reflected locations in Québec.

More than half of the manufacturers stated that they were taking full advantage of the available tax credits and other tax incentives, while the rest stated that they were partially taking advantage. No interviewees stated that their company was not taking any advantage of the available R&D tax credit schemes.

Somewhat in contrast to this, few companies felt that the impact was very significant, with the rest evenly distributed among significant impact, some impact, and little impact.

With regard to taking the impact of the tax credit programs into account when selecting R&D projects for corporate approval and funding, more than half of those responding stated that they took the incentives into account, while the remainder took them into account a little or not at all.

There was little consensus as to the strengths and weaknesses of the programs. One felt it had no weaknesses, one felt it was useful mainly to larger companies, while one indicated it was useful mainly to smaller companies. Other individual comments were that the definitions were vague, narrow, and ambiguous, did not reflect the reality of the current R&D environment, were complex, or were difficult to understand. One stated that the programs made things difficult when they dried up, one felt it was not a good fit to its business, one felt there was too much time lag between submission and action on the part of RC-T, and one felt that the administrative overload was too great.

With regard to changes that the various organizations would like to see, again there was little consensus. One respondent believed there should be no changes, three felt there should be greater levels of funding, one felt it should be more market-driven, one felt it should be a strong capital investment program, two felt it should be changed to reflect the current more integrated R&D/ production approach of many companies, one felt there should be offset deductions at source, and two felt the program should be simplified and clarified.

PROVINCIAL GOVERNMENTS

Discussions with provincial governments were restricted to those activities which RC-T does not currently consider eligible for R&D tax claims. All provincial governments responding felt that market research should be eligible, albeit several

qualified this with the comment that it should be related to R&D activities. Apart from full agreement on market research, there was no consensus on the other activities.

RECENT FEDERAL GOVERNMENT INITIATIVES

In its 1992 budget, the federal government announced its intention to implement measures to improve the federal R&D tax credit program. These measures, to be announced later this year, will include improvements to:

- The treatment of capital equipment that is used for both research and production purposes; and
- The allocation of certain overhead and administration costs between SR&ED and other activities.

The government is also finalizing its consultations with the R&D community on specific proposals to improve the administration of the system of SR&ED tax incentives, and many of these proposals are expected to address the needs of small businesses.

FINDINGS

Findings common to both carriers and manufacturers are as follows:

1. Essentially all eligible interviewees, whether carriers or manufacturers, made some use of the federal government R&D tax credit program and, for those provinces which had provincial programs, these were made use of whenever the interviewees were aware of them.

2. There is a comparatively low level of in-depth knowledge of the programs. To some extent, this can be explained by the relatively complex nature of this section of the Tax Act. However, since the R&D tax credits are part of an organization's income tax return, and since there appears to be little liaison between the accounting department and the R&D department in some organizations, this could account for the misunderstandings as well as the lack of full use of the tax credit programs in place.

3. The majority of those responding believe that those aspects of market research required to specify and identify areas for R&D should be eligible for tax credits (and, in fact, they are eligible).

The remainder of the findings are unique to either the telecommunications carriers or the telecommunications equipment manufacturers.

TELECOMMUNICATIONS CARRIERS

Additional findings which were unique to the carrier interviews are as follows:

4. Telecommunications carriers have the perception that federal R&D tax credits are product-oriented rather than being also applicable to the service industry. With the exception of the very major carriers, most of those interviewed did not have a good understanding of the eligibility of systems R&D activities.

5. Only half of the carriers responding take full advantage of the program, and few believe that its impact on their R&D activities was very significant.

6. The lack of knowledge likely also accounts for the lack of consensus regarding the strengths and weaknesses of the federal and provincial tax incentive programs, and, with the exception of making market research eligible, what could be done to improve these programs.

TELECOMMUNICATIONS EQUIPMENT MANUFACTURERS

One additional finding which was unique to the telecommunications manufacturer interviews is as follows:

7. The general level of knowledge of both the federal and the provincial tax programs was considerably higher in the case of the telecommunications manufacturers than in the case of the telecommunications carriers. However, there was still considerable misunderstanding with regard to areas of eligibility.

THE ROLE OF GOVERNMENT IN TELECOMMUNICATIONS R&D

During the interviews, several aspects of the role of government in the R&D process were discussed. Specific topics discussed were the existence of policy barriers to R&D, the appropriate role of government, the need for an explicit government R&D policy, and views on various government programs.

RESULTS OF THE INTERVIEWS

With a few exceptions, those interviewed believed there were no policy barriers to R&D. Those R&D policy barriers mentioned by the few respondents who believed there were barriers included the approvals process for funding programs, the tax treatment of R&D or tax rates in general (several mentions) and the requirements for Canadian Standards Association (CSA) approval. One respondent mentioned the difficulty of loaning R&D staff across international borders, which tended to hinder the R&D effort.

With respect to the appropriate role of government, the most common response was that government should encourage R&D, particularly development work, but several respondents stated that the government should not force companies to spend on R&D. One respondent suggested that the government should not attempt to pick winners.

Some respondents pointed to the role of government as a purchaser of goods and services, and noted that this can have an important impact by encouraging R&D in those areas.

The government plays a regulatory role in terms of its spectrum management and licensing activities, and these regulatory activities can have an impact on R&D. The provision of experimental radio licences and the relaxing of regulations to foster experimentation were noted by one respondent as being helpful to the R&D process.

With respect to the conduct of R&D by government, one respondent questioned the value of such R&D. This comment was directed to the point that it was difficult to assess the value, not necessarily that the value was low.

Regarding the broader responsibilities of government, one respondent indicated that the government could assist with employment and training programs related to R&D, and also in the provision of international market information.

With respect to the need for an explicit government policy on R&D, the results were mixed. Almost half of those interviewed were of the view that such a policy was not necessary, while a significant minority were of the view that an explicit government policy would be good. Some indicated that a policy exists now, with tax incentives and other government programs. One respondent indicated that it was not an R&D policy, but rather a national telecommunications policy, that was required.

With respect to views on government programs, most respondents took this opportunity to comment on the Vision 2000 Program. In general, the comments were not favourable, and indicated a widespread belief that the program had not lived up to expectations, particularly in terms of the degree of government funding expected. Some carriers indicated it was too manufacturing oriented. At the same time, some carriers and manufacturers supported the program, with one carrier terming it a "significant initiative".

Regarding other government programs, NSERC, technology transfer, IRAP and the DIP Program received positive views, but the DIP Program was also criticized for being over-funded, resulting in an overemphasis on the military sector. ISTC programs which have geographical constraints were also criticized by one respondent. The bureaucratic approvals process of government programs in general was also criticized by a few of those interviewed.

DISCUSSION AND FINDINGS

There was no consensus as to the need for an explicit government policy on R&D. Areas where there was consensus led us to the following findings:

1. There are few significant government policy barriers to R&D existing at present.

2. The appropriate role of government in terms of R&D is one of encouraging or providing an incentive, but not being too involved in directing the industrial R&D process.

MAXIMIZING THE BENEFITS OF TELECOMMUNICATIONS R&D

A wide range of issues with respect to the factors affecting R&D and the implications of R&D were discussed during the interviews. Under the heading of

factors, topics such as the implications of procurement policies, the relative merits of various R&D organizational models and the implications of GATT and the Free Trade Agreement (FTA) were discussed. Under the heading of implications, topics such as the preponderance of short term versus long term programs, the use of indigenous versus foreign expertise, the relationship of R&D to productivity, innovation, profitability and competitiveness, the impact of targeted R&D and the relative impacts of component, product, systems and service/application R&D were discussed.

This section of the report contains only the results of the interviews on these topics. In the chapter entitled "Models for Maximizing R&D Effectiveness" the discussion of maximizing the effectiveness of R&D continues with an in-depth description and evaluation of a number of R&D models.

RESULTS OF THE INTERVIEWS

Several respondents indicated that the impact of procurement on R&D is important. This procurement has two dimensions - purchases by government, and purchases by carriers. Since procurement by government can mean a substantial flow of revenues, it can provide an incentive to a firm to develop a product. Purchases by carriers, particularly long term purchase commitments, can mean an important endorsement to a smaller manufacturer, and assist in obtaining financing. One carrier mentioned it had participated in a "reverse trade show" at which it displayed the range of products it routinely purchased, so that local suppliers would have an opportunity to compete for that business. At the same time, some respondents were critical of the purchasing policies of governments and the carriers. In the case of governments, one carrier noted that downstream business opportunities for the product do not always result, while one manufacturer was critical of provincial favouritism. In the case of carriers, several manufacturers were critical of the relationships between carriers and major manufacturers which resulted in smaller manufacturers being shut out of the Canadian market, while at the same time they were successful with the same products in international markets.

With respect to the R&D organizational models which lead to the best R&D results, the responses varied widely. The models suggested included vertical integration, targeting resources to specific areas, aggregation of R&D resources (like Stentor or Bellcore), and alliances or collaborative programs. Some major carriers and manufacturers indicated that there was room for all of them. Many respondents pointed to the vertical integration of Bell and Northern Telecom as an example of the positive results which vertical integration could bring, although not all respondents indicated it was the best. INMARSAT and INTELSAT were also

mentioned as examples involving the aggregation of resources. Smaller companies generally favoured alliances or the targeting of resources. Those involved in joint programs which involved the aggregation of R&D resources were generally positive about the results, but this was only a part of their R&D effort in each case. One carrier suggested that the most important requirement was to create a focus or critical mass with respect to an opportunity.

A large majority of those interviewed stated that neither the GATT nor the FTA had any implications for telecommunications R&D. Three manufacturers saw the impact of the FTA on R&D as positive, good or essential, while another stated it was very, very bad, that it will cause R&D to move out of Canada. However, several firms expressed concerns that there might be a negative reaction on the part of the U.S. to Canadian R&D support programs and R&D tax credits whereby they might be viewed as subsidies.

Interesting responses were obtained on the topic of the relative preponderance of short term versus long term R&D. In almost every case, respondents from the telecommunications manufacturing industry took this opportunity to point out that development was a short term process, and that it is unusual to have projects of more than two years. Development cycles of 12 to 18 months are the norm for products. Many respondents emphasized how important it is to be in the market first with a product, since the telecommunications manufacturing sector is so competitive.

With respect to the use of indigenous versus foreign expertise, the responses indicated overwhelmingly that almost all R&D in Canada uses Canadian expertise.

Regarding the relationship of R&D to productivity, innovation, profitability and competitiveness, the responses varied widely, with most indicating a strong correlation between R&D and innovation and competitiveness, but with some noting that there were other factors, such as marketing and production, involved in enhancing profitability. At the same time, several respondents noted that some types of R&D, such as process R&D, are aimed specifically at enhancing productivity or efficiency which can also affect profitability directly. One carrier indicated that all its R&D was related to efficiency improvement.

With respect to the relative impacts of component, product, systems and service/ application R&D, carriers generally believed that service development had the greatest impact, while manufacturers tended to favour product and systems R&D as having the greatest impact. One carrier noted that process R&D leads to efficiency which leads to better applications and systems.

DISCUSSION

The most general observation which can be made under this heading is the opinion of those interviewed is generally that each R&D organizational model has its own unique strengths and weaknesses which renders it more or less helpful to a given firm. At the same time, many firms tend to participate in as many of those models as they can, because each represents a source of information regarding the market as well as access to specific developments.

As noted in the introduction to this section, we have presented here only the results of the interviews on these topics. In the chapter entitled "Models for Maximizing R&D Effectiveness" the discussion of maximizing the effectiveness of R&D continues with an in-depth description and evaluation of a number of R&D models.

4. THE STATE OF TELECOM R&D IN CANADA

INTRODUCTION

In this chapter, we focus on the quantitative aspects of telecommunications R&D in Canada.

With a relatively small population of 26.5 million, domestic markets for Canadian telecommunications manufacturers and service providers are limited. These limited markets account for the relatively small size of the service providers and suppliers in Canada. For example, Bell Canada, by far the largest Canadian service provider, is smaller than each of the seven U.S. Regional Bell Holding Companies as well as the European monopolies. Whereas the larger players in the international marketplace are able to rely on greater financial resources and larger markets, Canadian companies in this industry are constrained due to their relatively limited resources and smaller markets. The Department of Communications believes that trends such as network intelligence, ISDN, integration of technologies, and convergence of services will amplify the challenge to Canadian service providers[26].

The chapter continues with a review of information in the public domain regarding Canadian telecommunications carriers and manufacturers. It then presents and analyzes the R&D data from telecommunications carriers and telecommunications equipment manufacturers which participated in the study.

It should be noted that all dollar figures reported in this chapter are in current Canadian dollars.

THE CANADIAN TELECOMMUNICATIONS CARRIER INDUSTRY

The Canadian telecommunications carrier industry is the major generator of telecommunications revenues in Canada, approaching $16 billion in 1991. Some of this revenue is invested directly in R&D. The recent Interexchange Competition proceeding before the Canadian Radio-television and Telecommunications Commission (CRTC) generated some data with respect to R&D expenditures by a number of federally regulated carriers. In recent years, both Bell Canada and the British Columbia Telephone Company (B.C. Tel) have been investing approximately

[26] Department of Communications, "Request for Proposals: A Study on Telecommunications Research and Development," (Ottawa: Department of Communications, Government of Canada, 1990), 2-3.

2% of annual operating revenues in R&D, most of which qualifies as eligible activities under Revenue Canada's definition of Scientific Research and Experimental Development. In 1989, Bell invested $140.2 million in R&D (2.0% of total operating revenues)[27], while B.C. Tel spent $31.3 million (also 2.0% of total operating revenues)[28].

THE CANADIAN TELECOMMUNICATIONS MANUFACTURING INDUSTRY

The Canadian telecommunications equipment industry is comprised of one very large firm - Northern Telecom - and a large number of small to medium-size firms[29]. According to the Science Council of Canada, no other hardware supplier is even one-twentieth the size of Northern. The smaller Canadian equipment manufacturers are in widely divergent markets, selling largely to end users or specialized carriers, focusing on niche applications which differ from core telecommunications products, and relying on international sales for success. Their products and services are not necessarily related to the prime interests of the Canadian telephone companies.

Northern is a full-line supplier of telecommunications equipment. Other product development firms tend not to compete with each other, but specialize in different areas. As the Science Council of Canada points out, the Canadian telecommunications equipment industry has a broad base of experience and suppliers complement each other well[30]. It is thus well positioned to take advantage of the increasing variety and expanding opportunities in the global telecommunications market.

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[27] See the response to Interrogatory Bell(BCRL)28Dec90-101 IC2 at page 2 of 3. Forecasts by Bell are provided in the response to Interrogatory Bell(BCRL)28Dec90-110 IC2, at page 2 of 2.

[28] See response to Interrogatory BCTel(BCRL)28Dec90-210 IC2, Attachment 1, at page 1 of 1.

[29] Science Council, "Canadian Telecommunications Sector," 44.

[30] Ibid., 45.

DATA COLLECTED DURING THIS STUDY

All firms interviewed during this study were asked to provide detailed data on their R&D expenditures for the last five years as well as their forecast of expenditures for the next five years. In addition, the extent to which these expenditures were eligible or were expected to be eligible for Revenue Canada R&D tax credits was requested. We also asked for the provincial distribution of expenditures, the nature of the projects (whether component, product, system or application), and the breakdown of projects into short term and long term. Finally, the breakdown of R&D expenditures into in-house, university and other firms was requested.

The following firms provided detailed, year by year historical and, in most cases, forecast data on their R&D expenditures:

FACILITIES-BASED AND OTHER TELECOMMUNICATIONS CARRIERS

- AGT Limited
- Bell Canada
- B.C. Tel
- ED TEL
- Island Tel
- Manitoba Telephone System
- MT&T
- NB Tel
- Newfoundland Tel
- Québec Téléphone
- Rogers Cantel Inc.
- SaskTel
- Teleglobe Canada Inc.
- Telesat Canada
- Telesat Mobile Inc.

MANUFACTURERS

- Develcon Electronics Limited
- Eicon Technology Corporation
- Gandalf Data Limited
- Harris-Farinon Inc.
- Northern Telecom Limited
- Motorola Information Systems
- Newbridge Networks Corporation
- Spar Aerospace Limited.
- TIE Communications Research

For the service providers and equipment manufacturers which supplied data, total 1990 worldwide revenues were almost $22.5 billion, and employees of these firms numbered some 176,000 worldwide. Total 1990 worldwide R&D expenditures for these firms was $1.2 billion.

Adding to this data additional data from published sources on another eight firms (Mitel Corporation, NovAtel Communications Ltd., SR Telecom Inc., TIL Systems Limited, Positron Industries Inc., Glenayre Electronics Ltd., Alcatel Canada

Wire Inc. and Prism Systems Inc.) provides a view of R&D expenditures on what we believe is over 95% of the Canadian telecommunications industry. With this additional data, 1990 worldwide industry revenues totalled $23.6 billion, employees numbered 183,700 worldwide and worldwide R&D expenditures were $1.3 billion. Of this $1.3 billion, an estimated $950 million was telecommunications R&D conducted in Canada by manufacturers and carriers.

Based on this data and forecasts provided by many of those interviewed, our estimate of current and future telecommunications R&D expenditures is provided in Table 2 below.

TABLE 2: ESTIMATES OF TOTAL R&D EXPENDITURES FOR THE CANADIAN TELECOMMUNICATIONS INDUSTRY

Year	R&D Expenditures Worldwide $(millions)	R&D Expenditures in Canada $(millions)
1990	$1,300	$950
1994	$1,850	$1,225

Note: Figures are in constant 1990 Canadian dollars.
Source: Interview data and consultants' estimates.

Table 3 on the following page shows the actual and forecast R&D expenditures by year for the period 1986 to 1991 for the group of service providers and manufacturers which provided detailed year by year data.

TABLE 3: ACTUAL R&D EXPENDITURES 1986 - 1991

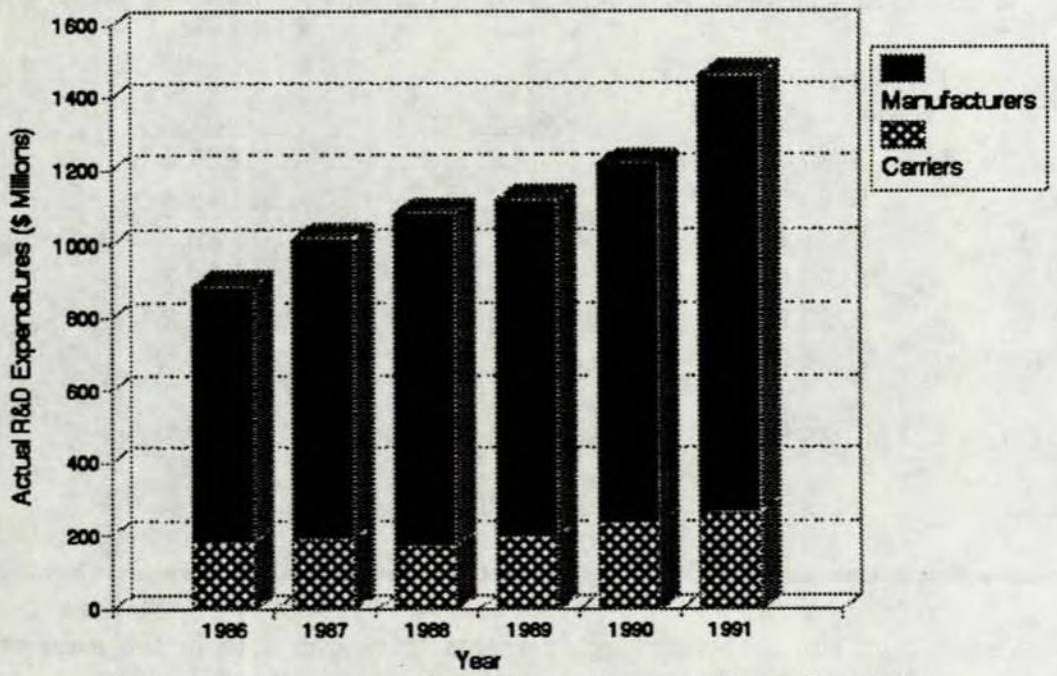
(All figures in millions of current Canadian dollars)

Year	Facilities-based and Other Carriers	Manufacturers	Total
1986	$184.3	$704.2	$888.5
1987	$189.8	$828.6	$1,018.4
1988	$171.4	$912.4	$1,083.8
1989	$195.8	$923.9	$1,119.7
1990	$233.3	$985.9	$1,219.2
1991	$264.9	$1,197.6	$1,462.5
TOTAL	$1,239.5	$5,552.6	$6,792.1

Source: Interview data from 15 carriers and 9 manufacturers.

Figure 2 on the following page presents this same data in the form of a graph.

Figure 2
Actual R&D Expenditures



Note: All $ figures are in millions of current Canadian dollars.
Source: Interview Data (15 Carriers, 9 Manufacturers)

Of the total R&D expenditures for the two groups over this period of $6.8 billion, 68% was eligible for Revenue Canada R&D tax credits. This figure should not, however, be taken to mean that only 68% of expenditures fit the Revenue Canada definition. As noted in the previous chapter, essentially all firms participating in the study use the Revenue Canada definition. All those firms which provided data stated that they use the Revenue Canada definition for internal purposes. When an expenditure is not eligible, it usually means that it was or is expected to be paid for by government grants, or it is contracted research for which another party holds the intellectual property rights and the party paying for the R&D cannot therefore claim the tax credit, or the R&D was conducted outside Canada. Such grants and contract arrangements appear to be more prevalent in the manufacturing sector where 38% of the $5.5 billion in actual R&D expenditures over the 1986 to 1991 period were not or are not expected to be eligible for R&D tax credits. For the telecommunications carriers, 95% of actual expenditures of $1.2 billion over this period were indicated as eligible.

THE TELECOMMUNICATIONS CARRIER SECTOR

The telecommunications carrier sector was divided into two groups for purposes of data collection and analysis: the facilities-based telecommunications carriers, and the other telecommunications carriers. The "other" group includes resellers, cellular carriers, and other specialized carriers. However, since there was limited response from the "other telecommunications carrier" group, it has been necessary to combine the reported results with those of the facilities-based telecommunications carriers in order to avoid reporting data which can be attributed to an individual company.

Of those facilities-based and other carriers providing data, total 1990 operating revenues totalled approximately $14 billion, and 1990 R&D expenditures were some $233 million, or 1.7% of total operating revenues. For individual companies in the sample, the range is from 0.09% of operating revenues to 9.49% of operating revenues. Total employment by the facilities-based and other carriers reporting is 109,250.

With respect to the forecast of future annual R&D expenditures for the group of facilities-based and other carriers, they are expected to peak at $402.5 million in 1994, declining to $311.1 million in 1995 due to one carrier planning to complete a substantial portion of its very significant R&D program in 1994. The resulting compound annual growth rate over the 1990 to 1994 period is 15%.

The provincial distribution of R&D expenditures by the facilities-based and other telecommunications carriers is as shown in Table 4 on the following page. Please note that, for reasons of confidentiality, the Atlantic provinces and the Western provinces have been grouped. One company did not provide a provincial distribution of its expenditures, and therefore its expenditure data does not appear in the total.

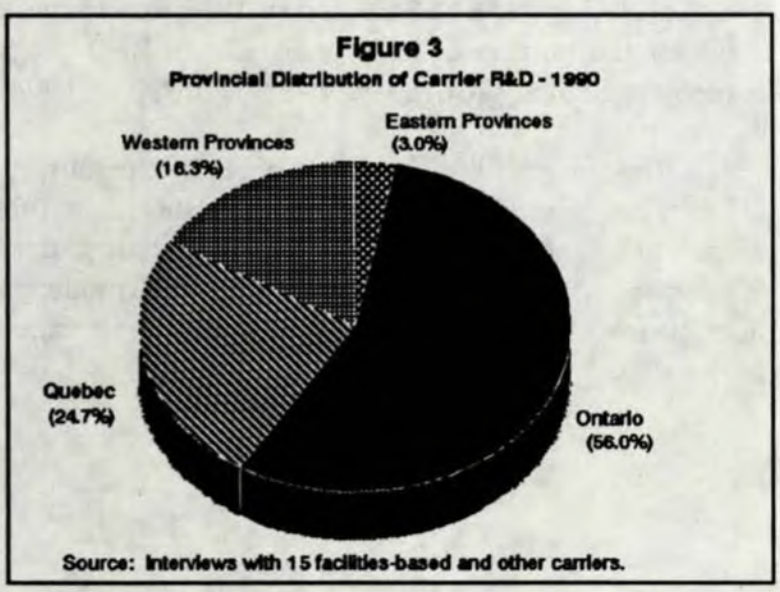
TABLE 4: PROVINCIAL DISTRIBUTION OF CARRIER R&D EXPENDITURES

Province	1990 R&D Expenditures ($ thousands)	% of total
Atlantic Provinces	$6,411	3%
Québec	$51,915	25%
Ontario	$117,774	56%
Western Provinces	$34,202	16%
TOTAL	$210,302	100%

Source: Interview data.

Note: Only 14 of the 15 carriers provided a provincial breakdown and therefore the total does not correspond to that for 1990 in Table 3.

This data is represented in pictorial form in figure 3.



With respect to the relative expenditures on component, product, system and service/application R&D, it is not surprising to find that the emphasis of the facilities-based and other carriers is on systems and applications, with system or network R&D accounting for 53% of the total, and services another 45%. Similarly, over 70% of the expenditures of the facilities-based carriers is on short term projects (projects of three years or less in duration).

With respect to in-house R&D versus outside R&D contracts, more than 58% of the R&D is conducted in-house. Of the R&D done outside the firm, 85% of the work is done in Canada, with other organizations (principally Stentor which

contracts out R&D projects on behalf of its members) and firms accounting for approximately 94%, and universities accounting for 6%.

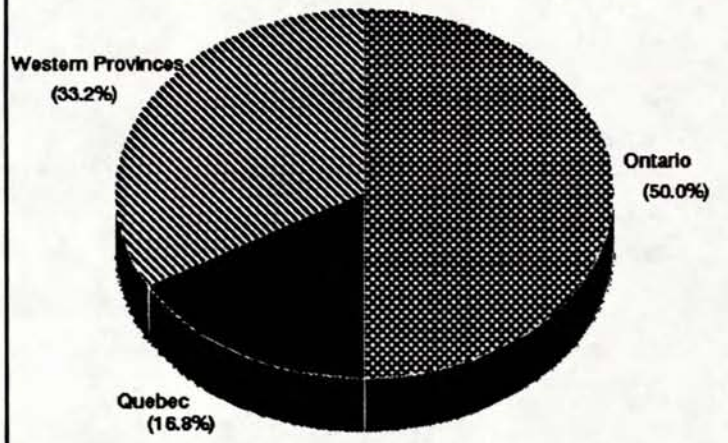
THE TELECOMMUNICATIONS MANUFACTURING SECTOR

Nine firms in the telecommunications manufacturing sector have provided detailed data on their R&D expenditures. Total 1990 worldwide operating revenues for these nine firms was $8.5 billion, with total worldwide employment at 66,755. Worldwide 1990 R&D expenditures were $986 million, or 11.6% of revenues.

Only eight firms provided a forecast of annual R&D expenditures for the period 1990 through 1994. The resulting compound annual growth rate is 14%, one percentage point lower than that forecast by the group of facilities-based and other carriers. It should be noted that Northern Telecom did not provide a forecast and therefore is not included in this figure.

Only eight telecommunications manufacturing companies provided a provincial breakdown of R&D expenditures. The provincial distribution of R&D expenditures by those companies which supplied data is as shown in Figure 4. Again, because of the small number of companies reporting, the provinces in Western and Eastern Canada are grouped so that data cannot be attributed to one single firm. Similarly, the actual data are not shown because to do so would reveal data about a single firm.

Figure 4
Provincial Distribution of Manufacturer R&D - 1990



Source: Interviews with nine manufacturers.

With respect to the relative expenditures on component, product, system and service/application R&D, the emphasis is definitely on product and systems, although not all nine firms provided data at this level of detail. Of those reporting, the R&D expenditures on products is about 65% of the total, and expenditures on systems R&D is about 35% of the total, with no expenditures indicated on components or services. With respect to long term versus short term expenditures

(programs of more or less than three years in duration), the emphasis was almost exclusively on short term projects to the extent of 98% of total expenditures.

With respect to in-house R&D versus outside R&D contracts, over 95% of the R&D is conducted in-house. Of the outside contracts, about half are in Canada and half in the U.S., with universities accounting for slightly less than half the outside contracts.

CONCLUSIONS

The data collected in this study with respect to the telecommunications carriers gives a reliable picture of the R&D situation over the last five years, and given the high rate of participation of the firms in this sector, the forecast is also considered reliable. While the rate of participation by the telecommunications equipment manufacturers was not as high, the addition of information from published sources means that over 95% of the value of R&D is included for the historical period. For the forecast period, the data is not as reliable.

5. INTERNATIONAL COMPARISONS

INTRODUCTION

In this chapter, we provide a comparison of telecommunications R&D among several countries. The chapter begins with an international overview, then examines telecommunications R&D in the U.S., the Netherlands, Sweden and Australia as a basis for a comparison with telecommunications R&D in Canada. These countries were selected in consultation with the Department of Communications at the commencement of the study.

Sources of information for this chapter included the embassies and high commissions of these countries in Canada, broad searches of the literature, OECD statistics, and information requests directed to government officials in each country. In the case of the U.S., personal interviews were conducted with officials of several government agencies.

INTERNATIONAL COMPARISONS OF TELECOMMUNICATIONS R&D

Due to difficulties inherent in measuring and comparing R&D expenditures, it is difficult to build a comprehensive picture of international R&D activities. This is also true for comparisons across OECD countries[31]. A comparison in monetary terms, for instance, is affected by differences in price levels and currency values over time and between countries.[32] The accounting requirements for the reporting of R&D costs in annual financial statements vary among countries. Comparing R&D in terms of personnel conducting R&D creates the difficulty of reducing the data to a standardized person-year basis. For instance, a normal working day may differ from sector to sector and from country to country.

In spite of these difficulties, certain measures have been developed to facilitate country to country comparisons. They include: the GERD/GDP ratio, per

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[31] Organization for Economic Cooperation and Development, Performance Indicators for Public Telecommunications Operators, (Paris: Organization for Economic Cooperation and Development, 1990), 153.

[32] Statistics Canada, Framework for Measuring Research and Development Expenditures, 11.

capita comparisons, the B-Index, and patent statistics. Due to the detailed nature of this statistical information, it is provided in Appendix E.

R&D Determinants and Expenditures

Most telecommunications carriers around the world conduct R&D. It appears that the primary determinants of R&D expenditures include the size of the carrier and the degree of competitive pressure it faces. AT&T, a vertically integrated carrier, spends the highest percentage of its revenues on R&D. Among non-vertically integrated carriers, NTT has the highest percentage of revenue devoted to R&D. The factors having an impact on the R&D decisions of NTT could be its size and the trend towards increasing competition in the Japanese telecommunications carrier industry. As shown in Table 5 below, with 1990 revenues of $38.1 billion, NTT is the largest telecommunications company in the world.

Table 5: R&D Expenditures as a Percentage of Revenues - 1990

	Revenues U.S. $(millions)	R&D U.S. $(millions)	Percentage
Bell Canada	6,599	99.1	1.5%
B.C. Telephone Co.	1,597	29.3	1.8%
British Telecom	20,012	370.5	1.9%
France Telecom	20,260	786.8	3.9%
Deutsche Bundesposte Telecom	34,490	40.3	0.1%
NTT	38,100	1,569.0	4.1%
Royal PTT Nederland*	8,029	66.3	0.8%
Swedish Telecom Group	5,735	209.9	3.7%
Telecom Australia	6,937	50.0	0.7%

Source: Annual reports and interrogatory responses.
Note: Revenue and expenditure figures have been converted to US$ at exchange rates in effect at the end of the reporting period (1990).
*Includes data for non-telecommunications sectors.

France Telecom and Swedish Telecom are fairly large organizations and spend 3.9% and 3.7%, respectively, on R&D. However, both are state-owned network providers. By way of comparison, British Telecom, now a private entity, spends only 1.9% of its revenues on R&D.

A recent phenomenon has been the expansion of the activities of the private telcos and, to some extent, the PTTs, outside their domestic markets, such as in purchasing newly-privatized PTTs (e.g. in New Zealand, Argentina, and Chile), in setting up mobile communications networks (e.g. Eastern Europe), in acquiring foreign manufacturing and services companies or in establishing joint ventures.

Telecommunications equipment manufacturers tend to spend a higher percentage of their revenues on R&D than do telecommunications carriers. As shown in Table 6 below, Northern Telecom, with 11.4% of its revenues being spent on R&D, has the highest percentage in the telecommunications sector. Fujitsu spends 11.8% of its revenues on R&D, but the company has diversified operations and does not spend all its R&D expenditures on telecommunications.

TABLE 6: R&D AS A PERCENTAGE OF REVENUE FOR MAJOR EQUIPMENT VENDORS - 1990

	Revenues U.S. $(millions)	R&D U.S. $(millions)	Percentage
Alcatel	18,344	2,087	11.4%
AT&T	37,285	2,433	6.5%
Ericsson	8,342	895	10.7%
Fujitsu	16,100	1,900	11.8%
NEC	21,900	1,500	6.8%
Northern Telecom	6,769	774	11.4%
Phillips	32,996	2,591	7.9%
Siemens	39,816	4,397	11.0%
Toshiba	26,911	1,683	6.3%

Source: Annual Reports

Note: The figures include data for non-telecommunications operations. Revenue and expenditure figures have been converted to US$ at exchange rates in effect at the end of the reporting period.

In 1988, revenues of the top forty telecommunications equipment manufacturers was $77.2 billion, up by 11.6% over the previous year.[33] AT&T continues to be a major producer, but is now being rivalled by Alcatel, which took over the European telecommunications business of IT&T, and Siemens/GPT, established through the joint takeover of Plessey in 1989. The fastest growing firms over the last year have been those with strong interests in mobile communications, such as Ericsson and Motorola. It is in this area where suppliers have been most active in forming joint ventures and alliances to exploit the newly-opening markets.

Challenges facing telecommunications equipment manufacturers with respect to R&D include the escalating costs of R&D and access to markets of a sufficient size to support those R&D costs. This challenge is particularly strong in core network product areas[34]. A digital telephone exchange, for instance, could be developed for approximately $100 million in the mid-1970s. Today, it would cost $2 billion to build the product and at least as much to market it[35].

The international comparison of military and civil expenditures of the U.S., Japan, Germany, France, the U.K. and Canada for 1987 presented in Table 7 on the following page shows that, at 14%, Canada has the highest ratio of telecommunications R&D as a percentage of national R&D.[36] The comparison also shows that, in the aggregate, Canada has the lowest R&D expenditures - 0.85 billion U.S. dollars. Canada's 0.18% civil and military telecommunications R&D expenditure as a percentage of GDP was also the lowest. Nevertheless, Canada's civil R&D expenditures as a percentage of GDP is comparable to other OECD countries.[37] In the U.S., the U.K. and France, 30-40% of total telecommunications R&D expenditures are financed by the defence departments.

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[33] Organization for Economic Cooperation and Development, Communications Outlook, (Paris: Organization for Economic Cooperation and Development, 1990), 21.

[34] Science Council, "Canadian Telecommunications Sector", 40.

[35] Ibid.

[36] Department of Communications, Telecommunications Research and Development Statistics, (Ottawa: Department of Communication, Government of Canada, July 1991), Table 1.

[37] Ibid.

TABLE 7: TOTAL MILITARY AND CIVIL TELECOM R&D EXPENDITURES - 1987

US$(billions)

	U.S.	Japan	Germany	France	U.K.	Canada
Total R&D Spending	13	4.7	2.5	1.9	2.1	0.85
% National R&D	10%	10%	10%	11%	13%	14%

Source: Wissenchaftliches Institut für Kummunikationsdienste (WIK) and DOC Telecommunications R&D Statistics.

OVERVIEW OF INTERNATIONAL TELECOMMUNICATIONS R&D

In Canada, as in many other developed nations, R&D in telecommunications accounts for a large percentage of total R&D spending. The amount of total R&D budgets that is spent specifically on telecommunications is estimated to average some 10-13% for all developed countries.[38] Canada is well above this range, with telecommunications equipment manufacturers alone accounting for 15% to 16% of total Canadian industrial R&D expenditures.[39]

Research and development budgets are funded by carriers, governments and equipment manufacturers. General observations with respect to the roles of each are as follows:

- Carriers: The amount of R&D financed by telecommunications carriers across countries is not uniform. In the United States, carriers finance approximately 50% of the R&D effort, whereas in France, Japan and the United Kingdom, carrier financing averages between 16

[38] Organization for Economic Co-operation and Development, Telecommunications Equipment: Changing Markets and Trade Structures, (Paris: Organization for Economic Co-operation and Development, 1991), 17-18.

[39] Statistics Canada, Industrial Research and Development Statistics 1988, (Ottawa: Statistics Canada, October 1990), 21.

and 22%.[40] Germany is at the low end of the scale with only 5% of R&D financing furnished by the carrier. In 1990, the Canadian carrier industry is estimated to account for 19% of Canada's total industrial telecommunications R&D.[41]

- Governments: According to the OECD, the bulk of the government financing in telecommunications R&D is in the military sector. However, R&D in the military sector spills over into the civilian area. It is difficult to determine the value of this spill-over.

- Manufacturers: Leading manufacturers rely heavily on R&D to develop innovative products and to remain on the leading edge of technology.

It should be emphasized once again that there are definitional problems in making international comparisons. While the OECD tries to encourage the use of a consistent definition (the Frascati definition), individual companies do not generally use such definitions since there is little incentive for them to do so. As previously described, most Canadian telecommunications carriers and telecommunications equipment manufacturers use the Revenue Canada definition. Accordingly, international comparisons can only be used for general indications of relative levels of R&D spending, not for precise comparisons.

R&D Spending in OECD Countries

R&D spending is an important component of a telecommunications carrier's commitment to its future subscribers[42]. In OECD countries, most carriers carry out some R&D work internally in addition to putting out contracts to private firms. According to an OECD report, the R&D organizations of carriers are among the leading centres of excellence in the telecommunications field.[43] These include AT&T's Bell Labs, Bell Canada and Northern Telecom's BNR, NTT's eleven

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[40] Organization for Economic Co-operation and Development, Telecommunications Equipment, 17-18.

[41] This estimate is based on R&D figures in Table 3.

[42] Organization for Economic Cooperation and Development, Performance Indicators, 153.

[43] Ibid.

telecommunications laboratories, British Telecom's Marlesham Heath laboratory, the Centre National d'Etudes Telecommunications (CNET) in France, and FTZ in Germany.

Governments in the U.S., Japan and Europe have been participating and continue to participate in the conduct and funding of telecommunications R&D.

In the United States, which is behind Japan but ahead of Europe in terms of spending levels, the Pentagon finances more than one third of the telecommunications R&D budget. Although the projects are primarily for telecommunications equipment for military use, it is likely that there are spill-over effects for civil use.

The United States government also supports civil telecommunications R&D indirectly. The Economic Recovery Act of 1981 provides tax cuts for R&D spending. It has been estimated that this indirect subsidy reached $7.2 billion in 1985.

Some industry observers expected that the advent of competition and divestiture would have a negative impact on the level of R&D expenditures by AT&T. In fact, however, predictions that AT&T's R&D investments would decline after divestiture have not come true. The company's R&D investments have increased and the research organization at AT&T Bell Labs is roughly the same size.

Bellcore, the part of Bell Labs which was split off at the time of divestiture into a separate R&D entity owned by the Bell Regional Holding Companies, is about 40% of the size of Bell Labs. Overall, the research as well as the development expenditures for telecommunications have increased substantially as a consequence of divestiture. Noll found an increase of nearly 60% for the combined R&D expenditure of AT&T and Bellcore in 1985 over the pre-divestiture level of 1982.[44] The RBOCs invest about 1.5% of their operating revenues in R&D. This figure appears to be low when compared with the R&D intensity of manufacturing companies and vertically integrated carriers like AT&T. However, it should be kept in mind that the RBOCs are neither vertically integrated nor involved in manufacturing. In absolute numbers, the BOCs combined R&D budget is the third largest of any carrier within the group of non-vertically integrated carriers. In the U.S., AT&T, GTE, and RBOCs perform half of the total amount of non-military telecommunications R&D.

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[44] A. Michael Noll, "Bell System R&D Activities: The Impact of Divestiture," Telecommunications Policy, June 1987, 178.

According to Schnöring, Japan has taken the lead in telecommunications development activities by investing a great deal of resources in developing its technological capabilities.[45] Japan has accumulated a very large stock of proprietary knowledge in all areas of telecommunications. At the same time, it is alleged that Japan does not have the basic research it urgently needs, and as a result many corporations are establishing basic research centres and increasing R&D budgets.[46]

Although Japan has had a lag in software development, a major objective of Japan's current R&D policy is to upgrade the country's software development capabilities. Japan's manufacturers finance and perform almost three quarters of the national R&D. The companies most active in R&D are NEC, Fujitsu, Hitachi and OKI, the so-called Denden family, with strong ties to NTT. Japan's manufacturers have a strong and broad commitment to long-term R&D. About 5% of their R&D budgets is for basic research and 20% is for applied research.

The European Economic Community has created specific R&D programmes to work in the field of telecommunications. Among the dominant European research programs are RACE (Research and development on Advanced Communications in Europe), EUREKA (European Research Co-ordination Agency) and ESPRIT (European Strategic Program for Research in Information Technology). Each of these programs receives its resources from the large FRAMEWORK programme which has an overall budget of ECU 5.4 billion.

In terms of individual countries in Europe, Germany has the largest telecommunications R&D budget, but the European countries on average are far behind the U.S.A. and Japan. North American and Japanese firms have not yet penetrated the newly competitive European market on a large scale, but there are concerns in Europe that competition from the U.S. and Japan will increase rapidly.

A more detailed discussion of telecommunications R&D is provided in the following sections on the U.S., the Netherlands, Sweden and Australia. Each section begins with an historical perspective, then describes the telecommunications carrier and manufacturer sectors, and provides available data on telecommunications R&D.

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[45] Schnöring, Research and Development in Telecommunications, 19.

[46] Ronald K. Jurgen, "R&D Isn't What It Used To Be", IEEE Spectrum, October 1990, 38.

THE U.S.

HISTORICAL PERSPECTIVE

The United States is the largest single market for telecommunications equipment and services. The country has already permitted long distance competition over the public network, and now even the local loop has become vulnerable to competition. In the equipment business, unfettered competition is allowed.

The divestiture of AT&T under the provisions of the Modified Final Judgement (MFJ) brought to an end the tradition of integrated local and long distance telephone services in the United States.[47] AT&T organized the twenty-two Bell operating companies (BOCs) into seven regions and formed seven stock-holding companies to own the stock of the operating companies in their respective regions. On January 1, 1984 AT&T divested itself of the regional holding companies (RHCs).

THE CARRIER INDUSTRY IN THE U.S.

With the opening of long-distance services to competition, several inter-exchange carriers have entered the market. Interstate services are regulated by the FCC, whereas intrastate services are regulated by the state regulators. Twenty-four states have allowed interexchange carriers to offer intrastate intraLATA services on a competitive basis as well.

The major interexchange competitors are AT&T, MCI and US Sprint. Since 1984, the overall annual rate of growth of interstate telephone traffic has been 13%.[48] AT&T's traffic increased at a slower rate than the industry average, reflecting a decline in its market share. AT&T's share of the telephone traffic declined from 80% in 1984 to 66% in 1989. During 1984, AT&T's toll revenues of $35 million accounted for about 90% of the revenues received by all long distance carriers.[49] By 1988, AT&T's revenues were virtually unchanged and its share of

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[47] Harris, "Divestiture and Regulatory Policies," 107.

[48] Federal Communications Commission, "AT&T's Share of the Long Distance Market," (Washington, D.C.: Common Carrier Bureau, Federal Communications Commission, December 1989), 2.

[49] Ibid., 3.

revenues had fallen to 75 percent. In 1988, MCI's share of revenues was 10% and that of U.S. Sprint was 7%.[50] For all carriers, revenues grew at a far slower pace than the volume of long distance calling because of sharp price cuts.

The BOCs are prohibited from providing long distance interstate or interLATA services. Moreover, their monopoly status in most local markets is being challenged by alternate access providers who have set up fibre optic networks in the business districts of the major metropolitan areas.

THE EQUIPMENT INDUSTRY IN THE U.S.

AT&T and Northern Telecom are the largest players in the U.S. equipment market. In 1988, for instance, AT&T had a 47 percent market share of the U.S. digital central office switching equipment market, while Northern had a 39 percent share.[51] Typically, switching equipment represents about 50 percent of the total U.S. telephone industry investment. Overall, the U.S. networks operated by the regulated companies constitute a capital investment in plant substantially in excess of $200 billion.[52]

In the PBX market, AT&T had a share of 25 percent in 1988, while Northern trailed with 18 percent.[53] There are about 230,000 PBXs installed in the United States. In 1988, about 25,000 PBX systems were sold in the U.S., valued at over $3 billion.

Since unfettered competition is allowed in the U.S. telecommunications equipment market, several European and Japanese companies have also found market niches for their products. Under the terms of the MFJ, the RHCs are prohibited from entering the manufacturing businesses.

AT&T is a long distance service provider and a leading manufacturer of telecommunications equipment. Although its primary businesses is telecommunica-

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[50] Ibid., 9.

[51] U.S. Department of Commerce, U.S. Telecommunications in a Global Economy: Competitiveness at a Crossroads, (Washington, D.C.: U.S. Department of Commerce, August 1990), 50.

[52] Ibid., 47.

[53] Ibid., 54-55.

tions, AT&T also produces computer products, and provides value-added financial and leasing services. For 1990, the company's revenues were $37.3 billion, a 3.1% increase over 1989 revenues.[54]

TELECOMMUNICATIONS R&D IN THE U.S.

The MFJ split Bell Labs off into a new research facility for the Regional Holding Companies (RHCs) under the name of "Central Services Organization" (that was subsequently changed to Bell Communications Research or Bellcore). At the same time, Bell Labs was itself renamed AT&T Bell Labs to clearly reflect its affiliation with AT&T.

During 1990, AT&T spent $2.4 billion on R&D, accounting for 6.5% of its total revenues.[55] This was down from 2.7 billion spent in 1989, which accounted for 7.3% of revenues. In 1990, a greater proportion of development work related to customer support and ongoing product enhancements. More software development work was capitalized in 1990 and the company reduced the research staff dedicated to microelectronics products development.

Bellcore operates under the joint ownership of all the seven RHCs. Bellcore conducts applied research and develops uniform standards. Bellcore's current budget is $1.2 billion. The facility employs 8,300 people.

THE NETHERLANDS

HISTORICAL PERSPECTIVE

The Netherlands' 14.85 million inhabitants live in an area of 40,800 square kilometres. Its small size is one of the major reasons why the country continues to have a monopoly telecommunications carrier.

The Netherlands has been reviewing its telecommunications system since the early 1980s, but it was the recommendations of the Steenbergen Committee that triggered the process of privatization. In 1985, the Steenbergen Committee

[54] AT&T Annual Report 1990, 25.

[55] Ibid.

examined the PTT's existing status and future role.[56] In its report to the Netherlands government, the Committee made several recommendations on the structure and regulation for the telecommunications industry. In December of the same year, the government decided to adopt the Committee's proposals with some reservations. The Committee's recommendations formed the basis of the 1989 Telecommunications Act.

Acting under the Committee's recommendations, the government moved to privatize PTT Telecom. The Netherlands is the second country in Europe after the United Kingdom to privatize its national telecommunications company.[57] However, the telecommunications entity continues to retain its monopoly position.

The Netherlands is also home to Philips, a major equipment vendor with an international presence.

PTT TELECOM

As of January 1, 1989, Royal PTT Nederland NV was established as a holding company.[58] PTT Nederland NV has a number of subsidiaries, the largest being PTT Post BV and PTT Telecom BV. The company's shares may be issued to third parties, but the state is obliged to retain a majority. PTT Nederland NV's 1990 revenues were $8 billion.[59] With a revenue of $5.4 billion, PTT Telecom had the largest share of these revenues.

PTT Telecom BV is a monopoly provider of basic telecommunications services in the Netherlands, but only until January 1, 1994.[60] However, the basic premise of the telecommunications regulation in the Netherlands continues to be the provision of universal service. For the fulfilment of the objective of universal

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[56] Datapro Research Group, "The Netherlands: The Commercial and Regulatory Environment," International Telecommunications (Delran, NJ: McGraw Hill, Inc., May 1991), IT10-020-431.

[57] Wim Dik, "Royal PTT Netherlands: Strategy for the Future," 1992 Single Market Communications Review, October 1990, 10.

[58] Ibid., 13.

[59] PTT Nederland Annual Report 1990, 6.

[60] Datapro, "The Netherlands," IT10-020-432.

service, the prices of telecommunications services are mandated to remain reasonably low. The PTT's regulatory responsibility has been entrusted to the Ministry of Transport and Public Works.[61]

Except for the basic services provided by PTT Telecom, other service providers are permitted to offer a wide range of services through the public infrastructure without special licenses or conditions.[62] These include value-added services. The new regulatory environment facilitates the establishment of "closed" and special networks for the purpose of providing telematic services.

The Steenbergen Committee had recommended the implementation of many of the European Economic Commission's recommendations as set forth in the 1987 Green Paper on Telecommunications Equipment and Services. However, the Dutch telecommunications industry will need to be further restructured to meet the requirements put forward by the Commission.[63]

THE EQUIPMENT INDUSTRY IN THE NETHERLANDS

PTT Telecom's monopoly is limited to the network termination point within a customer's premises. Competition in terminal equipment is open, subject to the provision that only approved equipment may be sold and connected to the public network. One of PTT Telecom's business units also supplies terminal equipment to customers and can purchase that equipment from its competitors.[64]

Philips is a diversified manufacturer of a wide range of products, including telecommunications equipment. Over the past few years, Philips has reduced its activities in telecommunications and has invested more heavily in its lucrative consumer electronics business. Total revenues for 1990 were $33 billion, a 3% decline from 1989 revenues.[65] The drain on Philips equity due to persistently large losses on information systems and integrated circuits were compounded by the intense price competition faced by the company's Lighting Division in Europe and

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[61] Dik, "Royal PTT Netherlands," 11.

[62] Datapro, "The Netherlands," IT10-020-435.

[63] Ibid., IT10-020-431.

[64] Ibid., IT10-020-432.

[65] Philips: Annual Report 1990, 1.

the United States.[66] Furthermore, exchange rate movements and appreciable rises in interest rates had an adverse impact on the company's earnings. In view of the foregoing, Philips has intensified measures to enhance the company's manoeuvrability.

TELECOMMUNICATIONS R&D IN THE NETHERLANDS

Royal PTT Nederland set up a research subsidiary, PTT Research in 1990, combining the operations of Neher Laboratories (RNL) in Liedschendam and Telematics Laboratories (PTL) in Groningen.[67] The move was aimed at achieving synthesis between and within departments and to optimize the effectiveness and efficiency of the organization.[68] Complementary research in the socio-scientific field is conducted within PTT Nederland by the Institute for Applied Business Research.

Both Neher Laboratories and Telematics Laboratories operate as profit centres and sometimes undertake projects for third parties. The two research facilities employ a total of 480 research staff.[69] In 1990, PTT research spent $66.3 million on R&D, accounting for 0.8% of revenue.[70]

PTT Research undertakes projects on a contractual basis, either for the company as a whole, or for the operating companies. A large proportion of research is carried out on behalf of the operating companies who pay for the services rendered and are the main source of funding for PTT Research. For the latter, the R&D focus is primarily applications-oriented. The research at PTT Research "enables the company to identify opportunities created by technical and social developments." [71]

The R&D carried out at Neher Laboratories focuses mainly on telecommunication and postal infrastructures. It involves the development of long-term applica-

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[66] Ibid., 8.

[67] PTT Nederland NV: Annual Report 1990, 22.

[68] PTT Research: 1990 Laboratory Activities, 3.

[69] PTT Nederland Annual Report 1990, 22.

[70] Ibid., 42.

[71] Ibid., 22.

tions and technical systems research.[72] The Telematics Laboratories specializes in application-oriented research and strategic research in telematics. Both organs of PTT Research are involved in international research through co-operative arrangements and through participation in the EEC's technology programs.

Philips has its main research laboratories in Eindhoven, where almost half of the company's research personnel are stationed. The company has smaller laboratories in Germany, the United Kingdom, France, Belgium, and the United States. Philips' 1990 Expenditures for R&D amounted to $2.6 billion, accounting for 7.9% of revenues.[73] In 1989, the R&D expenditures were $2.7 billion, accounting for 8% of revenues. According to Philips, the decline in R&D expenditures in 1990 was entirely due to the fact that Philips sold its major defense businesses in Europe in 1990.

Most of Philips' research is centralized, whereas development is organized on the basis of product divisions. For division-oriented research, contractual agreements are drawn up with product divisions regarding programs and cost.

SWEDEN

HISTORICAL PERSPECTIVE

With an area of 450 thousand square kilometres and a population of 8.49 million, Sweden has 18.9 inhabitants per square kilometre.

A series of parliamentary decisions successively liberalized Sweden's telecommunications market during the 1980s.[74] However, the Swedish Telecom Group continues to be a state-owned monopoly. It also manufactures equipment through

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[72] Datapro, "The Netherlands," IT10-020-435.

[73] Philips Annual Report 1990, 28.

[74] Tony Hagström, "Swedish Telecom: Proposal for Privatization and Internationalization," 1992 Single Market Communications Review, April 1991, 38.

its subsidiary Scandinavian Telecommunication Trading (STT).[75] Sweden is also home to Ericsson, one of the world's largest equipment manufacturers.

In 1988, the parliament decided that the overall objective of Sweden's telecommunications policy would be to provide individuals, commerce, industry and the public sector throughout Sweden access to adequate telecommunications at the lowest possible socio-economic cost. In 1990, the Postal and Telecommunications Commission presented proposals for defining precisely how the government's social and regional policy responsibilities, exercised through Swedish telecom, should be implemented.

THE CARRIER INDUSTRY IN SWEDEN

As a consequence of measures to liberalize the telecommunications industry, the Swedish Telecom Group has undergone changes in its structure and role. Although the government still determines the subscription fee for residential service, the company was made responsible in 1984 for raising its own capital. Despite its ownership of Scandinavian Telecommunication Trading, it is obliged by regulation to tender for all equipment.

Notwithstanding its government ownership, the Swedish Telecom Group has essentially been operating as a public corporation. The formation of a new regulatory body, Statens Telenamnd (STN) (or the National Telecommunications Council), may further change its role. The Swedish Telecom Group is required to register its products with STN before they can be connected to the telecommunications network.[76]

In 1980, the Swedish parliament permitted the Swedish Telecom Group to form a holding company, Teleinvest PLC, a move that was designed to boost the Swedish Telecom Group's ability to compete in a liberalized market.[77] The Swedish Telecom Group's strategy was to use Teleinvest to gain access to domestic and

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[75] Datapro Research Group, "Sweden: The Commercial and Regulatory Environment," International Telecommunications (Delran, NJ: McGraw Hill, Inc., November 1991), IT-020-502.

[76] Hagström, "Swedish Telecom," 38.

[77] Tony Hagström, "The Swedish Road to Liberalization," 1992 Single Market Communications Review, July 1989, 16.

international markets and to form joint ventures to expand the company's operations.

The Swedish Telecom Group is required to keep separate accounts for its monopoly and competitive services.[78] This "structural separation" is designed to prevent cross-subsidization of competitive services which include the supply of telecommunications equipment, cable TV services and certain operator-assisted services. Teleinvest is also required to maintain separate accounts.

Recently, the Board of Directors of the Swedish Telecom Group announced their intention to list the company on the public stock exchange by 1992.[79] The decision is seen by observers as part of a bid to ensure that when Sweden becomes a member of the EEC, it will be in a stronger position to compete. However, there are concerns within the Swedish government as to whether a privatized Swedish Telecom Group will be able to maintain the quality of its services.

In a troubled Swedish economy, the Swedish Telecom Group has shown favourable financial results. The company's sales outside Sweden have gradually increased. In 1990, the company's revenues amounted to $5.7 billion, a 15% improvement over 1989 revenues.[80] The Swedish Telecom Group is Sweden's largest investor.[81] In 1990, the Swedish Telecom Group invested $1.9 billion. Investments in the network accounted for a major share of capital expenditures.

THE EQUIPMENT INDUSTRY IN SWEDEN

Sweden has the highest level of exports among the OECD countries, but its level of specialization in telecommunications has declined since the late 1970s.[82]

A 1980 parliamentary decision opened the market for terminal equipment attached to Swedish Telecom networks to competition. The terminal equipment covered by the decision included telephone sets, data terminals, telex terminals, and

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[78] Swedish Telecom Annual Report 1990, 26.

[79] Datapro, "Sweden," IT-020-501.

[80] Swedish Telecom: Annual Report 1990, 2.

[81] Ibid., 14.

[82] Communications Outlook, 25.

modems. Subsequent decisions led to the full deregulation of the telecommunications equipment market by 1989. As a result, the markets for PBXs and pay-phones have also been opened to competition.

As a consequence of the parliamentary decisions, Swedish Telecom has lost market share to new players in the Swedish market. At the same time, the total market has rapidly expanded in terms of products, services and traffic.

Swedish companies are also facing competition from companies active in international markets.[83] AT&T recently entered into partnership with the Swedish company Esselte AB in an effort to increase its presence in Sweden. Another firm, Comvik AB, has sold 40% of its satellite company, Comvik Skyport, to Cable and Wireless.

Ericsson's parent company, Telefonaktiebolaget LM Ericsson, is headquartered in Stockholm. The company has 70,000 employees and operations in 100 countries. The company's worldwide revenues in 1990 were $8.3 billion, up from $7.2 billion in 1989.[84] In Sweden, Ericsson sold services and products worth over $990 million, amounting to 12% of total revenues. Recently, Ericsson sold its business communications marketing arm to Swedish Telecom Group.

Nearly two-thirds of Ericsson's operations are in Europe. Ericsson is active in all countries of the European Community and is well positioned for the opening of the EEC market in 1993. Sweden's anticipated membership in the EEC can further strengthen this position. Ericsson has played a strong role in European research projects, notably RACE which is focusing on the development of broadband communications.

TELECOMMUNICATIONS R&D IN SWEDEN

In 1990, the Swedish Telecom Group invested $210 million in R&D, accounting for 3.7% of company's total revenues.[85] Eighty percent of the investment was spent in development, while 20% was devoted to research.

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[83] Hagström, "Swedish Telecom," 39.

[84] Ericsson: Annual Report 1990, 21.

[85] Swedish Telecom: Annual Report 1990, 15.

The Swedish Telecom Group considers its R&D strategically important, since it is designed to identify and develop technologies and system solutions that can form a platform for launching new telecommunications services.[86] The research is also aimed at developing the telecommunications network.

The Swedish Telecom Group is participating in various international research programs in telecommunications, radio and data communications. It has a major involvement in EEC R&D programs.

The Swedish Telecom Group and Ericsson jointly own an R&D facility, Ellemtel Utveckling AB.[87] This research facility specializes in R&D on telephone and data networking. In 1989, 56% of its total expenditures related to telephone exchanges, 36% to PBXs, and 8% to development of technology.

Ericsson's expenditures for R&D during 1990 were $895 million, accounting for 10.7% of the company's total sales.[88] Total technical expenses, including costs of market adaptation of its products, were even higher, amounting to more than $1.3 billion, or 17% of sales.

AUSTRALIA

HISTORICAL PERSPECTIVE

Australia has a land mass of 7,687 thousand square kilometres and is inhabited by a population of 16.81 million, making it one of the most sparsely populated countries in the world. Australia has 2.2 inhabitants per square kilometre. Canada, by comparison, has 2.6 inhabitants per square kilometre.

As a part of the government's decision to liberalize and restructure the telecommunications industry, seven new telecommunications acts came into force in 1991.[89] This legislation coupled with other recent legislation has provided the

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[86] Ibid., 14.

[87] Datapro, "Sweden," IT10-020-501.

[88] Ericsson Annual Report 1990, 4.

[89] APEC Telecommunications Working Group, The State of Telecommunications Infrastructure and Regulatory Environment of APEC Economies (Seoul: APEC Telecommunications Working Group, November 1991), 3.

basis for the introduction of duopoly competition. It is planned that the carriage of telecommunications services will be opened to full competition on July 1, 1997. In 1989, the regulatory functions were handed over to the newly created regulatory authority, AUSTEL.

THE CARRIER INDUSTRY IN AUSTRALIA

In 1990, Telecom Australia, with a staff of 87 thousand, had revenues of $6.9 billion.[90] The revenues of the country's international carrier, OTC, were $1.2 billion. The revenues of AUSSAT, the domestic satellite carrier, were $116 million.

Telecom Australia has traditionally been the monopoly provider of telecommunications services throughout Australia. It also performed the functions of the industry regulator.[91] OTC Limited is now being merged with Telecom Australia. At the same time, the government has selected Optus Communications to be Australia's second telecommunications carrier. Following its acquisition of the country's monopoly satellite carrier, AUSSAT Pty Ltd, from the government on January 1, 1992, Optus was granted the license to compete with Telecom/OTC. With a $1.6 billion investment planned over the next six years to build its network, Optus is committed to having 70% of its capital investment in equipment supply and installation as Australian content.

THE EQUIPMENT INDUSTRY IN AUSTRALIA

In recent years, Australia's telecommunication equipment market experienced significant growth. For 1991, projected revenues amounted to $2.2 billion[92]. The equipment market is dominated by foreign multi-nationals. The most established player is Ericsson, followed by Alcatel. Other companies active in the Australian market include NEC, Hitachi, Fujitsu, GPT, Northern Telecom, Siemens, and AT&T.

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[90] Datapro Information Services Group, "Australia: The Commercial and Regulatory Environment," International Telecommunications, (Delran, NJ: McGraw Hill, Inc., September 1991), IT10-060-204.

[91] Datapro "Australia," IT10-060-201.

[92] Allen Consulting Group Pty Ltd., Australia's Telecommunications Industry: Market Opportunity, Industry Capability and Government Role, Report to the Department of Industry, Technology and Commerce, July 15, 1991, 41.

The only local player of any consequence is Exicom. Exicom began operating in 1986, and since then has expanded its operations to the United States, Europe, New Zealand, Hong Kong, and Taiwan.[93] In 1989-1990, Exicom generated $105 million in revenues worldwide. In 1991, Exicom signed an agreement with Northern Telecom to manufacture Northern's products under license. The products will be sold in the Australian market and exported to countries in the region.

TELECOMMUNICATIONS R&D IN AUSTRALIA

Since July 1989, the Australian government has operated a program that is designed to promote R&D, increase exports, and boost Australian-based production and content in the telecommunications industry.[94] Under the "Industry Development Arrangements" (IDA), equipment suppliers are required to meet specific targets or lose their permits to supply. The IDA is based on a scheme which requires suppliers to achieve a minimum aggregate number of points in each financial year of the scheme.[95] The points are awarded for activities in R&D, exports and Australian production. The scheme applies to telephone sets, PBXs, key systems and cellular phones. The program, which is monitored by AUSTEL, is due to end in July 1993.

Telecom Australia invested $50 million in R&D in 1990.[96] Telecom Research Laboratories (TRL), the largest telecommunications research establishment in Australia, is a unit of Telecom Australia.[97] TRL's research program is derived from the business plan of Telecom Australia. TRL employs a total of 550 people. TRL also sponsors a wide variety of research in institutions such as photonics at the University of Melbourne and advanced mobile communications at the South Australian Institute of Technology. Within the Department of Transport and Communications is the Bureau of Transport and Communications Economics that conducts applied economic research.

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[93] Ibid., IT10-060-206.

[94] Ibid.

[95] AUSTEL: Annual Report 1990-1991, 32.

[96] APEC, State of Telecommunications Infrastructure and Regulatory Environment, 12.

[97] Telecom Research Laboratories: 1991 Review of Activities, 9.

Telecom Australia Product Development Fund was established in 1987 to encourage Australian innovation in the fields of telecommunications and related technologies. Over $5 million has already been spent from the fund to support Australian companies lacking the financial wherewithal to take their product from concept to testing.[98] Beside financial assistance, Telecom Australia also provides expert assistance and advice from its engineers and scientists.

During 1990-91 OTC spent $11.3 million on R&D[99] and the R&D expenditure of AUSSAT Pty Ltd totalled $28.5 million. Optus Communications, the new owner of AUSSAT, has undertaken to boost substantially Australia's R&D capability. One of Optus' major suppliers, NorTel Australia, is a subsidiary of Northern Telecom which plans to establish a Bell Northern Research laboratory at Wollongong University.[100]

CONCLUSIONS REGARDING INTERNATIONAL COMPARISONS

The United States, the Netherlands, Sweden and Australia, the countries that were the primary focus of this chapter, are all undergoing transition. While the United States already allows competition in equipment and long distance markets, its local exchange carriers are also facing competitive challenges from alternative access providers. Sweden, the Netherlands and Australia are also undergoing a major revamping of their telecommunications systems. All these countries allow competition in the equipment markets, and have opened the service industries to partial competition. These developments have implications for telecommunications R&D. Sweden and the Netherlands are positioning themselves for the opening of the European market to competition. Australia, with a less developed equipment market, is concentrating on strengthening its manufacturing capability through intensive R&D.

It is also apparent from the countries studied in this chapter that there is room for only one major manufacturer in each country. In these cases, the large manufacturers also have strong historical or corporate ties to the major carrier. In Sweden, for example, the quasi-integrated relationship between the Swedish Telecom Group and Ericsson has left little room for small or medium sized manufacturers.

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[98] Ibid., 66.

[99] OTC: 1991 Research and Development Annual Report, 24.

[100] OPTUS Communications: The Essential Facts, 12.

6. MODELS FOR MAXIMIZING R&D EFFECTIVENESS

INTRODUCTION

This chapter of the report examines a number of R&D models from the point of view of their effectiveness in bringing about positive results from R&D in the telecommunications field. It begins with a brief discussion of theoretical models of R&D, and continues with an evaluation of a number of models in use in various countries.

While the conventional innovation cycle proceeds linearly from scientific research to development, development to production and production to marketing, there is evidence that collaboration, even with sometimes competitors, and feedback are becoming increasingly critical to the innovative process.

As telecommunications, computer and microelectronic technologies converge, for instance, switch manufacturers enter into joint R&D with computer and microelectronic firms to gain access to complementary technologies. Moreover, as telecommunications technologies continue to share more and more commonalities with computers, it is becoming more difficult for individual firms, even very large firms, to hire and train staff with all the expertise they require. Collaboration can make it unnecessary for the major equipment firms to track all the relevant technological fronts for themselves.[101]

Feedback means interaction among research, development, production, distribution and marketing. It is designed to generate knowledge and understanding about both the technologies and the markets.

Perhaps for these reasons, equipment manufacturers are increasingly turning to joint R&D ventures and strategic alliances. Other reasons for joint ventures and strategic alliances include:[102]

- Companies wanting to integrate their product lines into a system ;
- Companies needing to modify products for use in particular markets, with local know-how required or advantageous;

[101] Harris, "Divestiture and Regulatory Policies," 118-119.

[102] Ibid.

- Production economics or political barriers making local production necessary.

There are considerable benefits of cooperative research, both private and social. Harris identified a number of social benefits of cooperative research, such as:[103]

- Cooperation among competitors may solve problems of leakage of the results of R&D;
- There are economies of joint research, such as economies of scale, synergism or complementarities among participants, avoidance of duplication, and risk sharing.
- Cooperatives treat knowledge as a public good, at least among members, which guarantees diffusion of the results of R&D and thereby increases the return on R&D.

Alliances and cooperation can be realized in a number of ways. The rest of this chapter describes and analyzes R&D models which are currently in use in the telecommunications industry.

R&D MODELS IN THE TELECOMMUNICATIONS INDUSTRY

This chapter examines three models for R&D:

- The Vertical Integration Model
- The Aggregation of Carrier Resources Model
- The Pre-Competitive Collaboration Model

In order to determine the effectiveness of each model, examples of each are examined with respect to a number of variables, such as levels of spending, sources of funding, nature of research, and so on. It should be noted, however, that most of the information in this chapter came from public sources. Given the competitive nature of the industry, information on R&D tends to be guarded closely, and therefore the extent of quantitative information is quite limited.

[103] Ibid., 114.

THE VERTICAL INTEGRATION MODEL

The examples of vertical integration examined are Bell Canada - Northern Telecom and the Bell System (AT&T). Since the AT&T vertical integration both preceded and is related to the Bell Canada - Northern Telecom vertical integration, it is discussed first.

THE BELL SYSTEM

Bell Telephone Laboratories, Inc. (Bell Labs) operations date back to January 1, 1925 when it began functioning under the joint ownership of AT&T and Western Electric Company.[104] As originally envisaged, the objective of Bell Labs was to conduct fundamental research for the Bell System, and design equipment for manufacture by Western Electric Company. At the same time, AT&T separately operated its own Department of Development and Research. In 1934, this department was merged with Bell Labs to centralize the R&D operations for the entire Bell System.[105]

Until the Modified Final Judgment (MFJ) in 1984 resulted in the divestiture by AT&T of the Bell Operating Companies (BOCs), Bell Labs served the interests of the entire Bell System. AT&T was characterized as a national resource in view of its outstanding accomplishments in research. At the time of divestiture, however, part of Bell Labs was split off into a separate research entity, Bellcore, in order to serve the research, development and engineering needs of the Regional Holding Companies (RHCs). As a result, the divested AT&T retained a reduced version of Bell Labs.

The breakup of Bell Labs as part of the divestiture led to the establishment of three separate telecommunications R&D groups. They are:

- AT&T Bell Labs
- Bellcore
- The independent research efforts of the Regional Holding Companies (RHCs)

The first of these continues to be an example of vertical integration, since AT&T Bell Labs serves the interests of AT&T's service and manufacturing divisions.

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[104] Noll, "Bell System R&D Activities," 164.

[105] Ibid.

It is discussed below. Bellcore, however, is an example of the aggregation of resources model and is therefore discussed later in this chapter under that heading. For completeness, the independent research efforts of the RHCs is discussed at the same time.

AT&T Bell Labs

Divestiture allowed AT&T to retain its profitable long-distance business, albeit in a competitive milieu. Divestiture also permitted AT&T to enter computer and other high tech businesses. These developments have put competitive pressures on AT&T.

Complementary to the split of Bell Labs, the R&D facility reorganized its operations internally. Researchers and development specialists were integrated into the operations of the company by streamlining R&D activity along the lines of its business operations. This decision was designed to overcome a limitation in Bell Labs' operations, namely its failure to exploit research results at the product development and commercialization stages. Moreover, there appeared to be concern within the AT&T marketing department over the lack of prompt responsiveness on the part of Bell Labs.[106] Under the new arrangement, the heads of business divisions assumed authority for managing the design and development of products.

Prior to divestiture, the BOCs were a major source of financial support for AT&T's R&D. These companies licensed the patents held by AT&T, and paid license fees to support R&D activity at the Bell Labs. The operating companies paid 82% of the research and systems engineering work performed at Bell Labs before divestiture. Divestiture, therefore, produced concerns that the loss of contract license fees from the BOCs would deprive Bell Labs of the secure revenues needed to support pure research.[107]

As a quid pro quo for divesting the operating companies, AT&T received permission to be able to enter new high-tech businesses. This meant that AT&T would invest heavily in research to assure the creation of these new business opportunities.

While AT&T has declined in size, its R&D expenditures have increased since divestiture. As Harris points out, AT&T's research budget soon after divestiture was

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[106] Ibid. 163.

[107] Harris, "Divestiture and Regulatory Policies," 108.

$3 billion compared to $2 billion before divestiture.[108] Noll speculates that AT&T may be overspending on R&D in comparison with the R&D expenditures of comparable firms. In fact, AT&T's total R&D spending has shown a decline in more recent years to $2.7 billion in 1989 and $2.4 billion in 1990.[109]

Harris contends that an intensive R&D effort is crucial to sustaining AT&T's competitive advantage for countering both foreign competitors and meeting the RHCs' challenge if and when they are allowed into manufacturing. There are fears, nonetheless, that competitive pressures may force AT&T to devote a larger share of R&D to product development and less on long-term research.

The company is also tending to be more secretive and proprietary about its research. For instance, AT&T did not release the details of the "Karmarkar" algorithm for linear programming since it was considering the development of commercial products based on the algorithm.[110] This type of protective publication will probably increase in future. The discontinuation of the "Bell System Technical Journal" is another illustration of AT&T's policy to restrict the publication of R&D results.

The company's licensing policy has also undergone changes as a result of the MFJ. The MFJ required AT&T to issue licenses to the BOCs on its existing patents, but on new patents, the MFJ required licensing for only five years from the date of divestiture.[111] Moreover, AT&T is no longer required to license its patents to non-RHCs since the MFJ lifted that requirement of the 1956 Consent Decree. AT&T now treats patents as assets, and grants licenses only when doing so would serve to promote its business.

However, Bell Labs has not lost its standing as a world class research facility. For instance, in terms of patents, publications, employment, budget, and research climate and composition, there have been no dramatic changes at Bell Labs since divestiture.

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[108] Ibid.

[109] AT&T : Annual Report 1990, 25.

[110] Noll, "Bell System R&D Activities," 166-167.

[111] Harris, "Divestiture and Regulatory Policies," 108-109.

According to Crandall, total research and development spending by AT&T and the BOCs is now a larger share of total revenues than before divestiture.[112] The number of people employed in conducting R&D has increased as well. Moreover, divestiture encouraged competitive equipment manufacturers and had a positive effect on technological innovation in the telecommunications industry. Western Electric was the instrument for transferring technology between Bell Labs and the operating companies, and there is substantial evidence that exposing Western Electric to competition has had far more important and positive impacts than the divestiture of the BOCs.[113] However, while divestiture eroded AT&T's position as a supplier to the RHCs, it did not provide significant benefits to local telecommunications manufacturers. Harris contends that foreign equipment manufacturers gained the most from divestiture.

Post-divestiture, AT&T has been subject to more competition. It therefore wants to diversify by entering other new business areas. Thus, the research performed at AT&T Bell Labs has become more proprietary to AT&T. Bell Labs is much more attuned to the narrow interests of AT&T and its equipment customers. Consequently, the role of AT&T Bell Labs as a national telecommunications R&D resource has diminished. To some extent, Bellcore has inherited the role of assuring the future of telecommunications in the United States and it may also assume the role of a new national resource in communications-related R&D.

BELL CANADA - NORTHERN TELECOM

The relationship between Bell Canada and Northern Telecom has been subject to regulatory scrutiny since 1926 and throughout that time has been found to be in the public interest. However, some years ago, the Director of Investigation and Research, Combines Branch, of the Department of Consumer and Corporate Affairs initiated an inquiry into the relationship between Bell and Northern.

By the time this thorough inquiry reached the Restrictive Trade Practices Commission (RTPC), Northern had embarked on its expansion program and Bell no longer accounted for the bulk of Northern's sales. Nevertheless, a good deal of evidence was presented by the two companies concerning the tangible benefits that

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[112] Robert W. Crandall, "The Evolution of Telecommunications Regulation in the United States," in From Monopoly to Competition: Telecommunications in Transition, ed. Jan Fedorowicz (Mississauga, Ontario: Informatics Publishing Inc, January 1991), 118.

[113] Ibid.

had flowed and would continue to flow from the relationship and their joint ownership of Bell-Northern Research. At the end of the proceeding, the Commission found no cause for action to change the relationship.

As noted in the proceeding, a major benefit for Northern is that its close relationship with a major carrier ensures that most of its research and development is market driven. Specifications for new products or systems can be drawn up which incorporate the carrier input, and close interaction between the developer, manufacturer and potential customer can continue through every stage of the development. The development work can thus proceed with the certainty of an assured market for the product.

Today, Northern has many other large customers, and is able to spread its development costs over a much larger customer base. For example, Northern could never have undertaken the development of digital switching if it were dependent on recovering the costs from sales within Canada. However, the relationship with Bell is no less important, because carrier input remains an essential ingredient of the development process, not only with respect to Bell's own requirements, but also for other markets. Bell also acts as a test bed for Northern products, which gives other potential Northern customers the assurance that the product has been thoroughly tested.

The RTPC Hearing also heard evidence on how Bell and, indirectly, its subscribers benefit from the relationship. Bell's input to the development process tailors the product to carrier needs, taking into account technology, performance and cost considerations. Planning for the introduction of major new systems or services is also facilitated when the carrier has hands-on access to the development process and is assured of delivery on time, to specification, and at the agreed price.

Both parties benefit from the relationship which functions as a meeting ground between the "technology push" of the research process and the "market pull" of the carrier and its subscribers.

It might be that Bell's influence over Northern's product development will decline over time as Northern seeks to further expand its offshore markets and attract new customers. However, it is certain that, in the past, the relationship has been a major factor in Northern's success, and it is likely to remain an essential link in the research and development chain for the foreseeable future. Moreover, there are valuable lessons to be learned from the relationship which might assist in the development of mechanisms to increase the level of effective R&D in Canada. Those lessons include the fact that knowledge of the market, access to markets, the

availability of a test bed and long term supply agreements are all important factors in maximizing the effectiveness of R&D.

THE AGGREGATION OF RESOURCES MODEL

Examples of the aggregation of resources model are at the national level are Bellcore and the joint R&D efforts of Stentor, soon to be managed by Stentor Resource Centre Inc. International examples of the aggregation of resources model are INTELSAT and INMARSAT. In the context of this study, national models have more significance than international models, and therefore the international models are not discussed further.

In both Canada and the U.S., the carriers pursue their own R&D as well as participate in joint efforts. Much information has been published by academics and researchers about Bellcore and its R&D efforts; in contrast, we are not aware of any published studies of Stentor's R&D programs. The only information obtained during the study regarding the Stentor jointly-funded R&D program was obtained during confidential interviews with individual members of Stentor, and cannot be reported here. For this reason, only Bellcore is discussed as an example of this model.

BELLCORE

Bellcore's Technical Services conducts research, technical operations (such as network planning and software development), and standards development. Bellcore considers all of its research to be applied research.[114] The non-technical activities of Bellcore at one time included market research, but now that no longer appears to be the case. In addition to providing technical and marketing services to RHCs, Bellcore's mission, as mandated by the MFJ, is to serve as a single point of contact for national security and emergency preparedness.[115]

Bellcore's projects can be divided into four segments.

- Network: Constituting 31% of Bellcore's current budget, the network operations are geared toward developing new architectures, meshing networks with international standards, and specifying generic requirements for switching and terminal equipment for manufacturers.

[114] Noll, "Bell System R&D Activities," 175.

[115] Ibid., 174.

- Integrated operations: With 46% of Bellcore's current expenditures devoted to this segment, integrated operations involves the development of software systems to mechanize telephone company operations, to control networks, and to streamline internal operations. By making the operations cost-effective, the telephone companies hope to minimize operating costs and enhance competitiveness.

- Services: Only 8% of Bellcore's current expenditures are on services, which includes technical training as well as the national emergency preparedness function.

- Applied Research: This constitutes 15% of total current Bellcore expenditures. Applied research encompasses network services, information services and underlying architectures.

Bellcore undertakes two kinds of projects:

- Core projects: These projects generally benefit all the RHCs equally. To proceed, a core project must have the approval of at least five RHCs.[116] Once approved, these projects are funded equally by all seven RHCs. About one-third of Bellcore's budget is devoted to core projects. These projects primarily involve infrastructure work. This includes most of the applied research as well as standards, network architecture and generic requirements.

- Client projects: These projects are specific to one or more RHCs who must sponsor these projects. These projects generally entail about two-thirds of Bellcore's expenditures.[117] These elective projects are market-focussed and service-oriented, and are primarily designed to meet the special requirements of RHCs. Often, as many as six RHCs might be participating in an elective project. The amount of one-on-one work for individual companies is fairly small.

Some of the unique advantages that Bellcore offers the RHCs include the following:

[116] Ibid.

[117] Harris, "Divestiture and Regulatory Policies," 109.

- Economies of shared resources
- R&D that is tightly coupled to their needs
- Standards for equipment for a major portion of the U.S. market

In a 1990 article, Harris pointed out that Bellcore's budget accounted for 1.3% of the total revenues of the BOCs.[118] Harris compares it with British Telecom and NTT's R&D spending of 1.7% and 1.9% of revenues respectively. As shown in Table 4, 1990 R&D spending as a percentage of revenues for British Telecom and NTT was 1.9% and 4.1% respectively. Both British Telecom and NTT are common carriers with little direct involvement in telecommunications equipment manufacturing, although unlike, the RBOCs, both have "quasi-integrated" relationships - including joint R&D ventures - with domestic telecommunications equipment manufacturers.

When the R&D expenditures of the RHCs and AT&T as a percentage of sales are compared, the RHC expenditure level is only 20% of the AT&T level.[119]

A substantial portion of the RHCs R&D expenditures is spent on ensuring compatibility through standardization.[120] Harris contends that divestiture has imposed an enormous cost that was unnecessary in an integrated AT&T. In the absence of Bellcore, the RHCs would have had considerable problems in coordination and communication.

Bellcore makes recommendations on design specifications and standards to the RHCs, but these recommendations are not mandatory. Since Bellcore and RHCs are prohibited from developing or manufacturing telecommunications equipment themselves, Bellcore can only specify the criteria or design standards for outside vendors' equipment.[121]

Bellcore works with the American National Standards Institute to establish and maintain industry-wide telecommunications network connection standards. The development of uniform standards for multiple vendors ensures compatibility within and across local operating systems. Bellcore issues Technical Advisories and Techni-

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[118] Harris, "Divestiture and Regulatory Policies," 111.

[119] Ibid.

[120] Ibid., 114.

[121] Ibid., 111.

cal References and conducts "Technical Requirements Industry Forums". Bellcore also acts on behalf of the seven RHCs in international standards setting activities.

R&D ACTIVITIES OF THE REGIONAL HOLDING COMPANIES

Until recently, Bellcore alone handled virtually all the R&D activity of the RHCs. The focus of the R&D is network and access services, areas that are directly relevant to basic telephony. The RHCs traditionally have not been involved in any substantial in-house R&D themselves. However, the RHCs are increasingly getting involved in proprietary and in-house R&D. The reason for this trend is the RHC's changing perception of R&D:

- They need their own research capability, if only to measure, monitor, and decide whether to fund Bellcore activities.

- They can conduct some types of R&D more effectively themselves. For instance, Project Victoria, a prototypic integrated services technology, was designed and tested by Pacific Bell in-house.[122] Similarly, Pacific Bell chose to develop its own system, rather than fund Bellcore's Trunk Integrated Records Keeping System.

- There are inherent problems in collective decision-making including potential disagreements over which projects to fund and for how much.[123] According to Harris, for instance, US West has argued that Bellcore research should reflect growing rivalry among RHCs by undertaking more proprietary research.

- It would be difficult to conduct shared and common R&D in areas where RHCs are competing against one another. The RHCs have formed unregulated subsidiaries to expand into new business areas. As the RHCs compete in more markets and attempt to differentiate their products from each other, their need for proprietary R&D will increase.

At the time of divestiture, the RHCs had a mutual interest in developing a collective research, development, standardization and testing facility. By spreading

[122] Ibid., 110.

[123] Ibid.

the cost of such a facility over the seven owners, they could realize significant economies of scale and scope. In recent years, however, the RHCs have increasingly become competitors, particularly in non-regulated lines of business such as marketing telephone equipment and providing cellular service. As the BOCs branch out in new directions, the RHCs are likely to directly compete in more markets. As a result, they are likely to be more secretive about their R&D. This may cut Bellcore out of top-priority projects. Each of the RHCs could be wary of leaving the development of key, competitive technologies to an agency it does not directly control. This may reduce the social benefits of widespread diffusion of the results of the research conducted at Bellcore. Most of the RHCs are already developing in-house R&D capabilities. Examples include:

- NYNEX plans to create an internal R&D organization of about 350 people, including a small applied research group of 35, mostly software related.

- Pacific Bell has a small group of people who track and assess technologies considered important for the future business of the company. Pacific Bell sponsors a modest amount of research in focused areas of interest at California universities.

- US West plans to create a small internal R&D organization, somewhat similar to that planned for Nynex. Moreover, the company is providing $1.2 million in university grants for R&D in key technologies.

- Southwestern Bell has announced the creation of its own R&D group to generate needed proprietary research to support new, competitive businesses ventures.

Bellcore too is shifting its efforts from core projects shared by all seven RHCs to proprietary, client-oriented R&D. It has declared that more regional-specific work will be committed, executed and delivered to satisfy separate RHCs. It seems that Bellcore will eventually assume the role of a contract research lab, which will compete with the RHCs internal labs, private concerns and universities for R&D projects.

Due to line-of-business restrictions imposed on them, the BOCs are prevented from involvement in manufacturing. Harris contends that the restriction decreases the incentive for RHC investment in R&D by curbing their ability to benefit directly from the results of any R&D the implementation of which involves any manufacturing. As discussed earlier, vertically integrated structures such as those which could

result from permitting the RHCs to enter the manufacturing business can be successful models for maximizing the effectiveness of R&D.

The BOCs have been successful in their bid to have the restriction on the provision of information services lifted, and appear closer than ever before to being allowed into manufacturing.[124] At the first session of the 102nd Congress, the legislation to lift the manufacturing restrictions had overwhelmingly passed the Senate, while similar legislation was being considered by the House of Representatives.

According to Harris, it is unlikely that when the line-of-business restrictions are lifted, the RHCs would become heavily involved in manufacturing. However, they are likely to get involved in collaborative research and joint ventures with equipment manufacturers. The removal of the restriction is, therefore, likely to generate a high level of joint R&D.

Bellcore is not itself regulated as a common carrier, but its budget is subject to regulatory scrutiny by the state public utility commissions (PUCs). This puts limitations on RHCs. In California, for example, the Public Staff Division proposed disallowing $30 million of Pacific Bell's roughly $100 million contribution to Bellcore. Similarly, a National Association of Regulatory Utilities Commissioners study raised questions about $115 million of operating company support for Bellcore, contending that the primary beneficiaries of Bellcore applied research are equipment manufacturing companies.

The aggregation of resources model is most applicable where the participants are in the same line of business, but do not compete with one another due to the fact that they operate in different markets. This is the case for carriers like the BOCs and Stentor members.

The aggregation of resources model has some advantages for its participants. They can share the costs of jointly funded R&D. Since they do not compete directly with one another, they can also share fully in the results. However, in terms of providing the participants with market knowledge and access to markets, the aggregation of resources model would not seem to be as effective as the vertical integration model discussed earlier or the pre-competitive collaboration model discussed below. The participants are serving geographically different but otherwise similar markets, and it is likely that they all have similar knowledge of the markets they serve.

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[124] D.A. Ford and Associates, "Recent Events in U.S.," Issues in Telecommunication Policy and Regulation, Issue 10, February 1992, 1-3.

THE PRE-COMPETITIVE COLLABORATION MODEL

Two examples of the pre-competitive collaboration model were considered during the study. The first is the Canadian Vision 2000 Program. The second is the RACE (Research and development on Advanced Communications in Europe) program of the European Economic Commission.

VISION 2000 INC.

Vision 2000 Inc. is a non-profit private- and public-sector partnership that came into existence as a result of a federal government initiative. The original goals of Vision 2000 were to foster collaboration in R&D, to accelerate innovation in communication and information technology, and to introduce new products and services to world markets[125].

Working closely with DOC and other government departments and agencies, Vision 2000 has proposed a strategy and action plan which identify seven project areas. The earlier projects focus on improved utilization of existing technologies and facilities, while the remaining projects emphasize the implementation of systems that depend on improvement in capability and cost for new technologies and capital investment. These projects range from national systems for the interchange of text and video images, through improved mobile systems, to multimedia and video, security and network personalization and future bandwidth.

According to Vision 2000, Canada has only 4% of the world's telecommunication equipment market, and without effective action, this share could be cut in half by the year 2000[126]. Except for Northern Telecom, Canadian suppliers are mid-sized and small. Their competitors on the world market are larger, have greater financial resources, have greater access to large markets and, in most cases, are better supported by their governments. Vision 2000 hopes to resolve some of these disadvantages of size and resources through cooperation and collaboration among participants of all sizes.

The main difference between Vision 2000 and the RACE Program is that the extent of government funding in the RACE Program is much higher. However, there

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[125] Vision 2000 Inc. "Networking the Global Village: A Framework for the Evolution of Personal Communications in Canada," Vision 2000 Inc., 14-17.

[126] Ibid., 3.

is a potential problem with the extensive EEC funding of the RACE program and other similar EEC initiatives in that such funding may well be found to constitute a subsidy which contravenes the General Agreement on Tariffs and Trade (GATT).

RESEARCH AND DEVELOPMENT ON ADVANCED COMMUNICATIONS IN EUROPE (RACE)

The RACE program, which is a major telecommunications initiative of the EEC, began with a definition phase in 1985. The purpose of the definition phase was to plan a major programme of consultation, standards and technology R&D.[127] The first phase of the main RACE program began in 1988. It is focusing on the development of Integrated Broadband Communications (IBC) and the development of technology for the introduction of commercial IBC services in Europe in 1995.

CRITERIA FOR COLLABORATIVE RESEARCH

RACE uses the following process in establishing and conducting collaborative research (It terms them "Criteria related to implementation of collaborative research"):

"
- The cooperation of the sector actors in the definition of the action;
- The value of open competition for the realization of the work;
- The value of horizontal and vertical collaboration;
- The value of sharing of R&D work and results."[128]

The RACE effort is considered to lie between basic research and market-oriented development. In the opinion of DG XIII, it creates opportunities for innovation in product design, development and manufacturing.

SCOPE OF THE RACE PROGRAM

The total cost of the program is over ECU 1.1 billion for the five year period from 1988 to 1992. The costs are shared equally between the participants in individual projects and the EEC. The process followed is to call for proposals and to enter into contracts with consortia for the conduct of individual projects.

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[127] Communications Technologies and Applications in Areas of General Interest, DG XIII, Direction F Programmes and Plans, September 1991.

[128] Ibid.

To encourage collaboration between different types of organizations and between different EEC member countries, at least two partners must participate in projects. They must be independent and must be based in different EEC countries. Organizations in European Free Trade Association (EFTA) countries are allowed to participate, but they must also then contribute to general administrative costs.

Since 1988, the RACE program has let 86 contracts involving 330 organizations. Within the EEC, 11 PTTs, 91 universities and research organizations and over 230 companies are involved. Major U.S. companies which are established in Europe, such as IBM and AT&T, also participate, but the work must be done in Europe.

The pre-competitive collaboration model has advantages and disadvantages compared to the vertical integration and aggregation of carrier resources models. The main disadvantage is that, since pre-competitive collaboration often involves collaboration among direct competitors, the scope of jointly-funded activities is quite limited, and there is a reluctance to share knowledge and findings with competitors. At the same time, if the collaborators represent a broad range of roles within different parts of the industry, they may be able to benefit mutually by sharing their unique perspectives on the markets they serve. If, as was the case in the two examples described above, the pre-competitive collaboration model includes both manufacturers and service providers, the process might also assist manufacturers in gaining access to the markets.

CONCLUSIONS

It appears that the major benefits of all the telecommunications R&D models currently in use is to share information. Some of the information shared is related to technologies. However, much of the information shared is about the market - its needs and its trends.

With respect to the advantages and disadvantages of the various models examined, our conclusions are as follows:

- The vertical integration model provides many advantages in terms of market information and market access for the vertically integrated firms, but the corollary is that outsider manufacturers have little opportunity to access the market served by the vertically integrated supplier.

- The aggregation of carrier resources model results in an efficient sharing of the results of jointly-funded R&D, but provides limited benefits in terms of market knowledge or market access.

- The pre-competitive collaboration model has limited scope due to the participation of direct competitors, but can provide real benefits in terms of market knowledge when the participants cover a broad range of different roles in the market. The involvement of service providers can also assist manufacturers in obtaining market access.

Perhaps the conclusion of this chapter can be most usefully summarized in terms of an observation made during an interview with a representative of a major Canadian firm. This individual noted that while it might be more efficient for the firm to conduct all its R&D in one location, the reason why it is important to decentralize R&D is so that they will know what to do. An intimate knowledge of the market is the key to knowing what to do.

The information gathered during this study does not provide a basis for deciding which of the models discussed above is most effective in ensuring that the positive results of R&D are realized. In fact, it is not necessary to do so, because it will be readily apparent to the reader that each model plays a different role in providing telecommunications carriers and telecommunications equipment manufacturers with information about the technologies and the markets over and above what they can obtain through their own resources.

It is therefore obvious that an individual firm should access these resources to the maximum extent possible, given the resources available to do so. Vertically integrated manufacturers participate in pre-competitive collaborative research efforts with other firms with which they are not integrated, and vertically integrated carriers are also involved in aggregating their resources. The reorganization of Telecom Canada, including the creation of Stentor Resource Centre Inc., could be interpreted, among other things, as indicating an increased need for such aggregation of resources.

In the next chapter, we develop and discuss a number of alternatives for the government to assist in the telecommunications R&D process.

7. ALTERNATIVES REGARDING TELECOMMUNICATIONS R&D IN CANADA

INTRODUCTION

This chapter begins with a review of global telecommunications industry trends and their implications for Canada. It then proposes and evaluates a range of alternatives which are designed to increase the effectiveness of telecommunications R&D in Canada, taking into account the changing structure of the industry and its objectives. It ends with conclusions with respect to the most promising alternatives.

TELECOMMUNICATIONS EQUIPMENT MARKET TRENDS

From the preceding discussion and our interviews it is possible to form some conclusions as to the major trends which are shaping the future direction of the telecommunications manufacturing sector:

- The major costs of developing switching and transmission systems are forcing a rationalization of manufacturing in most European countries. International alliances are now being developed which could result in only two major European manufacturers by the turn of the century.

- The enormous U.S. market for telecommunications equipment generated by the seven Regional Bell Holding Companies will support at least one additional supplier on the scale of Western Electric's successor, AT&T Technology. Northern Telecom has partially assumed this role but in the longer term it is likely that the RHCs will be authorized to establish manufacturing subsidiaries. Whether the entry of the RHCs into manufacturing will help or hurt Northern Telecom will depend on the extent of Northern's alliances with the RHCs.

- Europe, North America, and Japan are the only markets which can support more than one major manufacturer of switching and transmission equipment.

- It is unlikely that there will be exports of telecommunications switching and transmission equipment between the three major trading blocks in the foreseeable future. Competition will focus on Third World markets.

- Major manufacturers can only achieve significant penetration of the domestic markets of their international competitors by establishing manufacturing facilities in the host country.

- Northern Telecom's domination of the Canadian market is not peculiar to Canada. In countries with a large demand for telecommunications, the pattern has been one dominant supplier or the allocation of the market to a few suppliers, each making essentially the same equipment. The result in these countries has been to inhibit the growth of small suppliers. The situation is exacerbated in Canada because the domestic market is small.

TELECOMMUNICATIONS SERVICES MARKET TRENDS

Similarly, drawing on our research and carrier interviews, it is possible to form some conclusions as to the major trends which are shaping the future direction of the telecommunications service sector:

- To promote competition, some countries have licensed additional facilities-based carriers and value added carriers.

- Many countries now permit the connection of customer provided equipment to carrier networks.

- The introduction of domestic competition in the provision of services is encouraging the new carriers to seek alliances with new carriers in other parts of the world. In this way, the new carriers can compete with the traditional carriers in the provision of international services.

DISCUSSION OF INDUSTRY TRENDS

In countries where competition has been introduced, the result has been increased innovation and the introduction of new services. However, most of the new carriers are essentially providing the same new services as the traditional carriers, using in most cases the same types of equipment.

A few years ago, the opening of the terminal equipment market in North America spawned a number of new manufacturers of terminal equipment, but the traditional manufacturers soon responded with new designs and have regained their dominance of the major markets, such as those for PBX equipment. The new

manufacturers that entered the market have, for the most part, disappeared. Smaller items of terminal equipment such as telephone sets, facsimile and answering machines are rapidly becoming consumer electronics products and many are manufactured in Third World countries, often under traditional manufacturer labels.

In summary, a major consequence of the introduction of competition at the carrier and services level has been to galvanize the traditional manufacturers into action to preserve their existing markets and to serve the new markets created by the competition. It has been predicted that by the year 2000, more than 50% of telecommunications equipment will be purchased by non-carriers. However, the traditional manufacturers' aggressive pursuit of new customers indicates their intention to ensure that their overall market share will be maintained.

The overall conclusion that emerges from the above trends is that the design, development and manufacture of telecommunications equipment is for the most part carried out by very large firms and it is expected that this trend will continue. Regardless of the industry structure, the major requirements of the carrier industry can only be met by large integrated firms. Even large integrated telecommunications manufacturers are seeking strategic alliances with other large firms outside the telecommunications industry - in the computer industry, for example. In the major areas of the telecommunications manufacturing industry, only the largest suppliers will survive. Successful small firms will be those which concentrate on specialized niche markets.

As a consequence, it is evident that the introduction of competition among carriers and the trend towards multiple service providers has provided only limited opportunities for the majority of small and innovative manufacturers. As noted earlier, many of the new service carriers provide services similar to those offered by the traditional carriers, using similar equipment which they purchase from the traditional suppliers. New services suppliers are unwilling to take a chance on unproven technology for major systems. As a consequence, the smaller suppliers are left to serve the niche portion of the new services market, with all its attendant difficulties. The niche market for leading edge services is even more precarious than an established market. The niche player takes all the risks in developing equipment and in some cases pioneering a new service. If these products or services are successful, the traditional manufacturers often enter the market, thereby creating a difficult competitive situation for the small suppliers.

In the telecommunications service industry, there are significant barriers to entry for facilities-based carriers. The extent of the regulatory proceedings which Unitel experienced in its attempts to compete with the established carriers in data services in the late 1970s, and more recently in terms of voice services, demonstrate

the regulatory barriers to entry. Even when entry is permitted, the capital required to become a facilities-based carrier is a major impediment to many firms.

The resale for joint use of private line voice services, approved in Ontario, Québec and British Columbia in 1990, is a limited form of competition. The extension of resale to other parts of Canada is still under consideration by the regulator. Under certain circumstances, the resale of international private lines to provide international telephone service is also permitted.

R&D in the telecommunications services industry does not often lead to the same direct economic benefits as are found in the telecommunications manufacturing sector. While the development of new telecommunications products by the manufacturing sector leads to additional investment in plants and facilities, increased employment, and increased product exports or decreased imports, many of the developments in the telecommunications service industry lead to improved efficiency in the provision of services, which tends to have a negative impact on employment levels and investment. However, the economic benefits from such increased efficiency are realized in different ways. First, traffic which had used non-conventional routings will tend to be repatriated by Canadian domestic and international carriers, which means reduced imports of telecommunications services. Second, there will be an increased probability of foreign traffic using Canadian facilities, which means an export of telecommunications services. Third, and most important, increased efficiency in the provision of telecommunications services, when it results in lower rates for users, improves the competitiveness of Canadian industry for which telecommunications expenses are a significant cost of doing business. The economic benefits of much of the R&D in the telecommunications service industry, then, are realized indirectly through the resulting lower costs of telecommunications services to business users.

R&D by the telecommunications service industry can also result in the development of new and innovative telecommunications services. Then the economic benefits are realized both directly by the carriers and indirectly by the users. New services will often result in increased investment and employment, and increased exports and reduced imports in the manner described above, and the users as well will benefit from the availability of new services. Business users, relying heavily on telecommunications will improve their competitiveness not only through lower telecommunications costs but also through the use of new, more efficient and more versatile telecommunications services.

IMPLICATIONS FOR TELECOMMUNICATIONS R&D IN CANADA

The trends discussed above confirm that, over the time frame contemplated by this study (up to the year 2000) and probably beyond, the telephone companies the world over will remain the major market for telecommunications equipment. Moreover, despite the introduction of competition and the visionary predictions regarding potential new services, the telephone companies and their traditional suppliers will continue to influence the evolution of telecommunications technology and systems, including the equipment requirements of new carriers.

The continued dominance of the world market for telecommunications equipment by the traditional manufacturers suggests that the first consideration in developing an R&D strategy for Canada is the role of Canada's world scale supplier, Northern Telecom. In reality, the Canadian domestic market cannot now and never could support a competitive world class telecommunications manufacturer. Initially, Northern Telecom became the dominant manufacturer in Canada because of its privileged status as a Western Electric branch plant. Northern's later development as a world class manufacturer came about through its ability to develop and manufacture products that compete in international markets.

The rationalizations and mergers of manufacturing operations taking place elsewhere provides evidence that the costs of entry into the design and manufacture of large scale digital switching and transmission systems are so high as to preclude the entry of a second major Canadian company. It is therefore necessary, as the first element of a telecommunications R&D strategy, to accept that Northern Telecom is in a class by itself, and thus deserving of a strategy for itself. Fortunately, this strategy is in place and largely of Northern's own making. As an example, in recent years Northern has eschewed government R&D grants and programs but has campaigned for more favourable tax treatment of R&D spending and for incentives that reward success.

For the purposes of this study, it is assumed that Northern is well qualified to present its point of view on future government policies that might be required to meet its unique requirements, and that it will continue to make the R&D expenditures needed to maintain its dominant position. Accordingly, and in view of Northern's demonstrated record of success, we conclude that it would be presumptuous for this report to recommend an R&D policy for Northern. A more important concern for government is to ensure that Northern does not further shift its base of decision-making from Canada to the U.S. The environment created by the Canadian government for Canadian-based global corporations like Northern will have a major impact on Northern's decisions in this regard. The environment, in this context,

means the fiscal environment, the availability of a qualified workforce, suitable training benefits, etc.

In terms of R&D in the remainder of the telecommunications manufacturing sector, it is important to examine in more detail some of the reasons for Northern's success, with a view to determining if mechanisms can be developed to enable smaller Canadian manufacturers to emulate this success.

For the telecommunications service industry, it is appropriate to examine in more detail the appropriate relationship between the carriers and the smaller manufacturers, as well as the appropriate government policy with respect to R&D in the telecommunications service industry itself. But first we will examine the effectiveness of R&D in the telecommunications sector.

EFFECTIVE R&D

Among the objectives of this study are "to analyze options which maximize the effectiveness of R&D", and "to develop options to encourage appropriate levels of R&D by carriers, equipment manufacturers, universities and governments".

Our research confirms that R&D expenditures in telecommunications by Canadian firms compare favourably with those of most developed countries when the problems of definition are taken into account. It is also evident that the overwhelming proportion of the dollar amount of this R&D is conducted by one corporate group (Bell/Northern/BNR) and that, in terms of marketplace success, this R&D is indeed effective. By the same measure, it is equally evident that research carried out by the majority of smaller manufacturing firms, while representing in some cases a proportion of their revenues which is as high as or higher than that of Northern, is less effective in terms of marketplace success, particularly in the Canadian market.

For the owners of a small firm, there is nothing glamorous about R&D. It is an expense, but an expense unlike any other, since it is both necessary to the growth of the company and increasingly fraught with risk and uncertainty. To offset the risks, a number of government programs provide grants and loans to assist small companies, and the government itself undertakes R&D which is often handed off to the private sector. Several provincial carriers have worked with smaller or nascent manufacturers within their provinces by providing support for R&D activities. All of these initiatives have had mixed and, on the whole, somewhat disappointing results. There seems to be a general consensus that the root cause of the ineffective R&D performance of most small firms is <u>not</u> a lack of money, and

that more money for R&D does not of itself mean more effective R&D, or the creation of large and successful firms.

As noted earlier, despite the introduction of competition, the major market for telecommunications equipment is, and will for some time remain, the telephone companies. Canadian manufacturers other than Northern are small and struggling because they have never been integrated into the telephone company market in the same way that Northern has. If we accept from the Northern example that effective R&D requires close cooperation between the carrier (customer) and the manufacturer (supplier), this helps explain why many of the R&D initiatives undertaken by the government in support of small firms and much of the R&D performed by small firms has not been effective.

To address the problem of market access, some supplier groups proposed to the Restrictive Trade Practices Commission that Bell Canada should be required to seek competitive bids for its equipment purchases. The RTPC rejected that proposal. In any event, it became obvious from the proceeding that the most likely beneficiaries from such a negative policy would have been large foreign manufacturers whose own domestic markets were effectively closed to Canadian suppliers. There is no reason to believe that this situation has changed for the better, since there are still no domestic suppliers capable of mounting a serious challenge to Northern.

More positive initiatives are required to promote the effective R&D required to sustain the continued growth and development of Canadian manufacturers. In the next section of this report we review a number of mechanisms which could be developed to meet this goal. No single initiative is startlingly new or original. However, taken together they might assist in determining the role of the government, the carriers, manufacturers, and universities in effective research and development. All of the options start from the premise that the essential ingredient for successful and effective R&D is access to markets.

ALTERNATIVES FOR INCREASING THE AMOUNT AND EFFECTIVENESS OF TELECOMMUNICATIONS R&D IN CANADA

In this section, we discuss various alternatives for increasing the amount and effectiveness of telecommunications R&D in Canada. These alternatives are then evaluated in the next section.

It was established in the previous chapter that the most significant issue is not the R&D model itself, but the way in which the R&D model is developed,

implemented and funded. Alternatives for increasing the amount and effectiveness of telecommunications R&D in the Canadian context are discussed under the following headings:

- Vertical Integration
- Carrier Cooperation with Smaller Manufacturers
- Quotas for R&D Expenditures
- Access to Other Markets
- Product Mandates

It should be emphasized that the alternatives developed in this section are not mutually exclusive. Some apply to the manufacturing sector, others apply to the carrier sector, and for the most part they are complementary. We also discuss, in a separate section, the roles of governments and universities.

VERTICAL INTEGRATION

As discussed earlier, Northern Telecom occupies a unique and dominant position in the manufacture of telecommunications equipment and is Canada's only world scale supplier. We believe that without Northern, the Canadian telecommunications equipment market would now be served by a dominant U.S. supplier or would be a battleground for major Japanese and European manufacturers. To this extent, Northern provides a protective umbrella for small Canadian firms in the Canadian market, although all too often the effect has been to freeze them out of the Canadian market.

The next alternative explores mechanisms designed to adopt some of the principles of vertical integration for the benefit of other Canadian manufacturers.

CARRIER COOPERATION WITH SMALLER MANUFACTURERS

Our research led to the conclusion that large telecommunications manufacturers throughout the world achieved their dominant positions by having assured access to large and protected markets. This alternative is aimed at securing better market access for smaller manufacturers in the near term. These smaller manufacturers cannot afford to engage in or await the results of pre-competitive research. Their growth, or in some cases their survival, might depend on a breakthrough strategy to gain access to today's markets. Without a determined effort to develop mechanisms to improve market access now for small manufacturers, they will not have access to markets in the year 2000 and beyond. In fact, given the trend to

mergers and consolidations by the large manufacturers, there might be few small firms left by that time.

As discussed earlier, a major reason for Northern's continued success over a long period has been its close ties with a major carrier. While the association has been based on ownership followed by common parentage, it might be possible to extend some of the positive benefits of such a relationship to other carriers and suppliers in order to promote more effective R&D in the telecommunications sector. As a first step, the federal government could explore with the major telephone companies the development of mechanisms for effective and collective cooperation between the carriers and smaller equipment suppliers, with a view to emulating, as appropriate, the factors that have contributed to Northern's success.

QUOTAS FOR R&D EXPENDITURES

Since some carriers undertake less R&D than others, the federal government could empower the CRTC to prescribe and regulate the levels of R&D expenditure by the carriers under its jurisdiction.

In this way, rather than doing what has to be done and only deciding at year-end whether the engineering work carried out during the year was R&D, as some carriers do, they would be encouraged to take a proactive approach to the planning and conducting of R&D.

Since the Commission is not empowered under existing legislation to prescribe levels of R&D for the carriers under its jurisdiction, amendments to legislation would be required.

ACCESS TO OTHER MARKETS

Because Northern Telecom is a dominant supplier to the domestic telephone company market, most of the Canadian manufacturers interviewed during this study make the bulk of their sales to export markets, or to a broad range of small customers in Canada. Compared to the telephone company market, these markets are small, fragmented, diverse, extremely competitive and often specialized, and inherently more difficult to serve and maintain. The customers in these markets are usually less dependent on long term standardization on a single product or system, and are therefore less likely than telephone companies to be tied to a single supplier. There is no question that competition in telecommunications services

creates new market opportunities for all suppliers since there are more carriers to purchase equipment.

One way to assist smaller manufacturers to gain access to other markets would be for the government to act as a catalyst to encourage these smaller companies to combine their efforts in pre-competitive research. The government can play a role in fostering partnerships to bring together the resources of smaller manufacturers with other non-aligned carriers or service providers to promote more effective R&D. Other carriers include Unitel, cellular carriers, radio common carriers and resellers. Unfortunately, there are no common bonds or objectives uniting them, and no common interest group like the Stentor organization which could aggregate other carrier resources to foster more effective R&D. The emphasis could then be placed on developing relationships between specific "other carriers" and manufacturers, rather than all-embracing consortia arrangements to address subsets of the marketplace.

PRODUCT MANDATES

The tariff barriers erected more than one hundred years ago encouraged the development of manufacturing in Canada, albeit on a branch plant basis. For the past thirty years or so, the government has encouraged established Canadian branch plants of foreign firms to seek from their parents world wide product mandates, including responsibility for research and development. This strategy has been quite successful in the past. For example, companies like IBM have made a conscious effort to maintain a corporate balance of trade between the limited range of products manufactured in Canada for export to world markets and the wider range of products imported into Canada.

It is possible that the eventual elimination of tariff barriers as a result of the Free Trade Agreement might lead to a reduction in the number of U.S. branch plants in Canada. Certainly, a major incentive for maintaining branch plants is removed. However, for European manufacturers, Canada remains an attractive market in its own right and a convenient location for access to the U.S. market. Recently, European companies like Ericsson have been encouraged to establish R&D facilities in Canada with a corporate mandate for certain products.

With the growing internationalization of the marketplace for telecommunications equipment, and to counter a possible decline in the number of U.S.-owned plants in Canada, the government might review the possibility of revitalizing the product mandate strategy by identifying specific market segments that might be served by large foreign manufacturers and targeting specific foreign firms that could

be invited to establish in Canada. There is growing competition between nations to attract large multi-nationals. In spite of this competition, Canada has some advantages, particularly in the telecommunications field, that could be exploited.

EVALUATION OF THE ALTERNATIVES

In this section, each of the alternatives developed and described above is evaluated in turn. It should be emphasized again that the alternatives are not necessarily mutually exclusive, and in fact many of them are complementary.

VERTICAL INTEGRATION

Despite the theoretical difficulties that vertical integration causes economic purists, and despite the U.S. government initiatives to weaken the bonds between carriers and their suppliers, the relationship between Bell Canada and Northern Telecom is, for the foreseeable future, probably the most effective mechanism to ensure that Canada maintains its position in the forefront of telecommunications technology. However, vertical integration was put into place a hundred years ago and cannot be replicated on the same scale today. Nevertheless, it has been demonstrated that vertical integration facilitates effective R&D, and remains a viable alternative for Canada.

CARRIER COOPERATION WITH SMALLER MANUFACTURERS

The recent reorganization of Telecom Canada to form three new organizations under the name Stentor presents a favourable opportunity for the government to explore with Stentor the development of mechanisms to improve the lot of smaller manufacturers. Responsibility for all the marketing and R&D currently carried out by Stentor and its member companies will be assumed by Stentor Resource Centre Inc. effective January 1, 1993. The aims and objectives of Stentor Resource Centre Inc. are to promote and accelerate the introduction of new services on a national basis as a response to the more competitive environment.

With the increasing diversification of services, it might be that many of the specialized and low-volume equipment requirements of the carriers are of less interest to Northern, but could be a major order for a smaller company. However, to meet these needs, a small company needs to be fully aware of the requirement an "R&D distance" away from the service introduction date, just as Northern is.

As a first step, the Department of Communications could ask Stentor to consider establishing a group which would be charged with the responsibility of developing liaison mechanisms to assist in making small Canadian manufacturers aware of upcoming industry requirements. Stentor could also be asked to develop and propose mechanisms whereby the group could enter into contractual arrangements with small firms to support R&D needed to meet identified requirements.

Stentor might also be asked to develop options for funding R&D conducted by small firms to meet specified carrier requirements. Among the funding options that could be considered are self-funding by manufacturers (a purchase commitment from Stentor could be like money in the bank for many small firms), joint funding by Stentor and the manufacturer, or government loan or grant funding subject to Stentor providing an assured market for the final product.

The creation of a relationship between Stentor and independent Canadian manufacturers which would bring to independent manufacturers some of the proven benefits of the Bell/Northern relationship will not be easy. There will be suspicions on both sides, and commercial confidentiality issues will be a concern. At an early stage of this initiative, it will also be necessary to involve provincial governments to ensure that their individual R&D support programs can be realigned where necessary to take into account the aggregation of telephone company markets.

It is not difficult to understand the attraction to Bell Canada (by far the largest participant in Stentor) of dealing exclusively with Northern Telecom. The vertical integration and common parentage and ownership of the two companies creates a high level of confidence. As a consequence, it might be difficult to gain the effective co-operation of Stentor in a program to source business to smaller telecommunications equipment manufacturers. The government should therefore consider alternatives which could be presented to Stentor should they decide not to participate in a program to establish effective R&D and purchasing agreements between Stentor and smaller manufactures.

While the development of such arrangements might be difficult, history has proven that no matter how much money individual companies or the government are prepared to invest in R&D, the ultimate measure of effectiveness is success in the market place. For telecommunications equipment, the major market is provided by the telephone companies. Big and powerful as Northern might be, it still values its ties with the Canadian telephone industry. Developing a structure which would bring together the consortium of telephone companies with a number of small independently-owned manufacturers will be a challenge, but it might be the best mechanism for increasing the level of effective telecommunications R&D by these firms. For the telecommunications carriers, the benefits will be in direct proportion

to the effort expended, but as a minimum would offer an opportunity for some of the smaller telephone companies to aggregate their R&D spending with the assurance of a more effective return.

QUOTAS FOR R&D EXPENDITURES

The CRTC does not view R&D expenses differently than it views other expenses incurred by the carriers under its jurisdiction. It does not set quotas for the expenses of any carrier, but applies a general test of reasonableness to all categories of expenses, both capital and operating.

If quotas were set for R&D expenditures by the carriers, there is no question that the carriers would meet those quotas. Whether this would increase the level of R&D expenditures in fact, or whether it would merely encourage a more careful classification of expenses which are already incurred, is one issue. Whether the setting of quotas would lead to more effective R&D and better results is a more significant issue.

In our view, it is unlikely that the setting of quotas would lead to more effective R&D and better results. The carriers are in the best position to determine what R&D is most likely to benefit their businesses and to serve the needs of their customers. In the only example we are aware of where the regulator has issued an order regarding R&D, that being the order of the Régie des Télécommunications with respect to Québec Téléphone, the project was not a success. While the lack of success may be for many reasons, it does not represent a justification for embarking on such an approach at the federal level.

However, given the apparent lack of understanding of the CRTC's approach and attitude to R&D on the part of many of the regulated carriers interviewed, there is an opportunity for the government and the Commission to communicate the Commission's views in this regard.

ACCESS TO OTHER MARKETS

The Search 20 Forum which led to the Vision 2000 initiative dealt at length with some of the difficulties facing smaller manufacturers in Canada. However, the recommendations for action placed much of the burden on the federal government. True, there is much that the government could or should do to improve the business climate, but many of the recommendations would have involved the Department of Communications in such matters as the development of long term strategies,

technology and procurement forecasting, and other functions which are essentially marketing functions. Large and successful manufacturers know that these marketing activities are best carried out by the industry which will also be responsible for making the investment decisions resulting from these strategies and forecasts.

Other recommendations of the forum were heavily dependent on government funding, which it now appears is not available. In our interviews, we detected a waning of enthusiasm for Vision 2000, not for the concept, but for the perceived lack of results to date. Smaller firms are disappointed with the lack of government funding, and larger firms are treating competition as more of a priority than cooperation.

It is difficult for governments to admit to supporting large, successful monopolies such as the telephone companies. The government initiatives to introduce competition between a limited number of carriers will lessen the monopoly issue, but competing carriers must also become large and powerful if they are to compete effectively with the telephone companies. What this means is that the idea of a small group of Canadian entrepreneurs leading Canada into a future laden with technological change through a proliferation of new and innovative services is a comforting but false illusion. At the carrier level, telecommunications is big business, and the fringes of the market, while admittedly growing, are not the forces driving technological change.

PRODUCT MANDATES

With the growing internationalization of the marketplace for telecommunications equipment, and to counter a possible decline in the number of U.S.-owned plants in Canada, the government might review the possibility of revitalizing the product mandate strategy by identifying specific market segments that might be served by large foreign manufacturers and targeting specific foreign firms that could be invited to establish in Canada. There is growing competition between nations to attract large multi-nationals. In spite of this competition, Canada has some advantages that could be exploited.

THE ROLES OF GOVERNMENTS AND UNIVERSITIES

In general, research carried out by universities is considered to be more long-term in nature. However, much of the work is funded by industry and ultimately directed to the market place. Government in-house research also tends to be longer term and generic in nature, and in recent years there has been closer cooperation

between government laboratories and the private sector, notably in space communications. As mechanisms are developed to give smaller manufacturers better access to immediate markets, it might be appropriate to build new linkages between government laboratories, universities and smaller manufacturers.

If we assume that the ultimate measure of accomplishment for university and government research is also related to success in the marketplace, then it follows that a good deal of the research must be conducted in close cooperation with manufacturers that are or have the potential to be successful. While this conclusion might seem rather obvious, it is a fact that much of the research conducted in government laboratories did not benefit from adequate market inputs and was often handed off to private sector interests that were equally out of touch with the market, and/or lacking the manufacturing know-how to bring the product to market.

From our interviews, it appears that there is a definite and vital role for governments, universities and industry in R&D, and that these roles are interlocking but distinct from each other. The comparative lack of strong and viable telecommunications manufacturers in Canada has caused the government to undertake many research projects that would normally be left to the private sector. Assuming that some of the models described above can be implemented, it would be appropriate for the government to review its own role in R&D to ensure that its efforts are supportive of the overall marketplace approach.

Initiatives such as TR Labs are also effective in retaining intellectual skills and resources at the Masters and Doctorate level in Canada. This results from its close working relationship with a number of the universities in Western Canada.

In Chapter 3, in the section entitled "The Financial Environment", we discussed the results of our interviews with carriers and manufacturers relating to the federal government R&D tax credit program. Few of those interviewed had an in-depth understanding of the program. This was particularly the case in small companies. We believe that the Department of Communications could play an active and important role in helping both telecommunications carriers and equipment manufacturers better understand this program. For example DOC could work with the Department of Revenue - Taxation to develop written and audio visual material to explain the program. The Departments could then work together to provide briefings to telecommunications firms to increase their knowledge of the program.

The federal government influences R&D through its purchases. The larger government procurement contracts are required to include a section on the

industrial and regional benefits (IRBs) which will be provided. Major Crown Projects, ie. those valued in excess of about $100 million, require comprehensive coverage of IRBs, which may include R&D work in Canada or technology transfer to a Canadian firm as well as Canadian production. Most of such projects are undertaken by DND and MOT, and have included large purchases of telecommunications equipment. There may well be other opportunities for these departments, and for others such as DOC, to develop alliances with small potential supplier firms similar to the model proposed above for Stentor. The transfer of essential government-developed technologies to those small firms could be a factor in such an approach.

CONCLUSIONS

Several alternatives for increasing the amount and effectiveness of telecommunications R&D in Canada were developed and evaluated in this chapter.

It is assumed that the extent of direct government funding for telecommunications R&D will remain limited, or become even more limited than it is today. Accordingly, the most promising alternatives were support of the existing vertical integration, promoting carrier cooperation with smaller manufacturers through a "simulated vertical integration" involving the new Stentor Resource Centre organization, promoting access by smaller manufacturers to other markets, improved communication of the CRTC's approach to R&D and promoting world product mandates for Canadian subsidiaries.

Of the alternatives discussed, only the setting of quotas for R&D expenditures by carriers is unlikely to lead to more and more effective telecommunications R&D.

In terms of the roles of governments and universities in telecommunications R&D, it was concluded that such research will be more effective if it is conducted in close cooperation with manufacturers that are or have the potential to be successful - that is, manufacturers that have knowledge of the market and access to the market.

The government should mount a program to assist carriers and equipment manufacturers to better understand the federal R&D tax credit program.

Government can also support smaller Canadian firms by establishing a "buy Canadian" policy and developing alliances with smaller Canadian firms which can supply their telecommunications equipment needs.

8. CONCLUSIONS AND RECOMMENDATIONS

INTRODUCTION

This final chapter contains the overall conclusions and recommendations of the study. Before presenting these conclusions, however, it is appropriate to provide a brief discussion of strategies.

STRATEGIES

Most modern technology-based industries originated from a single breakthrough invention and have been sustained by constant improvements resulting from research and development. As a specific industry matures, it develops a unique structure. The automobile and telephone industries are good examples. A mature industry also sets the priorities for further research and development efforts. What this means in practice is that successful R&D strategies are generally industry-specific, and are guided by the overall objectives of the sector.

The factors that help promote successful R&D include[129]:

- Market access: Access to the markets for the sale of the product or service resulting from the R&D is a prerequisite to success.
- Market Research: Products not driven by market needs are more likely to fail. According to the Science Council of Canada, NEC's 2400 PBX is an example of such a product. NEC spent a huge amount of R&D on a product that appears to have been too sophisticated for the market it serves.
- Involvement of all aspects of a company's operations: A new product innovation process requires the involvement of manufacturing, marketing, sales and service, as well as designers.

CONCLUSIONS OF THE STUDY

This study has explored a broad range of issues regarding telecommunications R&D in Canada. Accordingly, the range of topics included in the conclusions is

[129] Ibid.

similarly broad. They begin with factual data from the interviews, then proceed to definitional problems and international comparisons, then to management, regulatory, financial and government issues, and end with conclusions with respect to the most appropriate models.

The overall findings and conclusions of the study are as follows:

- R&D expenditures by Canadian telecommunications service providers (facilities-based carriers and other service providers) in our sample totalled $233 million in 1990, or 1.7% of total revenues. It is estimated that the carriers in our sample represent over 95% of the R&D activity by Canadian telecommunications service providers.

  The historical trend has been one of moderate growth in expenditures, with a compound annual growth rate over the period 1986 to 1990 of 6%. For the period to 1990 to 1994, a compound annual growth rate of 15% is forecast, largely due to two major programs announced by Teleglobe and TMI.

- R&D expenditures by the nine Canadian telecommunications equipment manufacturers in our sample, plus expenditures for other manufacturers obtained from published sources, totalled $1.06 billion in 1990, or 11.0% of total revenues. It is estimated that the manufacturers in our sample represent over 90% of the R&D activity by Canadian telecommunications equipment manufacturers, and with the addition of data from published sources, over 95% of the industry is covered.

  The historical trend for those nine companies providing data has been one of slow growth in expenditures, with a compound annual growth rate over the period 1986 to 1990 of 2%. For the period to 1990 to 1994, a compound annual growth rate of 14% is forecast by those eight companies providing forecast data, but it should be noted that Northern Telecom is not included in this group.

- There are difficulties in measuring R&D expenditures by Canadian companies, and further difficulties in making international comparisons. Most Canadian companies use the Revenue Canada definition, which is more restrictive than the Frascati definition used by the OECD. However, a lack of understanding of the Revenue Canada regulations and a conservative approach to the claiming of credits in order to avoid disqualification of any expenditures means

that R&D expenditures reported by Canadian companies are in many cases understated. In making comparisons with other OECD countries, it is likely that Canadian R&D expenditures in total are understated for the same reasons.

- Canada ranks seventh among major OECD countries in terms of R&D expenditures by all industrial sectors in absolute terms. In terms of total per capita R&D for all industrial sectors and in terms of total R&D as a percentage of GDP, Canada ranks ninth among OECD countries. However, since Canadian telecommunications R&D accounts for a disproportionately large share of Canadian R&D (16%) compared to 10-13% for all developed countries, it is highly likely that Canadian telecommunications R&D expenditures compare much more favourably with other major OECD countries.

- With respect to individual corporate levels of R&D expenditures, larger carriers tend to spend a greater percentage of revenues on R&D than smaller carriers, with most at around 2% of revenues. Canadian telecommunications manufacturers have much higher levels of expenditure on R&D, with most spending in the range of 10% to 12% of annual revenues.

- All Canadian service providers and most manufacturers tend to concentrate their R&D efforts on service/system and product development, not on applied research. This short term focus, while understandable from a competitive perspective, will nevertheless lead to longer term problems unless there are other Canadian sources of basic research on which to base applied research and service and product development.

- The positive results of R&D in the telecommunications manufacturing sector are found in the conventional measures of industry success - increased employment, increased investment, increased domestic and export sales, and decreased imports.

- R&D in the telecommunications services industry does not often lead to the same direct economic benefits as are found in the telecommunications manufacturing sector. In this case, one must often look to the users of telecommunications services to determine the benefits of R&D. While the development and implementation of new services can result in increased investment and employment as well as assisting business users of the services to be more competitive, most

of the economic benefits of those developments result in increased carrier efficiency and lower rates which will accrue to users.

- Regulated telecommunications carriers are uncertain with respect to the level of R&D which the CRTC believes is appropriate, and the lack of direction in this respect has given some carriers the impression that the Commission is either not interested in or wants to constrain expenditures on R&D.

- Given the potential for cross-subsidization among carrier services through the assignment of R&D expenses according to the CRTC's Phase III costing procedures, a greater degree of regulatory scrutiny might be required in order to ensure that they are assigned to the appropriate costing categories.

- Essentially all carriers and manufacturers which are subject to federal income tax make some use of the federal R&D tax credit program, and where provincial programs are applicable, some use was made of them as well. However, there is a lack of understanding of the programs on the part of many companies, which leads to many companies taking less than full advantage of either the federal or provincial programs.

- The industry generally believes that there are no government policy barriers to R&D, and that the appropriate role of government should be one of encouraging and providing incentives to companies to undertake R&D. Industry also believes that the government should not be actively involved in directing the industrial R&D process.

- With respect to maximizing the benefits of telecommunications R&D, the experience of most telecommunications equipment manufacturers is that development is a short term process and it is getting shorter, with development cycles in the range of 12 to 18 months now becoming the norm. Concurrent engineering (carrying out the last stages of development on the production line) is becoming increasingly common as manufacturers strive to be first to market with the latest products.

- With the private sector focus on short term development, it is also apparent that the longer term research which forms the basis for such developments is not being conducted by industry. In order to be able

to continue to develop new products, industry will require timely access to the results of the underlying basic research.

- The three industrial R&D models examined in this study - vertical integration, aggregation of carriers resources and pre-competitive collaboration - all have advantages and disadvantages. Each plays a different role in providing telecommunications carriers and equipment manufacturers with information about the technologies and the markets over and above what they can obtain through their own individual resources.

- Constraints on overall spending by government mean that direct funding of telecommunications R&D by government is likely to be limited in future. Other alternatives available to the government to promote and encourage R&D in telecommunications include encouraging Stentor to deal with smaller manufacturers on a long term basis; setting quotas for R&D expenditures; promoting increased understanding and use of the federal R&D tax credit program; assisting manufacturers to gain access to other markets; and promoting the world product mandate concept among Canadian subsidiaries of foreign-owned multinational corporations. Of these, all except the setting of quotas would be expected to yield positive results in terms of the quantity and quality of telecommunications R&D.

RECOMMENDATIONS

Based on the research, interviews, data collected from public and proprietary sources and analysis conducted during this study, we have developed a few key recommendations for consideration by the government.

In developing these recommendations, we envisage three distinct roles for the government with respect to telecommunications R&D:

- The government as a performer of R&D;

- The government as the creator of an appropriate private sector R&D environment; and

- The government as a facilitator of the implementation of private sector developments.

In developing the specific recommendations under each heading, we have also been cognizant of the constraints on government spending which continue to reduce the government's ability to fund directly those initiatives which it believes are important.

THE GOVERNMENT AS A PERFORMER OF R&D

Given that the focus of the private sector is on short term development, but that it requires timely access to the results of basic research in order to have a continuing basis for such developments, the most appropriate role for the government is as a performer or funding agency for more basic, longer term types of research. Whether such research is conducted directly by government or is conducted by universities with government support, it is apparent that the most appropriate research role for the government is in such long term projects where the risk is higher and the returns are less certain.

With their focus on the market, private sector firms can then avail themselves of the results of such research which have promising applications. Appropriate cost recovery approaches should be developed to recoup a portion of the costs of the research while still promoting the transfer of successful technologies to industry.

Given the constraints on government funds for R&D, we believe that the direct support of longer term research is the most appropriate direct funding role for government.

THE GOVERNMENT AS THE CREATOR OF AN APPROPRIATE R&D ENVIRONMENT

Recognizing that market knowledge and market access are the keys to attaining successful results of R&D, the most important role of government is to create an appropriate environment for R&D in Canada. The major aspects of the appropriate environment include the tax and regulatory environments. The government should also encourage R&D by recognizing and promoting R&D successes.

It is apparent from our interviews that the R&D tax credit program is a source of frustration for many of the smaller manufacturers. The most recent federal budget announced that changes would be proposed to some of the regulations regarding overhead expenses and shared facilities and equipment. However, there still remains an opportunity for the government to assist industry by increasing the level of understanding of the program.

One general misunderstanding of the tax credit program that should be corrected is that a company must be profitable to benefit from tax credits. The program provides for payments as opposed to credits where a company has no profits against which to apply the credits. This is of assistance to companies which are in a start-up phase.

The government should also work with the CRTC to develop a better understanding on the part of regulated companies of the approach and attitude of the Commission to R&D expenses. It is apparent that there are some misunderstandings of the Commission's intent in this regard, in spite of decisions which quite clearly state the Commission's position.

The government should increase its efforts to recognize and publicize the successful development and implementation of R&D.

THE GOVERNMENT AS THE FACILITATOR OF R&D IMPLEMENTATION

The government should promote collaboration among smaller manufacturers through active brokering. A forum for the collaboration of the pre-competitive development efforts of a number of smaller manufacturers would assist these companies with market knowledge and market access. The government should assist smaller manufacturers to acquire information on the markets and technologies in this way.

The creation of Stentor Resource Centre Inc. will consolidate the marketing, national standards setting and research and development activities for all the former Telecom Canada members. It is recommended that the government work with Stentor to develop mechanisms for effective and collective cooperation between the carriers and Canadian equipment manufacturers, with a view to extending to the smaller firms some of the benefits which have contributed to Northern's success.

One way to implement this initiative would be to form a Stentor-Government-Industry Steering Committee. This group would be charged with the responsibility of reviewing potential R&D opportunities and facilitating arrangements between Stentor and one or more equipment manufacturers. The Committee would subsequently monitor progress on each undertaking.

As a major user of telecommunications services the government could also serve as a test bed and initial market for new equipment and services resulting from carrier/industry cooperative ventures.

APPENDICES

APPENDIX A

STATEMENT OF WORK
AND
APPROACH AND METHODOLOGY

STATEMENT OF WORK

To carry out a study on telecommunications R&D in Canada. The study is to develop a thorough understanding of telecommunications R&D in Canada, the competitive environment which Canadians face, the regulatory, financial, policy and institutional factors affecting telecommunications R&D, and constraints to undertaking R&D."

WORK TO BE DONE

- Develop a comprehensive database of the state of telecommunications R&D in Canada, focusing on the telecommunications carriers and equipment manufacturers as the major suppliers and performers of R&D; expenditures, spending instruments and mechanisms; ratio between long term research, short term research, and development (products and services),

- To examine how Canada's situation compares to selected countries (using a common definition of R&D),

- To analyze the managerial, institutional, regulatory and financial environment in Canada for telecommunications R&D,

- To analyze organizational models which will maximize the effectiveness of R&D resources such as: vertical integration, the aggregation of R&D resources (e.g. Bell Communications Research, also known as Bellcore), the formation of alliances, the targeting of resources into specific areas,

- To develop options to encourage appropriate levels and mechanisms for Canadian telecommunications R&D by carriers, equipment manufacturers, universities and governments."

APPROACH AND METHODOLOGY

The approach to the study involved a number of major steps, as follows:

- Review of Background Information
- Update of Database of Telecommunications R&D
- Analysis of Financial Treatment of R&D
- Consideration of Regulatory Environment
- International Comparisons of Telecommunications R&D
- Models for Maximizing R&D Effectiveness
- Implications of Increased Telecommunications R&D

The methodology consisted of a combination of personal and telephone interviews with telecommunications carriers, manufacturers, provincial governments and the federal telecommunications regulator, personal interviews and telephone and letter communications with experts at the OECD, at the EEC and in Australia, Netherlands, Sweden and the United States. It also included an extensive literature search of regulatory proceedings and decisions in Canada, the international literature on telecommunications R&D, and a wide range of other literature sources.

The methodology for the interviews with Canadian telecommunications carriers and manufacturers and with provincial government officials consisted of the development of a detailed list of issues for discussion during the interviews as well as a list of data to be requested. The list of topics and the data request are contained in Appendix B to this report. They were circulated in advance of the interviews.

APPENDIX B

TOPICS FOR DISCUSSION
AND
DATA TO BE REQUESTED

TOPICS TO BE COVERED DURING INTERVIEWS

DEFINITION OF R&D

Definition of R&D used by the company, and any subsets of that definition (for example, component, product, systems or application/service development).

Relationship between company definition and Revenue Canada definition.

R&D DECISION-MAKING PROCESS

Decision-making process regarding levels of expenditures and priorities and criteria used in the decision-making process.

Factors governing or influencing R&D expenditure levels.

How overall R&D expenditure level is determined, and how individual projects are selected. Role of marketing, engineering, manufacturing and finance in the decision-making process, particularly in the selection of projects and throughout project management.

The potential implications of broadening the definition of R&D as used by Revenue Canada and CRTC.

Thoughts on whether there is an optimum level of R&D, and if so, what that level is for manufacturers and carriers.

The notion of a minimum critical mass on R&D programs of various carriers and manufacturers.

THE ROLE OF GOVERNMENTS IN R&D

Policy and regulatory barriers to R&D.

Need for explicit government policies on R&D.

Views on programs such as the Technology Transfer Opportunities Program, Vision 2000, STP, DIP.

The appropriate role for governments with respect to telecommunications R&D.

Opportunities for joint industry-government R&D initiatives.

The appropriate role and directions for government telecommunications R&D laboratories.

TAX INCENTIVES

Knowledge of the federal and (where applicable) provincial tax programs by R&D management, views on their strengths and weaknesses, and the extent of use of such tax credits and other tax incentives.

The impact of R&D incentive programs on the company's R&D activities, and suggested changes which would have a positive impact on the level and quality of telecommunications R&D.

ROLE OF THE CRTC (for federally regulated carriers)

The strengths and limitations of the CRTC approach in examining the appropriateness of R&D expenditures while renewing common carrier rates.

Does the CRTC have a role in stimulating R&D funded by federally-regulated carriers.

FACTORS AFFECTING R&D

Implications of procurement policies.

The impact of alliances and/or collaborative R&D programs.

Implications of funding support from other sources.

The implications of trade constraints or incentives stemming from agreements such as GATT and FTA.

The strategic importance of market globalization for R&D.

Organizational models.

Factors which would cause the company to decrease R&D spending levels.

Factors which would cause the company to increase R&D spending levels.

IMPLICATIONS OF R&D

Implications of long-term v. short term R&D.

Implications of R&D that is indigenous v. R&D based on foreign expertise.

The impact of R&D that is targeted at various sectors of the economy.

The relative impact of component, product, systems and service/application R&D.

Relationship between R&D and each of innovation, productivity, competitiveness, and profitability.

OTHER ISSUES

Interviewees will be invited to comment on any other issues which in their view are relevant to the study.

DATA TO BE REQUESTED

Ownership of company.

Statistics for year-end 1990:
- Revenues
- Number of employees.

Actual R&D telecommunications expenditures for 1985-1990
- within Revenue Canada definition
- outside Revenue Canada definition.

Projected R&D telecommunications expenditures for 1991-1995.

Provincial distribution of R&D expenditures.

Types of research conducted and breakdown by research category as used by the company (for example, component, product, system, service/application).

Breakdown of research into long-term (programs with a time horizon exceeding three years) v. short-term (programs with a one to three year time horizon), and allocation for each type.

Percentage performed in-house, in Canada and in other countries (specify country name).

Percentage eligible for income tax purposes.

APPENDIX C

THE FRASCATI DEFINITION OF R&D

THE FRASCATI DEFINITION OF R&D

Both UNESCO and the OECD have adopted a common definition of R&D which is commonly known as the Frascati definition. The current definition as contained in the Frascati Manual is as follows:

> "Research and experimental development comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society and the use of this stock of knowledge to devise new applications."[1]

In order to be classified as R&D, an activity has to have an "appreciable element of novelty". The construction of prototypes and pilot plants is to be included in the definition, as is design and building work, only to the extent that they are required for the R&D phase and not for the production process.

It excludes the following activities from the definition of R&D:[2]

- Teaching and training
- Scientific and technical information services and data collection
- Testing, standardization and normalization
- Economic activities directed toward marketing (innovation) and production.

However, many secondary activities may include some components which fall within the definition of R&D. Examples of this include[3]:

- If a secondary activity is undertaken primarily in the interest of R&D it should be included in R&D expenditures, otherwise it should be excluded.

- If a firm's library or documentation centre is open to non-research staff, its expenses should be excluded from R&D expenditures.

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[1] Schnöring, Thomas, Research and Development in Telecommunications: An International Comparison, (Bad Honnef: Wissenschaftliches Institut für Kommunikationsdienste, December 1989), presented at the 8th International Telecommunications Society Conference, Venice, Italy, March 18-21, 1990, 7.

[2] Ibid.

[3] Statistics Canada, A Framework for Measuring Research and Development Expenditures in Canada, (Ottawa, Statistics Canada, March 1984), 9.

expenses should be excluded from R&D expenditures.

- The activities of university libraries are excluded from R&D.

- In the case of pilot plants, the construction and operation of a plant is a part of R&D as long as the principal purposes are to obtain experience and to compile engineering and other data to be used in evaluating hypotheses, designing special equipment and structures required by a new process, and preparing operating instructions or manuals on the process.

- In the case of a prototype, the boundary of R&D has been reached when any necessary modifications to the prototype have been made and the testing satisfactorily completed.

Research and Development is a subset of the scientific and technological activities which also encompass scientific and technical education and training. Distinguishing R&D from related activities with a scientific and technological base poses definitional problems:

- Education and training and other industrial activities may contain an element of R&D.

- Post graduate studies which require students to perform independent research often go beyond structured course-work and may fulfil the criterion of R&D.

- It is difficult to determine the cut-off point between experimental development and related activities required for the realization of an innovation. In industrial R&D, for instance, the activities for preparing the innovation for production are expensive. These could include design engineering, tooling and manufacturing start-up. These costs may or may not be accepted in a definition of R&D.

There is a difference of opinion over whether software origination (programming) equates to an R&D activity[4]. It can be argued that if the state-of-the-art in software technology is improved, software generation is elevated to the status of a genuine R&D activity. However, well-established programming procedures employed for writing and improving programs cannot be given an R&D classification.

The 1980 Frascati Manual is currently being reviewed by the OECD with a view to

[4] Schnöring, Research and Development in Telecommunications, 7.

broadening the definition. It appears certain that the definition will not change substantially. The inclusion of market research within the definition was considered and rejected at a 1991 meeting. One area of the Frascati definition that likely will be modified, however, is that regarding software development. Canada has proposed that the Frascati definition be revised to include software development in a manner consistent with the way it is included in the Revenue Canada definition. It appears that this proposal will be accepted by a majority of OECD members, and will likely be approved in 1992.

Other changes proposed for the Frascati Manual include the way different countries treat research institutes, centres of excellence, and so on, for statistical purposes. These changes have no significance for this study.

APPENDIX D

THE REVENUE CANADA DEFINITION OF R&D

THE REVENUE CANADA DEFINITION OF R&D

In a broad sense, scientific research and experimental development is defined by the Income Tax Act as the systematic investigation or search carried out in a field of science or technology by means of experiment or analysis. This is then broken down into three classifications as follows:

- Basic Research: Research undertaken to advance scientific knowledge without a specific practical application in view.

- Applied Research: Research undertaken to provide possible uses for results of basic research or methods of achieving specific and pre-determined objectives.

- Experimental Development: Use of basic or applied research to create new, or improve existing materials, devices, products and processes.

While there are a considerable number of qualifying criteria, the key criteria used by Revenue Canada to ascertain whether the activity claimed is scientific research or experimental development are that the activity must:

- use a scientific method;
- be carried out with the intent of achieving an advance of knowledge in the field;
- involve scientific or technological uncertainty;
- be carried out by qualified personnel;
- be in an eligible field; and
- be carried out in Canada.

Eligible fields of activities include all natural or physical sciences and technologies, computer science and computer systems. Thus for telecommunications R&D the criterion of being in an eligible field of scientific activity is not usually a matter of contest.

In addition to activities that fully meet these criteria, certain support activities, which in themselves do not meet the criteria but which are necessary for the scientific research or experimental development to be carried out, are also considered eligible. An example of this might be the carrying out of tests on a new device. The development of the device itself would be required to meet the eligibility criteria, but the tests could use standard test equipment and standard test procedures which, in themselves, do not meet the eligibility criteria. However, as the supporting activities are required to ascertain whether or not the eligible device meets its design specifications, the testing activities are permitted as part of the tax claim. Typical support activities which are considered eligible

providing they support a core of eligible scientific research or experimental development are:

- activities of a standard practice nature, not involving technological uncertainties;
- psychological research and studies;
- data collection;
- feasibility studies;
- educational studies; and
- literature studies;

Certain activities are specifically excluded from eligibility for federal scientific research and experimental tax credits under any circumstances. Typical of these are:

- the commercial production of a new or improved material, device, system or product, or the commercial use of a new or improved process;
- production engineering;
- style changes;
- market research;
- sales promotions; and
- quality control or routine testing of materials, devices, or systems.

APPENDIX E

INTERNATIONAL R&D COMPARISONS

INTERNATIONAL R&D COMPARISONS

This appendix contains data on four measures for comparing R&D across countries:

- The GERD/GDP ratio
- Per capita comparisons
- The B-index
- Patent statistics

THE GERD/GDP RATIO

The GERD/GDP ratio has become a standard OECD tool for international comparisons, and is also the primary mechanism OECD employs for inter-country comparisons. GERD (Gross Domestic Expenditure on Research and Development) is defined as total intramural expenditure on R&D performed on the national territory during a given period. It includes R&D performed within a country and funded from abroad, but excludes payments sent abroad for R&D performed in other countries.[1] However, direct international comparisons of R&D can be confounded by constantly fluctuating exchange rates among international currencies and changes in the relative costs of manpower and financial inputs into the R&D programs of different nations. In order to circumvent this difficulty, OECD expresses GERD as a ratio of Gross Domestic Product (GDP).[2] This measure provides a more valid comparison since it takes into account the differences in size of population and economy across countries.

In analyzing R&D expenditures, OECD classifies member countries into four categories:[3]

- Major R&D countries
- Medium R&D countries
- Small R&D countries
- Countries giving little or no priority to R&D

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[1] Statistics Canada, "Total Spending on Research and Development in Canada, 1971 to 1991," Science Statistics, (Ottawa, Statistics Canada, July 1991), 1.

[2] Statistics Canada, A Framework for Measuring Research and Development Expenditures in Canada, (Ottawa: Statistics Canada, March 1984), 31.

[3] Ibid.

According to a 1979 OECD ranking, Canada with a GERD/GDP ratio of 1.12 was classified as a medium R&D country. Other countries in this group included Switzerland, Sweden, Italy, Belgium, Australia and the Netherlands. These countries were considered together purely because of their overall national R&D effort.[4] The countries in this group spent significantly less on R&D than the five major R&D countries, and spent significantly more than the smaller and far less industrialized countries. The countries in the major R&D category were the United States, Japan, Germany, France and the United Kingdom.

As shown in Table E-1 below, the United States is the highest spender on R&D among OECD countries in absolute terms, followed by Japan. Among European countries, Germany spends the highest, followed by France, U.K. and Italy. Canada is the seventh highest spender on R&D in absolute terms.

TABLE E-1: R&D EXPENDITURES OF MAJOR OECD COUNTRIES - 1989

Country	Total R&D $(millions)	Per capita R&D $	% of GDP %
Australia	2931.1	177	1.24
Belgium	2060.1	209	1.61
Canada	6,455.6	249	1.35
France	17,511.6	313	2.29
Germany	24,578.3	400	2.83
Italy	9,164.2	160	1.23
Japan	50,987.2	416	2.91
Netherlands	4,259.1	289	2.26
Spain	2432.5	62	0.67
Sweden	3,756.1	442	2.84
Switzerland	2,857.5	435	2.88
U.K.	17,042.4	299	2.20
U.S.A.	137,816.0	560	2.86

Note: Data is for 1989 and is expressed in current U.S. dollars.
Source: OCDE - Statistiques sur les pays membres, 1991.

[4] It should be noted that this measure is based on the R&D conducted by all industrial sectors, not the telecommunications industry by itself, and is therefore of limited use in this study.

In terms of the GERD/R&D ratio, however, Japan now assumes the leading position among the countries chosen for this comparison, followed by Switzerland, the United States, Sweden, Germany, France and the United Kingdom. According to OECD figures released in 1991, as shown in Table E-1, Canada's GERD/GDP ratio has risen to 1.35, but Canada now ranks tenth among the 13 major OECD countries since the ratios for other countries increased even more rapidly.

PER CAPITA COMPARISONS

Per capita R&D spending also yields an interesting comparison. As shown in Table E-1, for major OECD countries, the highest per capita R&D spender is the United States. It is followed by Sweden, Switzerland, Japan, Germany, France, U.K. and Netherlands. Canada's ranking among major OECD countries for per capita R&D spending is ninth.

THE B-INDEX

The B-index is a more complex measure of comparing R&D. The measure defines the minimum benefit-cost ratio at which an R&D investment becomes profitable. The value of the B-index depends on the tax measures of R&D. The more favourable a country's tax treatment of R&D, the lower country's B-index.

A comparison of the B-index for ten major industrialized countries by the Conference Board of Canada shows that Canada's tax treatment of R&D conducted by large manufacturing companies was the most favourable.[5]

[5] Jacek Warda, International Competitiveness of Canadian R&D Tax Incentives: An Update, (Ottawa: Conference Board of Canada, May 1990), vi.

TABLE E-2: COMPARISON OF B-INDEXES IN 10 COUNTRIES - 1989

Rank	Country	B-index
1.	Canada	0.657
2.	Australia	0.703
3.	Korea	0.805
4.	France	0.813
5.	United States	0.972
6.	United Kingdom	1.000
7.	Japan	1.003
8.	Germany	1.027
9.	Italy	1.333
10.	Sweden	1.040

Source: Conference Board of Canada.

As Table E-2 at left shows, Australia was next to Canada in its tax treatment. Canada ranked number one in a similar study conducted in 1981. The Conference Board of Canada study found that the competitive edge of Canada's R&D tax treatment is provided by tax incentives that exist in some Canadian provinces, especially Nova Scotia, Québec and Ontario. These provinces significantly broaden the variety and scope of tax incentives Canada offers.

PATENT STATISTICS

Patent statistics, a public record of inventions, provide an indicator of technological change.[6] Patent trend analysis can serve as a useful tool in R&D planning and in new product development. In Canada, information and communications technologies, at 12%, accounted for the largest proportion of patents issued between 1983 and 1988. 79% of the patents granted in this area were to the electrical and electronic product industry; 13% were developed for the office, store and business machine industry, and 8% were for the scientific and professional equipment industry. Inventions in information and communications technologies were almost exclusively product-oriented.

International comparisons suggest that almost half of all patent applications are filed by American institutions and persons. The U.S. dominates in information and communication technologies, followed by Japan, then Canada and France with almost equal numbers of patents filed. However, the validity of these comparisons is questionable since national patent offices have different conditions for granting a patent.

[6] Statistics Canada, Indicators of Science and Technology, 1989 (Ottawa: Statistics Canada, January 1990), 1-10.