Industry, Science and Technology Canada
Industrie, Sciences et Technologie Canada

LINKAGES AMONG SCIENCE AND TECHNOLOGY ORGANIZATIONS

INDUSTRY, SCIENCE AND TECHNOLOGY CANADA
Federal Research Directorate

Canada

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July 25, 1991

EXECUTIVE SUMMARY

A major theme of Canadian public policy in science and technology over the last few years has been the promotion of closer ties among industry, universities, and government. This approach has been seen as an effective way to use our limited scientific and technological resources in response to the growing globalization of business and the increasing technological sophistication of our competitors. Indeed, linkages are now commonly used as a means to improve industrial competitiveness in Europe, Japan, the United States.

Unfortunately, though much talked about, little about linkages among science and technology organizations has been specifically defined. This makes it difficult to move from vague generalizations about the perceived problem, to a quantified analysis of the situation which can support considered recommendations for action.

This was a pilot study which examined quantitatively the linkages among science and technology organizations in Canada. Information was gathered from the literature, a written survey, and in-person interviews. The findings of all three lines of inquiry were mutually supportive.

The study examined example horizontal (the environment and telecommunications industries across Canada) and vertical (all industry sectors in the province of Alberta) slices of the economy. Telecommunications was selected as a representative of a mature industry, in contrast to the environmental industry which is relatively new and growing rapidly.

A linkage was defined as a connection between two units in different organizations. A unit is a part of an organization with a defined purpose and boundary. The connection must exist over time and involve numerous transactions. Transactions must involve two-way flows, although the commodities flowing in each direction need not be the same nor simultaneous. The transactions must have some effect on research and development in the organization.

An organization can have linkages with a variety or other kinds of organizations. Vertically, there are suppliers and customers. Horizontally, there are competitors and complimentors. Experts provide specialized skills, and government provides support as well as acting in any of the other capacities.

The literature review was conducted through searches of bibliographic electronic databases. It attempted to focus on the quantitative analyses of linkages between organizations, however most of literature focused on anecdotal examples of the benefits and problems of linkages. The following are findings from the literature review:

- Most linkages are informal; and many authors think they are the most valuable. Linkages usually begin informally through personal contact and are formalized over time.
- Linkages are formed in reaction to changes in the competitive environment. Shorter product lives, increasing costs, global markets, increased specialization, and intense competition are reasons cited for linkage formation.
- Benefits from linkages include: access to knowledge and facilities, access to and influence over markets, risk sharing, leverage with government, flexibility, and generation of new thinking. Both the participants and the nation benefit from linkages.

- While there is ample evidence in the literature of the value in cooperative research, the point is often made that extracting the value is not easy. There are very strong deterrents, and often little motivation. Commonly cited problem areas include: time, interest, confidentiality, culture, myths and prejudices, and cost.

- In order to maximize benefits and minimize costs, care and effort should go into the management of linkages.

- Government is seen as having important roles in supporting and coordinating the development of linkages. These roles include: legitimizer, power broker, provider of supplemental funds, coordinator, and definer of national interests.

- Estimates are that about half of development work is undertaken in collaboration. This is such a significant volume as to warrant treating technological cooperation as a strategic phenomenon. Understanding this phenomenon is crucial to many industrial policy issues.

Organizations to be included in the survey were selected from a variety of databases and from consultation with experts. Only organizations which participate in research and development were included. The intent was not to create an exhaustive census of organizations, but rather to ensure that the sample was representative of the area.

Organizations were segmented by type (government, academic, non-profit, and large and small private organizations), and region (British Columbia, Prairies, Ontario, Quebec, and Atlantic), in the case of the environment and telecommunication sectors, or industry (manufacturing, resource, process, other), in the case of Alberta. A separate part of the study looked specifically at federal government laboratories. Sixty organizations were selected in each area such that at least two organizations were represented each type/region (or industry) combination.

Each of the organizations was contacted by telephone to solicit their participation in the survey. Only people who had agreed to participate were sent a survey. If an organization was not suitable, or if it declined to participate, a replacement was selected. A telephone follow-up of non-respondents was carried out to encourage response.

The survey collected information about the respondent, the organizations they link with, the linkage characteristics, traffic characteristics, and the quality of the linkage. Answers to the questions took one of three forms. Some questions required a short written answer. Some questions were multiple choice. Some questions asked that a subject be rated on a scale. The final survey form was approved by Statistics Canada.

The survey response (104 completed returns, 58% of surveys distributed) was felt to be representative of the regions and organizational types. Information from the surveys was coded into an electronic database.

In-person interviews were conducted with 34 of the survey respondents as a supplement to the survey. These were people who had contributed well to the survey. The interviews concentrated on the "hows" and "whys" which could not be captured in the survey, and on views about the roles of government. A simple one page interview guide was used to structure the interview and to help ensure that the information was complete and consistent among organizations.

The study verified and, in some cases, disproved many widely held beliefs within the Canadian context; however, its principal achievement was that for the first time in Canada, quantitative information is available concerning linkages.

The major findings of the study were:

- There is not a significant difference among linkages in the environmental sector, the telecommunications sector, and all sectors in Alberta, except that many environmental problems are seen as common among organizations and therefore confidentiality tends to be less of a barrier to the formation of linkages.
- Linkages are very important. This is supported by both the anecdotal information from the literature review and interviews, and by the rankings in the survey. In addition, the survey found that the future importance of linkages is expected to increase.
- Linkages are difficult to establish and maintain. The degree of effort required is reduced as the participants gain experience and establish organizational mechanisms for linkages. The survey found that the factors which most often inhibit the formation of linkages are expense and effort, followed by confidentiality.
- Linkages are more successful if they are more than financial. In the survey, money was rated as the least important exchange item and linkage satisfaction was least in those linkages which rated money as important. Information was the most important exchange item.
- Cultural differences among organizations affect linkage creation and success. Myths and prejudices are significant barriers and are best reduced through experience and personal interaction.
- communication is vital to the success of linkages. Ideally, communication should be initially face-to-face.
- linkages are more successful if they begin informally and are not forced. This allows the participants to develop an understanding of each other's culture and objectives, and to open lines of communication.
- Industry type and the competitive environment affect linkage creation and success. Linkages are more common and successful when there is a common and pressing need. The survey found that common needs, and savings are the most important facilitators.
- Government has a role to play, both as a linkage participant and as a promoter or facilitator. However, improvements need to be made in government communication of science policy and program implementation procedures.
- Federal laboratories are important linkage participants and there is potential for them to play a more active role in encouraging the creation of linkages. The survey found that federal laboratories were the linkage initiator in only 30% of the linkages in which they participated.

Recommendations were made in four areas:

- **Communications:**

  The full benefit of government programs is being limited by a lack of awareness and understanding, on the part of potential recipients, of linkages and available government support programs.

  - Rationalize, simplify, and explain programs.

    There is confusion over the proliferation of programs offered by different levels and departments of government; programs are perceived to be difficult and expensive to use; and close and continuing contact between companies and government contacts is seen as important.

  - Communicate the advantage of linkages.

    Examples of communication methods include publications, seminars for organizations, and government and private sector brokers who interact with industry, universities, and government laboratories.

  - Provide guidance on the creation and utilization of linkages.

    Involve as many organizations as possible in linkages with government laboratories. This will provide them with "hands-on" experience with linkages which can then be applied in other situations. Another approach is a government information centre which could help guide organizations with little or no experience. The information it provided would raise awareness, explain approaches, outline obligations, and discuss expectations.

- **Facilitation and coordination:**

  Government policy should, where possible, support the formation of natural linkages. This means that, ideally, the creation of a linkage should be instigated by the participants to fulfil a requirement which they have. The emphasis should be on organizations most receptive to linkages.

  - Review existing programs for linkage benefits.

    Many government programs already promote the concept of linkages. Much can be learned about ways to support linkages by examining the experiences of these programs. Also, as more is learned about how best to promote and maintain linkages, the effectiveness of current and future programs may be improved.

  - Create a Domestic Technology Linkage Program.

    If the need for is identified in the review of existing programs, a Linkage Program could be created to react to requests for assistance by industry, universities, and government in the creation of linkages,

and to proactively provide education about linkages and act as a broker between organizations.

- Promote personnel exchange programs.

  The findings of this study emphasize the need for personal interaction in the creation and maintenance of linkages. Personnel exchange programs are an excellent means of achieving this. They foster communications and breakdown cultural barriers.

■ **Research and Analysis.**

It is important to continue this work. Government, the private sector, and universities have roles to play in the research; the work should be done through linkages among the three.

- Continue mapping sectors:

  This was a pilot study, and therefore covers only a small part of the Canadian science and technology base. Future work could broaden the outlook and increase the amount of data available. It should be noted that linkages are transitory and that such a survey would provide only a snapshot in time. It is not felt that additional data will change the findings of this study, but it may be valuable in other ways.

- Trace linkage paths in detail:

  This study took a macro view of Canadian science and technology linkages. This approach was an excellent starting point. The next step, however, should be a detailed view a particular situation. Such a view will be an excellent complement to the existing data and is highly recommended.

- Conduct case studies:

  In-depth studies of individual linkages, both successful and unsuccessful, would provide information not obtainable from a general survey of the type done in this study. Such information would be useful in determining guidelines for a successful linkage.

- Improve the utility of the survey database:

  This study has been able to take only cursory look at the wealth of data contained in the survey database. The utility of the database could be improved by improving the software used to manipulate and analyze it. This will be especially important if the database is added to as a result of future work.

- Review models of linkages:

  Europe, Japan, the United States and others have valuable experience in forming linkages. In particular, some of their large research consortia (RACE, Sematech, Fifth Generation Computing, etc.) may

be useful models, with appropriate modifications, in the Canadian context.

- **Government participation in linkages.**

  The preceding recommendations concentrate on government's role in creating an environment conducive to linkages. It should be remembered that government also has an important role as a linkage participant through government laboratories and other organizations. However, for example, federal government laboratories were the initiator in only 30% of their linkages. There is potential for government to play a more active role in encouraging the creation of linkages between the federal laboratories and other science and technology organizations.

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1. INTRODUCTION

1.1 BACKGROUND

> *"But, with a few notable exceptions, we are not creating the relationships among academic research, government, and business ... To sustain our nation's leadership, we need more such communities where the barriers of time and space are reduced and the linkages to discovery and innovation are forged."*[1]

Canadian governments over the last few years have invested significant efforts to promote closer ties in science and technology among the three major national constituencies: government, industry, and universities. This objective has been a major theme in both federal and provincial science policies. One rationale for this direction has been the pressing need to improve the effectiveness of the Canadian scientific establishment, particularly in the face of growing globalization of business and the increasing technological sophistication of our major trading partners and competitors.

The considerable attention given to the need for improved linkages among science and technology organizations is because such linkages are seen as a way to improve the utilization of limited resources. The general feeling seems to be that current linkages are lacking and that government should act to encourage the development of higher quality links among industry, academia, and government.

However, before policy decisions can be made, much more needs to be understood about the problem. What is a linkage? What does it link? How important are linkages? How good are they now? How can they be made better?

A difficulty is that there are no recognized indicators for measuring the vitality of linkages and the strength of networking in the research and development domain. Yet, if so much of the national policy effort is directed towards building up these linkages, instruments are needed which can aid the policy-maker in measuring objectively the impact and effectiveness of linkage-strengthening programs and policies.

Unfortunately, though much talked about, little about linkages among science and technology organizations has been specifically defined. This makes it difficult to move from vague generalizations about the perceived problem, to a quantified analysis of the situation which can support considered recommendations for action.

What is needed is a taxonomy of the elements of linkages, a structure for the evaluation of situations, and the collection of data for analysis. The work summarized here begins the development of each of these.

1.2 REQUIREMENTS

1.2.1 Objective

Industry, Science and Technology Canada (ISTC) initiated this project to examine the linkages among science and technology organizations in Canada. The project examined a

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1 Edward P. Lee, "Forging linkages for discovery and innovation", Industry Week, February 21, 1983, p13.

sample of the government (federal and provincial), academic (universities and community colleges), and industrial facilities for science and technology and "mapped" their interactions with each other and international contacts. The nature of the linkages were described by characteristics such as their number, type and quality.

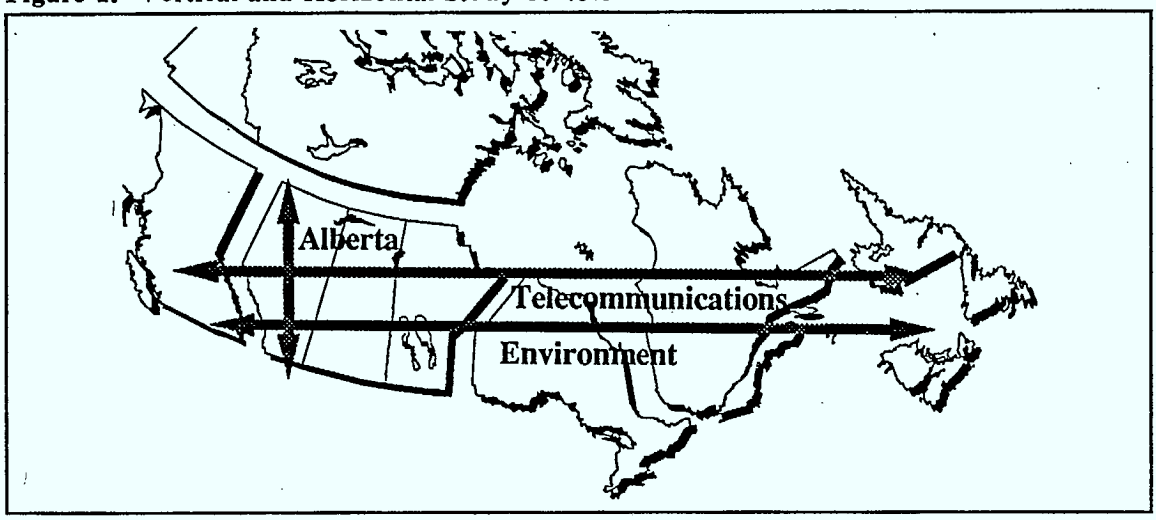
This information will be valuable for identifying gaps and opportunities in the integrated framework for science and technology in Canada. Together with knowledge of public and private sector goals, the map of S&T organizations will be a useful tool in the formulation of decisions concerning national science policies.

1.2.2 Scope

This initial pilot project concentrated on example horizontal (industry sector) and vertical (geographical region) areas. The following areas were selected for study:

- the environment industry,
- the telecommunications industry, and
- the province of Alberta.

Figure 1: Vertical and Horizontal Study Sectors



Information about each area was obtained from both existing databases and through primary data collection. The concentration was on the organizations performing the bulk of the research and development in each area.

The collected data was used to recommend government actions in support of industrial development and public policy. The study was not designed to examine any specific government programs.

1.2.3 Context of the Study

This study is one of several currently underway that examines the role of science and technology linkages. In concept, they lay the groundwork for a better understanding of the mechanisms that result in the formation of linkages and their value.

A major project that complements this study is being conducted by the Science Sector of ISTC. This work evaluates the alliances between laboratories in 20 federal science based departments with other science and technology organizations and is one of the first attempts to produce a comprehensive database and to understand the contribution of such federally-based alliances in the following areas:

- economic and regional development,
- achievement of the government's mission,
- advancement of knowledge and highly qualified personnel development, and
- international linkages associated with aid to the lesser developed countries and for achieving industrial competitiveness.

In addition, studies are also underway by the Royal Society on contracted R&D from universities and by the Canadian Research Managers Association (CRMA) on contracted research among Canadian industry, universities, and federal laboratories.

A key consideration for these complementary studies is to better understand the role played by government science policy which promotes linkages. They attempt to find quantitative answers about the value and effectiveness of linkages since they serve as the "underpinning" for such programs as the Networks of Centres of Excellence and the Industrial Research Applications Program. The studies are anticipated to confirm much of what is already known; however, they will generate a comprehensive database and methodologies to ensure that future comparisons are made in a precise and consistent manner.

1.3 DEFINITIONS

1.3.1 Units

Organization - An organization is a company, government department, or university involved in science and technology, either internally or through a linkage with another organization.

Unit - A unit is a part of an organization with a defined purpose and boundary. An organization may be made of one or more units. A unit may represent one or many people. The size and scope of a unit will depend on the circumstances of the organization. For example, a unit may be called a division, section, group, lab, or the unit and organization may be synonymous. It is important that the unit can be considered to be homogeneous, i.e. other organizations identify with and deal with the unit as a whole. Each unit will have characteristics which will influence the form and use of the linkages which connect with it. Important characteristics of units include the resources which they control, their need and willingness to receive or disseminate resources, and their physical location.

Linked Unit - A linked unit is a unit of another organization with which the unit being surveyed has a linkage. The linked unit need not be performing research themselves.

1.3.2 Linkages

A linkage is a connection between units and not individual people, although obviously people are necessary to conduct the transactions which occur over the linkage. The connection must exist over time and involve numerous transactions. Transactions must involve two-way flows, although the commodities flowing in each direction need not be the same nor simultaneous. The transactions must have some affect on research and development in the organization.

The characteristics of the linkage fall into six main categories:

- **What is exchanged:** There are six basic commodities which can be exchanged over a linkage; information (numbers, text, graphics, sound, etc.), money, material, services, people, and control. Information is the most predominate. Control includes any type of influence which one organization may have over another (for example, government legislation concerning the implementation of pollution abatement equipment). Exchanges are always two way; often with different commodities flowing in each direction.

- **Why is it exchanged:** There numerous reasons for a linkage to develop which may be commercial, professional, or personal. In each of these types of relationships the linkage may be either formal or informal. The motivating force for the linkage will influence its strength, duration, and effectiveness.

- **How is it exchanged:** There are many channels for exchange; telephone, computer, conferences, publications, discussions, and so on. Each mode of exchange has different tangible and intangible attributes.

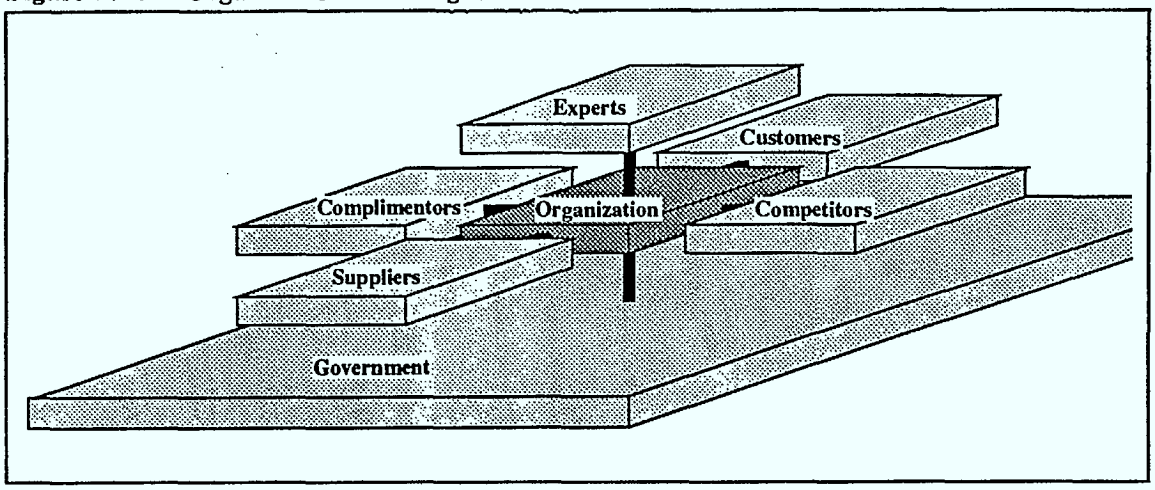
- **Where is it exchanged:** The spatial characteristics include the locations of the units and the distance of the linkage. Also important is the "direction" of the linkage; either horizontally between peer groups, or vertically to clients and suppliers.

- **When is it exchanged:** The temporal characteristics of a link include the frequency, duration, quantity and occurrence of transactions.

- **The effectiveness of the exchange:** The effectiveness of the exchange is measured in terms of metrics such as speed, cost, quality, connectivity, reliability, and ease of use. While most of these can be measured quantitatively, the effectiveness of a particular link can only be evaluated qualitatively relative to alternative means for satisfying the need for the link. The effectiveness of a linkage in a situation is dependent on all of the previous characteristics.

An organization can have linkages with a variety of other kinds of organizations. Vertically, there are suppliers and customers. Horizontally, there are competitors (organizations producing the same goods or services) and complimentors (organizations producing complementary goods or services). There are also various experts which can be called upon and government which provides support for all of these activities. Note that government may also act in any of the above capacities.

Figure 2: An Organization's Linkages



1.3.3 Research

This study is concerned with science and technology organizations which perform research. Research, however, has been given a very broad definition and includes work in basic research, development, engineering, and the production of both goods and services.

1.4 SECTORS

1.4.1 Environment

Identifying the units of environmental R&D in Canada is a challenging task, not the least because the field has yet to be recognized as a discipline. Generally, an environmental project is interdisciplinary, and involves several specializations: chemistry, physics, electronics and engineering.

The environmental industry represents about $8.5 billion a year in Canada, in terms of environmental protection equipment, services, and engineering consulting. There is some dispute as to whether those establishments offering research and technology in alternative less-polluting processes and technology should be included in the environmental or industrial process sectors. For the benefit of this study, we make the assumption that they are clearly an integral part of the environmental effort.

Environmental R&D in the private sector is conducted by two types of organizations. First are organizations who's business is not the environment, but who need to minimize the impact of their business on the environment. Second are companies who market environmental products and services to other organizations. One recent report produced by External Affairs lists close to 250 companies involves in selling environmental products and services. Close to half do some form of technology development and design.

In general, environmental R&D in the public sector is carried out in Canadian universities, in federal departments such as Environment Canada, the resource-based departments such as Forestry, Agriculture Canada, Fisheries and Oceans, and Energy, Mines and Resources

(EMR), and other agencies like the National Research Council (NRC). Environmental S&T activities can also be found in the provincial research organizations. Most provinces also carry out S&T efforts into environmental areas, usually under their resource departments.

1.4.2 Telecommunications

Telecommunications is Canada's most important technology sector. In 1986 sector shipments were $3.6 billion and the trade surplus was $100 million. Employment is at 41,000.

The sector has one world-scale corporation, Northern Telecom, with revenues of $6.4 billion, 30% of which are generated in Canada. Other significant players are Mitel, Gandalf, Microtel, Motorola, and NovAtel. Minor players include Spar, Canadian Marconi, SR Telecom, Positron, Develcon and Idacom. The medium sized companies generally compete in world markets against large multi-nationals, while the smaller firms play niche markets and supply the major firms.

Canadian manufacturing and research is concentrated in Ontario and Quebec, but all of the provinces have some representation. As a result of the historical monopolies held by telecommunication carriers, close ties and long-term relationships have developed between equipment suppliers and carriers.

This close working relationship is continuing in Canada in response to the growing competitive threat posed by large multi-national telecommunications companies and the move in product competition to a more commodity type market.

The major trends that characterize this sector worldwide are[2]:

- the increasing technological content of its products, requiring increasing investment in R&D;
- the application of digital technology to communications products and the merging of computer and communications technology into a new information technology sector;
- the liberalization of markets in many industrialized countries;
- the increasing significance of Third World markets, particularly Asian; and
- the use of mergers, acquisitions, joint ventures and research consortia to respond to the changing technological and market environments.

The best example of Canadian telecommunication linkages is the unprecedented cooperative venture among industry, universities, and government named Vision 2000. The initiative promotes the joint efforts of the Canadian telecommunications industry to develop future oriented products "for the year 2000". The objective of Vision 2000 is to position the Canadian telecommunications industry competitively in both domestic and international product, application and service markets through a concentrated R&D strategy. The Vision 2000 strategy and work program will be developed through a focused R&D program, shared

2 From the ISTC Industry Profile "Telecommunications Equipment".

ventures and the formation of project oriented consortia. Currently, over 50 organizations are Vision 2000 members.

Other initiatives supporting linkages among the telecommunications industry include the Information Technology Research Centre (ITRC) and the National High Speed Communications Network. ITRC is a provincial Centre of Excellence supported through the Ontario Technology Fund. It supports fundamental and applied research at a number of universities, industrial affiliates and the Government of Ontario.

The National High Speed Communications Network is an initiative of ISTC to provide a communications link to support collaboration among Canadian research and development organizations, while at the same time achieving a more internationally competitive information technologies sector by promoting joint development of leading edge communication technologies. The Network has not yet received approval.

In comparison to the environmental industry, the Canadian telecommunications industry is relatively established, stable and defined.

1.4.3 Alberta

Alberta spends more money per capita on science and technology than any other province. Total provincial expenditures reached over $240 million in 1989, the third highest in Canada. The science and technology sectors in Alberta produced billions of dollars in revenues last year, third only to energy and tourism. More than 50,000 Albertans are directly employed in about 1,200 advanced technology companies. In total, science and technology supports over 200,000 Albertans and the number may grow to half a million by the year 2000. Examples of science and technology linkages in Alberta include:

- Alberta Heritage Foundation for Medical Research established in 1979 with $300 million endowment has supported over 2,900 medical researchers and students.
- Alberta Technology, Research and Telecommunications was established in 1986 to help diversify the economy and coordinate science and technology efforts in the province.
- Centres for excellence such as the Alberta Research Council, the Biotechnology Pilot Plan, the Alberta Laser Institute, Alberta Microelectronics Centre and many others, make Alberta an attractive place to do business. It is the aim of the present government to see the technology intensive industries represents one of the largest manufacturing sub-sectors by the turn of the century. That translates to an average annual growth rate of about 15%.
- AOSTRA established in 1974 is a world leader in oil sands research.
- WESTAIM - the first major advanced industrial material (AIM) initiative in Western Canada, carried out with the cooperation of the governments of Alberta and Canada, under the auspices of wholly-owned subsidiary of Sherritt Gordon Ltd.
- Electronics Network of Alberta is a group of strategically linked applied R&D and service centres with an office in Ottawa to improve liaison in the East.

2. METHODOLOGY

2.1 LITERATURE REVIEW

Literature reviews are useful in: identifying issues, guiding research, suggesting applications and methodologies, and ensuring that work is not duplicated unnecessarily.

An initial literature search was performed by accessing the Dialog electronic database. This database provides information on government documents, domestic and international journals, news sources, industry newsletters, academic publications, other databases, etc.

Further lines of enquiry were pursued using the references in documents obtained as a result of the initial database search, from documents held by team members, and from informal 'linkages' with colleagues and associates.

The literature search attempted to focus on the quantitative analyses of linkages between organizations. It was hoped that previous work would help define the approach and terminology of the survey and interviews. However, only one publication was discovered which was of this character (1). Related publications dealt with the analysis of linkages within organizations (2,3). Most of the literature focused on anecdotal examples of the benefits and problems of linkages.

References used in this study are listed in Section 9, Annotated Bibliography. The results of the computer literature search are contained in Appendix E.

The study team is also aware of number of studies which may be valuable, but which could not be included in this study:

- The Alberta Government recently completed a confidential Cabinet report entitled: A Study Of the Management of Research Funded and Performed by the Government of Alberta, Prepared by the Technology and Research Advisory Committee, November 1990. The committee which compiled the report examined the coordination of research among government departments and identified gaps in research programs. The interviews undertaken as part of this investigation included questions regarding formal and informal linkages among government departments and agencies, and government contracts to universities and industry.

- At the May 1991 joint national meeting of The Institute of Management Sciences (TIMS) and the Operations Research Society of America (ORSA) a number of papers were presented which are directly relevant to linkages among science and technology organizations. Examples of sessions are: Social Networks: Implications for Technology Transfer, Creativity and Innovation; Industry University Cooperative Research; Interorganizational Issues in the Management of R&D/Technological Innovation; Different Approaches to Inter-Organizational Technology Transfer; Innovation Management in a Multi-Institutional Context; and Innovation Processes and Organizational Learning. This is the first time that such topics have been discussed at a TIMS/ORSA meeting and reflects the academic community's developing interest in this area.

2.2 SURVEY

2.2.1 Database Review and Creation

A database of organizations within each area (Telecommunications, Environment and Alberta) was developed from various published directories, electronic databases and through consultation with experts. Only organizations which participate in research and development were considered. The definition of research, however, was very broad and included work in basic research, development, engineering, and the production of both goods and services. The intent was not to create an exhaustive census of organizations, but rather to ensure that the sample was representative of the area.

The telecommunications database was constructed from numerous sources. The main sources used were electronic databases that were already in existence; the Vision 2000 database and the Business Opportunities Sourcing System (BOSS) database. Both databases were reviewed and combined in order to obtain a consistent database of relevant organizations. Data was also obtained from the Telecommunications Research Institute of Ontario (TRIO), the Natural Science and Engineering Research Council of Canada (NSERC) and the Alberta Ministry of Technology Research and Telecommunications. In addition, HICKLING had previously constructed a similar database during earlier related project work and this information was also referenced. The telecommunications database consisted of approximately 300 contacts.

The environment database was created with information from various industry associations, government publications and electronic databases. Industry associations that were contacted included the Canadian Environment Industry Association, Institute for Chemical Science and Technology (ICST), Canadian Chemical Producers Association . Canadian Steel Producers Association, Canadian Petroleum Association, Canadian Oil and Gas Land Association and the Mining Industry Technology Council of Canada.
Numerous Government publications were also referenced:

> Canada...A World Leader in Environmental Products and Services (ISTC)
>
> Inventory of Canadian Technologies in the Environmental Industry (ISTC and External Affairs - March 1990)
>
> Study on Canadian Producers of Environmental Science and Technology (prepared by Concord Scientific Corporation for ISTC)
>
> National Inventory of Environmental Research and Development Projects (compiled by the Research Advisory Committee to the Canadian Council of Ministers of the Environment)

Electronic databases include the ISTC BOSS system, Rawson Academy's Contacts Database and the Directory of Hazardous Waste Services were also utilized. The Environment database consisted of approximately 160 organizations.

The Alberta Database of R&D organizations was compiled based on several sources. The Dunn and Bradstreet Electronic Database of Research Laboratories in Alberta was one such source. The following two reports were used:

> Advanced Technology in Alberta, Interwest Publications Ltd., 1990
>
> The 1990 Directory of the Calgary Council for Advanced Technology.

In addition to these sources, internal Alberta Research Council reports were employed and several interviews undertaken. Interviewees were employees of the Alberta Research Council with extensive industry contacts throughout the province and in a variety of market sectors. The approximate number of firms in Alberta's final database was 140.

2.2.2 Survey Design

The survey was designed with a clear overall framework and included primarily closed simple to complete questions i.e multiple choice, ratings on a scale of 1 to 5. This type of design was used to help facilitate the analysis and improve the response rate. A few open ended questions were used to obtain information on the organization's mission and research purpose.

The survey consisted of three parts as described below. (A blank copy of the survey is provided in Appendix B)

Title page and Survey Description:	Background Information on survey/study purpose; Definitions and Instructions for completing the survey.
Section A - Unit Description:	Information on Respondent; Unit Purpose (Mission, Research, Products); Unit Classification; Unit Linkages.
Section B - Linkage Description:	Information on linked unit; Linkage Characteristics; Traffic Characteristics; Quality of Linkage.

Respondents were asked to complete Section B once for each of their seven major linkages. They were also asked to include an important linkage from within each of the five unit categories; government, non-profit, small private sector, large private sector and university.

The survey was directed to a unit within the organization which is responsible for some aspect of research. It was completed by someone who was familiar with the interactions of the unit with the outside world. Typically this was the manager of the unit.

Section A was concerned with the description of the unit and was filled out once.

Section B was concerned with description of the unit's linkages with the outside world. Section B was filled out once for each linkage. The respondent was asked to respond, where possible, for his most important linkage within each of five categories of linked units: government, universities, private sector suppliers, private sector customers, and private sector organizations doing similar or complementary work. And then, for any two other important linkages.

Answers to the questions took one of three forms. Some questions required a short written answer. Some questions were multiple choice. Some questions asked that the importance of a subject be rated on a scale of 1 to 5; in each case, 1 was the least important and 5 is the most important.

Surveys were returned by mailed in an enclosed postage paid return envelope, or by fax.

Since the survey was eliciting information which had not been explicitly collected before, and which the interviewees may not have considered before, a field trial of the survey was used to catch unanticipated problems such as sensitivities to certain questions, wording which was not clear, or questions to which answers were not available.

2.2.3 Approach

The organizations in the Environment and Telecommunications databases were segmented in two ways; by type of organization and by region. Five types of organizations were recognized: government, non-profit, university, large private sector, and small private sector. The size of a private sector company was defined by the number of employees; those having greater than 100 employees being defined as large. Five regions were recognized: British Columbia, Prairies, Ontario, Quebec, and the Maritimes. The resulting selection criteria matrix had 25 cells. Both databases were managed using a contact management software packaged called Maximizer. It was used to group and categorize the organizations in an effective manner and create mailing labels.

The organizations in the Alberta database were also segmented by type as described above, but the other segmentation criteria was the industry which used their research. There were four categories: manufacturing, resource, process, and other. The Alberta selection criteria matrix had 20 cells. Alberta Research Council used a software package called WINGS to organize and manage their database.

A 'short' list of 60 organizations was developed from the large databases in each area. The short list contained organizations representing each of the cells in the selection criteria matrix. Where possible, at least two organizations were chosen for each cell. Where more than two choices existed for a cell, the opinion of the project team and outside experts were used to make the choice. Factors which were considered when selecting organizations to be surveyed included: how familiar the project team was with the organization, how significant the organization's research contribution is in its area of expertise, and how likely the organization would be to cooperate in the survey.

Each of the organizations in the short list were contacted by telephone to solicit their participation in the survey. The type, location, and research capability of the organizations were also verified. If the firm was suitable, a person within the firm was identified to receive the survey. Typically this person was the manager of a research unit familiar with the interactions of the unit with the outside world. If an organization was not suitable, or if it declined to participate, a replacement was selected from the long list. It was hope that close to a 100% response rate to the survey would be achieved using this methodology. See the section entitled Response Rate for further details.

The survey packages were mailed out in early February with a deadline for return by the end of the month. The survey packages included a short memo thanking participant for their participation and ensuring the confidentiality of their responses, a copy of the survey and a return postage paid envelope. The deadline for the return of the survey was also clearly highlighted.

A telephone follow up of the non-respondents was carried out to encourage response.

2.2.4 Response rate

104 complete correct returns were received out of the 180 mailed out; 32 from the Telecommunications area, 32 from the Environment area and 40 from Alberta. This response rate of 58%was not as high as expected. A response rate closer to 80 or 90% was anticipated due to the fact that all potential respondents were personally contact by phone to confirm their commitment and to ensure their interest in participating in the survey.

The distribution of responses is shown in the following table. The responses were felt to be representative of the five regional areas and organization types.

2.2.5 Limitations

The survey and interviews were designed to discover the characteristics and 'flavour' of inter-organizational linkages. They do not provide a statistically robust analysis. In particular, the number of linkages which an organization has cannot be determined from the data in this study. Most organizations will have responded for their most important and successful linkages, and so the results here are not necessarily indicative of all linkages.

2.3 IN-PERSON INTERVIEWS

2.3.1 Interview Guide Design

A simple one page interview guide was designed to serve as an agenda for the in-person interviews. The interview guide was used by the interviewer to structure the interview and to help ensure that the data was complete and consistent among units. Issues to be discussed in the interviews were drawn from a preliminary analysis of the data from the surveys. General trends that were discovered in the data and new issues that arose during the survey process were highlighted in the guide. In addition, the "how" and "why" responses that were not captured in the survey were also included. Interviewees were also asked directly for their thoughts and ideas on government policy that could be developed to facilitate the formation of linkages and enhance the benefit derived from linkages. A copy of the complete Interview Guide can be found in Appendix C.

The following are the major topics discussed during the interviews:

1. Are linkages important to your organization/unit? What role do they play?
2. How does the external environment impact the linkages your organization forms? Is this environment changing?
3. Is the importance of linkages to your organization increasing or decreasing?
4. How and when do you create linkages? What form do they take?
5. What are the main barriers/facilitators to the formation of linkages?
6. What can be done to facilitate the formation of linkages/enhance the benefit derived from linkages?

Table 1: Survey Response Distribution

	ALBERTA					ENVIRONMENT						TELECOMMUNICATIONS						TOTAL
SENT	1	2	3	4	TOT	1	2	3	4	5	TOT	1	2	3	4	5	TOT	
Government	1	2	5	0	8	1	4	3	2	2	12	0	3	3	2	1	9	29
University	0	1	1	1	3	2	2	2	2	2	10	4	2	3	4	1	14	27
Non-Profit	0	2	0	0	2	2	4	4	1	2	13	0	2	2	2	1	7	22
Private (S)	11	5	8	3	27	2	2	3	2	2	11	3	4	3	4	3	17	55
Private (L)	4	4	5	6	19	2	2	6	3	2	15	3	2	3	4	2	14	48
TOTAL	16	14	19	10	59	9	14	18	10	10	61	10	13	14	16	8	61	181
RETURNED	1	2	3	4	TOT	1	2	3	4	5	TOT	1	2	3	4	5	TOT	
Government	1	1	4	0	6	1	2	3	1	2	9	0	0	3	0	0	3	18
University	0	1	1	0	2	1	0	1	0	1	3	3	2	1	2	0	8	13
Non-Profit	0	2	0	0	2	0	4	1	0	2	7	0	1	2	2	0	5	14
Private (S)	9	2	4	3	18	1	1	0	1	0	3	2	1	2	1	1	7	28
Private (L)	3	2	5	2	12	2	1	3	2	2	10	2	2	1	3	1	9	31
TOTAL	13	8	14	5	40	5	8	8	4	7	32	7	6	9	8	2	32	104
DECLINED	1	2	3	4	TOT	1	2	3	4	5	TOT	1	2	3	4	5	TOT	
Government	0	1	1	0	2	0	2	0	1	0	3	0	3	0	2	1	6	11
University	0	0	0	1	1	1	2	1	2	1	7	1	0	2	2	1	6	14
Non-Profit	0	0	0	0	0	2	0	3	1	0	6	0	1	0	0	1	2	8
Private (S)	2	3	4	0	9	1	1	3	1	2	8	1	3	1	3	2	10	27
Private (L)	1	2	0	4	7	0	1	3	1	0	5	1	0	2	1	1	5	17
TOTAL	3	6	5	5	19	4	6	10	6	3	29	3	7	5	8	6	29	77

Alberta

1 = Manufacturing
2 = Resource
3 = Other
4 = Process

Environment/ Telecommunications

1 = BC
2 = Prairies
3 = Ontario
4 = Quebec
5 = Atlantic

2.3.2 Approach

The individuals to be interviewed were selected from the survey participants who returned correctly completed surveys. Selection criteria included the quality and timeliness of the survey response; the probability that the individual would be willing to participate in the interview; the size of the firm (there was a heavier concentration on large organizations); generally perceived importance of the organizations research efforts in the particular industry area; geographical location and organization type. A sample group was finalized with representation in all geographical areas with a heavier emphasis on larger private sector research laboratories.

Interviews were scheduled with the individuals and a letter confirming the time and date was faxed to the interviewee along with a copy of the interview guide. Each interview took approximately one hour to complete.

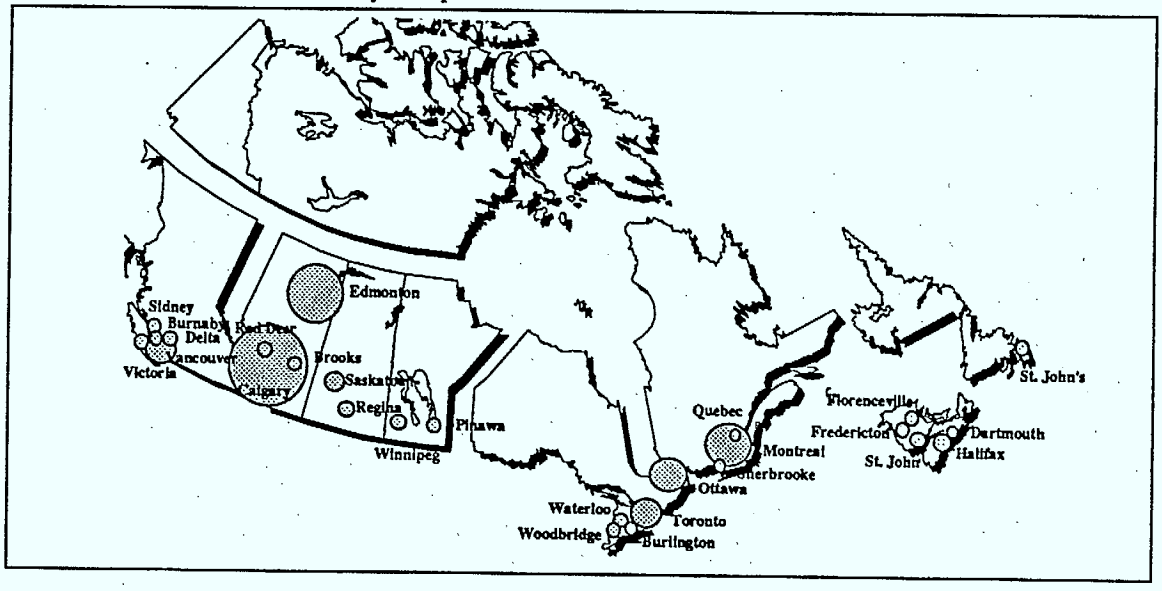
As the interviews progressed, conclusions were drawn and these hypophyses were tested in future interviews. As well, different questions were more heavily stressed depending on the organization being interviewed. This was done in order to maximize the relevancy of the information obtained and to avoid questions to which answers were not available.

Team members travelled to New Brunswick, Quebec, Southern Ontario, Alberta and Vancouver to complete the interviews in addition to the interviews that were conducted in the Ottawa area.

2.3.3 Response Rate

34 in–person interview were completed; 11 in the Telecommunications area; 11 in the environment area (additional interview was completed by phone) and 12 in Alberta.

Figure 3: Location of Survey Respondants



3. LITERATURE REVIEW

3.1 Definitions

To a limited extent, the literature has begun the task of describing and defining the attributes of linkages. These definitions have been adapted for use in this study.

Linkages are generally considered to exist when there are ongoing exchanges between companies. Each relationship should be regarded not only as a single link or strand, but as an accumulation of links or strands involving a number of people.(1)[3]

Linkages include relationships with customers, suppliers, or complementary organizations. Activities such as general technological monitoring or the recruitment of technological personnel have generally been excluded.(1,2) In the context of most studies, the exchange has to have some effect on technological development within the organization.

Important characteristics of a linkage described in the literature include(1):

- the duration of the relationship,
- the adaptations involved,
- the technological content,
- the range of contact, and
- the social content.

Classes of contact range have been described as isolated (few contacts), focused (few in one of either vertical or horizontal directions, many in the other), broad cooperation, very broad cooperation.(1)

3.2 Types

Most linkages are informal; and many authors think they are the most valuable. They are developed through personal relationships, often as a result of meetings in school, at conferences, or through business activities.

As the transactions over an informal linkage become more serious, perhaps because of the amount of money or the number of people involved, the linkage will be formalized. Types of formal linkages mentioned in the literature include (6,12):

- joint ventures,
- consortium,
- strategic alliances
- coalitions,
- licenses,
- long-term supply agreements.

3 Numbers in brackets refer to the bibliography in Section 9.

The forms of cooperation mentioned include (1):

- Mutual exchange of technological information,
- Tests, trials, etc.,
- Special technological projects,
- Joint development activities, and
- Long-term technological collaboration,.

3.3 Purpose of studying linkages

The literature which was reviewed considered a company's propensity to cooperate with external units on questions of technological development. The core question was 'how can companies exploit for their own benefit the technological developments occurring in other organizations'?

The objectives of these studies were to:

- learn more of the nature of interactions and the forms they take,
- acquire tools for analyzing the interaction and its effects at the corporate and societal levels, and
- get some idea of ways in which this type of interaction can be developed further.

Questions which were examined included (1):

- how much of a company's total development budget should be allocated to collaborative projects,
- choice of collaborative partners (customers, suppliers, parallel units), and
- content and form assumed by individual development relationships (formal, number of subprojects, duration).

3.4 Reasons for linkages

> *"One of the things industry can do is develop networks - recognize there is strength in cooperation and a competitiveness that can derive from sharing. They could cooperate in their technical development (with other companies in their sector), they could share support services... There is growing recognition that this is happening in Europe. This concept of shared systems and shared services has been very effective."* (10)

The world is changing quickly. Product lives are shorter, costs are increasing, the competition is keener, and most markets are now global.

A changing world demands new strategies. Companies must spend more on R&D to keep up, but need to diversify both the cost and the risk. Increasingly, business is returning to

core competencies and using specialists to fill their other requirements. Firms need larger markets, and to satisfy these extended market areas, they must depend more on supplier and distribution networks.(12)

Linkages are becoming one of the most important instruments of change in a rapidly changing environment. They are frequently transitional devices for industries undergoing structural change, facing escalating competition, or responding to uncertainty.(6)

Reasons for linkages include:

- Specialization. The increasing specialization of companies is increasing the need for cooperation.(7,11,12)
- Global competition. International alliances between firms that are based in different countries are one means of competing globally. Increasingly, these alliances are being extended beyond marketing activities.(6,7,11,12)
- Research. No R&D lab can be entirely self-sufficient. There is overwhelming support that improved communication among groups within the laboratory will increase R&D effectiveness.(1)

However, it should be remembered that linkages can extend or reinforce competitive advantage, but they rarely create it.(6)

3.5 Benefits

The literature contains many examples of benefits which accrue to organizations which develop linkages with outside organizations. Optimizing interdependencies between a firm and its suppliers and channels can create competitive advantage. The opportunities for savings through better coordination go far beyond logistics and order processing, and encompass R&D, after-sale service, and many other activities.6 Potential benefits which have been mentioned include(11,6,12):

- access to knowledge and expertise (product, process, buyer needs, marketing techniques),
- access to specialized equipment or facilities,
- attainment of economies of scale or learning,
- access to new markets or technologies,
- risk reduction and sharing,
- increased influence and control over markets and competition,
- increased leverage with government,
- differentiation from competitors,
- flexibility in developing, producing and marketing products,

- generation of new thinking as a result of interaction with others,
- exploitation of the specialization effect for competitive advantage.

In addition to the benefits obtained by individual organizations, there are additional benefits for society and the nation. For example:

- Business-government partnerships appear increasingly to be the most competitive method of aligning business with community needs.(7)
- International success in one industry can also increase demand for complementary products or services from the same country. This may be the result of foreign perception that domestic complementary organizations will be more cost effective. Domestic cooperation may also lead to better product performance. Such pull-through tends to be strongest in the early life-cycle of an industry.(6)
- There is concern that enrolment in science and technology education will not be sufficient to meet demand for technical disciplines in the future. One way to increase enrolment in scientific and engineering programs may be to form closer ties between industry and academia.(9)

3.6 Costs/Problems

While there is ample evidence in the literature of the value in cooperative research, the point is often made that extracting that value is not easy.(11) There are very strong deterrents, and often very little motivation.

Commonly cited problem areas include (11):

- time,
- continuity of interest,
- confidentiality,
- culture,
- myths and prejudices,
- cost.

Cooperation can have significant disadvantages, for example there will be loss of control, costs rise rapidly as collaboration becomes more extensive, there is the possibility of creating a competitor, and some profits will have to be given up.

There is the danger that, if the company reduces its research and development resources, it may no longer be able to provide a natural base for its core activities. In the end, areas important to competitive advantage must be sustained or improved by an organization internally, organizations cannot depend on others for everything.(6)

Cooperation can present surprisingly formidable organizational challenges because of complexity, cultural differences, need for open and credible information exchange, and different and conflicting objectives.(6)

Existing networks may either support or obstruct desired changes. While the accumulation of adaptions in the network means that the companies involved will function better, it also makes it more difficult for them to cooperate with companies outside the existing network.(2)

Organizations develop characteristic views of the world (corporate culture). This affects the way they communicate with the world. It can detract from the efficiency of communicating with anyone who follows a different coding scheme. Therefore engineers can communicate better with their colleagues because there is shared knowledge at both ends and less chance for misinterpretation (semantic noise). Organizational coding schemes both enhance the efficiency of communication among those who hold them in common, and detract from the efficiency of communication between holders of different coding schemes.(2)

The difficulties encountered in communicating across organizational boundaries are especially critical when the relation is of short duration.

In summary, in spite of the evident benefits of linkages, a number of authors urge caution. Some argue that alliances tend to ensure mediocrity, not create world leadership, and that they deter the firm's own efforts at upgrading.(6) From a public perspective, inefficient corporations may be coddled. Instead of winners being helped to win, losers may be insulated from the competition that should invigorate - or eliminate - them.(7)

3.7 Findings

The following points summarize some of the findings of previous studies:

- The best return, in terms of profit and growth, occurs when a company invests about half its development volume in external collaboration.(1)
- The typical partner is geographically close, important in terms of volume of business with the organization, and well established as a partner; thus general social characteristics are more important than purely technological or knowledge attributes.
- The greatest proportion of outside personal contact is with vendors. Next, are unpaid outside consultants (government, nonprofit, university). Contact with paid consultants is relatively rare, and then the consultants are usually university professors.(1)
- Often, even when the required competence should have been available in-house, an engineer will still turn first to an outside source. Possible reasons include: not being aware of the inside contact, belief that the external experience is unique, and belief that outside sources are more accessible and less costly to use (especially vendors).(1)
- Companies on average had ten collaboration partners of various kinds: 3.2 suppliers, 4.5 customers, 2.4 horizontal. Considerable investment has to be made in each relationship; vertical relationships must exist in any case and so are not under as much pressure to produce results as horizontal relationships.(1)

- Most companies in a survey by The Financial Post said they engage in cooperative research with universities, and 80% of those said the government should do more to encourage such efforts.(9) In general, the larger the firm, the more research funded at universities.(11)
- An average of three to seven people from the companies took part in the linkages, and personal meetings occurred every month or two on average.(1)
- The typical pattern for an industrial network is gradual development interrupted by short periods of dramatic change.(1)

3.8 Management

In order to maximize benefits and minimize costs, care and effort should go into the development of linkages. The literature mentions many aspects of linkages which should be considered before a linkage is formalized and will guide how it is managed during its life. These apply more to formal, than informal linkages.

- The culture of the two organizations must be compatible, they must speak a common language. They must develop a mutual knowledge of one another, know their separate interests, and be clear about how those interests fit with those of others. Mutual confidence and trust in each other must be developed. It is the relationships and communication among people that make linkages work.
- Geographical proximity of the partners is an asset, but not essential if adequate means of communication are developed. Face-to-face meetings are most important early in the relationship.
- Advanced planning and preparation will improve the chances of success. Objectives must be clear and understood by all participants. Participants need to have realistic expectations. Projects are most successful if the objectives are specific.
- The linkage should be designed with consideration to the protection of all parties, especially with respect to intellectual property rights.
- The participants should have the capability to perform the tasks for which they are responsible, both in terms of expertise and resources (money, people, time).
- Linkages are most successful when there is a sense of urgency. Deadlines should be set. Many view the most productive linkages as those which are temporary with a defined deliverable.
- All organizations must 'buy' into the linkage. There should be some financial commitment, possibly in the form of a membership or entry fee. There must be commitment form senior management and key players in the organizations.
- The organizations must support and encourage those involved in the linkage. The organizational reward system must recognize the value of linkages.

The process for developing a successful linkage has been described as follows. Perhaps the most important point, however, is not to underestimate the amount of work required.

- define strategic R&D objectives,
- screen and select potential partners,
- familiarize researchers with the practices and values of the partners,
- define the deliverables,
- provide incentives,
- manage the relationship,
- protect the investment, and
- develop long-term links.8

University - industry cooperation is a topic given special attention in the literature. Ways for industry to support and benefit from university capabilities include:

- develop a program for contracting research to universities or providing grants,
- sponsor a university chair,
- support graduate students,
- hire summer or coop students,
- provide support for post doctoral fellows,
- provide support and facilities for university professors,
- allow company scientists to hold part-time university appointments,
- set up management responsibility for university links,
- contribute research equipment to a university,
- allow company employees to pursue advanced research degrees,
- exchanging technical information,11

3.9 Roles

Of the three major types of organization which participate in science and technology linkages: government, business, and universities; Lodge sees business and government in particular as having the coordinating roles in developing the linkages for the nation. The movement toward more involvement with government has been exacerbated by the pressure of international competition.(7)

Lodge believes that central to this are improved business-government relations that rest on a redefinition of the roles of each and the design of new mechanisms and procedures for bringing them together.(7)

Lodge points out that in Japan, where industrial policy is inseparable from consortia, the definition of the national interest is a function of government acting closely with business.(7)

In the US, the 1984 National Cooperative Research Act was created to promote research and development, encourage innovation, stimulate trade, and make necessary and appropriate modifications in the operations of the antitrust laws.(7)

The government's roles are as a (7):

- legitimizer,
- power broker,
- provider of supplemental funds,

- coordinator,
- socializer,
- overseer, and
- definer of national interests.

Government is key in providing incentives, facilitating the achievement of success factors, perceiving and defining national interests, coercing key organizations to cooperate and facilitating their ability to do so, mediating and moderating differences among them, and keeping project standards high.(7)

However, while Government has the authority to define community needs, business has the competence that is essential for a wise definition and for its implementation. Industry leadership in governmental initiatives to foster competitiveness is essential. While industrial policy should be industry led, it will depend on government for success.(7)

Industry associations are an important mechanism to organize business leadership for new and more creative relationships with government. It is uneconomic, inefficient, and ineffective for each company by itself to attempt to design and conduct a partnership with government.(7)

3.10 Conclusions

> *That initiatives to further encourage university-industry and college-industry linkages be developed and implemented... The Council believes that more can and should be done to maximize knowledge, application and opportunity for the use of these mechanisms by stakeholders.* Draft national science and technology action plan, Council of Science and Technology Ministers, May 1990.(11)

It has been pointed out that few formal studies on linkages have been performed and much of the literature that is available is anecdotal in nature.(11) In particular, there is a scarcity of in-depth studies available on the effectiveness of industry-university-government laboratory interactions.

However, the anecdotal literature strongly suggests that such interactions can be very successful.(11) Estimates are that about half of development work is undertaken in collaboration. This is such a significant volume as to warrant treating technological cooperation as a strategic phenomenon.(1)

On the basis of such information, almost all new R&D initiatives are now aimed at increasing the quality and quantity of the working relationships between industry and university and public sector research establishments.(11) Therefore, understanding networks is crucial to many industrial policy issues.

The emphasis has been on formal information dissemination. Informal person-to-person communication has been recognized but not truly taken into account in planning overall systems.(1)

There is a general lack of awareness of the need for different channels and of the need to adapt to the nature of the existing network. The efficient transfer of knowledge calls for channels of high quality.(1)

It is fairly easy to find ways of giving marginal support to existing networks, or to encourage tentative efforts towards forming networks. However, if the aim is to generate any more substantial changes then major long-term investments are needed and the results will be subject to great uncertainty.(1)

4. SURVEY

This section has three parts. The first is a simple analysis of the responses to Part A of the survey dealing with the unit description. The second is a simple analysis of the responses to Part B of the survey dealing with the linkage descriptions. The third examines some additional interesting correlations. Additional survey results are contained in Appendix D.

4.1 UNIT DESCRIPTION

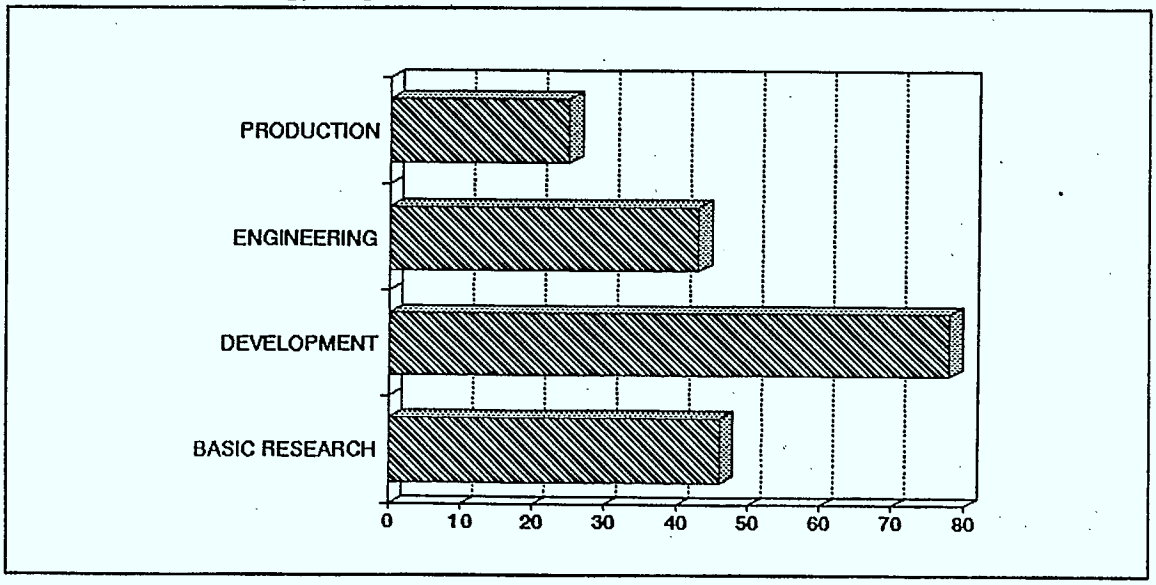
4.1.1 Technology Stage

Of the organizations that responded, the greatest number indicated that their R&D efforts are targeted at the developmental stage. Environment is somewhat of an exception showing basic and developmental research as evenly distributed. This is not surprising since many respondents from environmental organizations are involved in non–competitive, non–product oriented R&D.

Table 1–1: Technology Stage

	Telecom	Environ.	Alberta	All
BASIC RESEARCH	14	22	10	46
DEVELOPMENT	23	22	33	78
ENGINEERING	12	12	19	43
PRODUCTION	4	8	13	25

Figure 1–1: Technology Stage



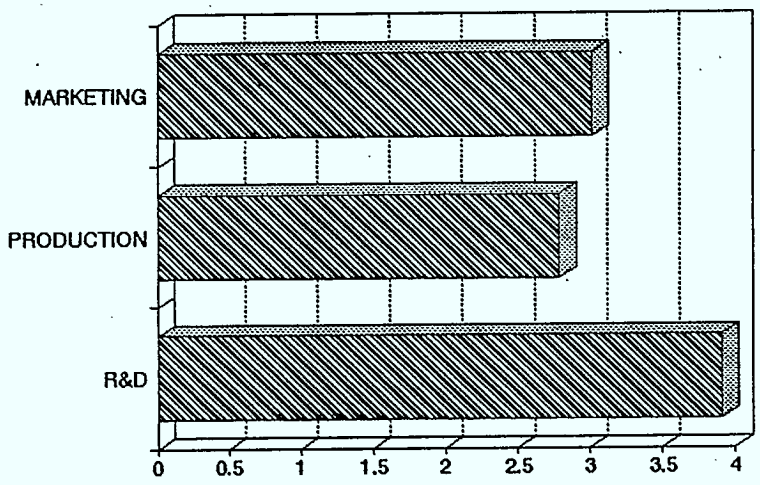
4.1.2 Linkage Importance

External linkages for R&D purposes are the most important, but this is obviously biased by the type of organizations that were survey. It is not surprising to note that linkages for production are not as important.

Table 1–2: Linkage Importance

	Telecom.	Environ.	Alberta	All
R&D	4.0	4.1	3.7	3.9
PRODUCTION	3.1	2.7	2.7	2.8
MARKETING	3.2	2.8	3.0	3.0

Figure 1–2: Linkage Importance



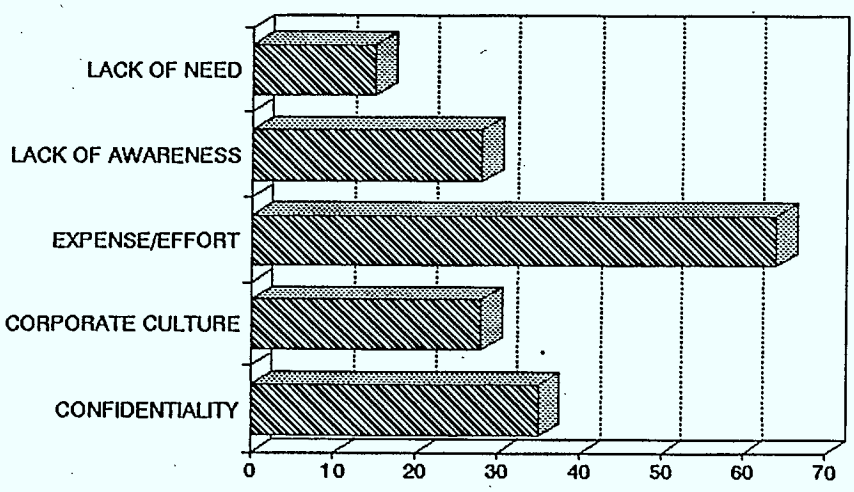
4.1.3 Linkage Barriers

The factors that most often inhibit the formation of linkages are the expense and effort involved in forming and maintaining the linkage. This is found to be the biggest barrier in all three sectors. The second most important barrier is confidentiality. Corporate culture is slightly more important in the Telecommunications area.

Table 1–3: Linkage Barriers

	Telecom.	Environ.	Alberta	All
CONFIDENTIALITY	9	10	16	35
CORPORATE CULTURE	13	8	7	28
EXPENSE/EFFORT	19	16	29	64
LACK OF AWARENESS	7	9	12	28
LACK OF NEED	4	6	5	15

Figure 1–3: Linkage Barriers



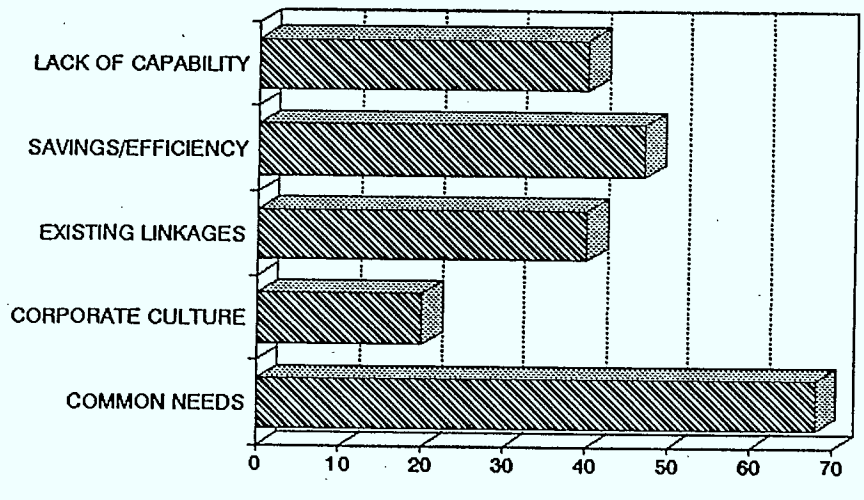
4.1.4 Linkage Facilitators

The factor that most often prompts the formation of a linkage is common needs; this is a strong trend and is the same in all three sectors. Corporate culture is found to be the least important facilitator but, as the results in Table 1–3 illustrate, it is also not an implicit barrier either.

Table 1–4: Linkage Facilitators

	Telecom.	Environ.	Alberta	All
COMMON NEEDS	21	28	19	68
CORPORATE CULTURE	6	8	6	20
EXISTING LINKAGES	9	14	17	40
SAVINGS/EFFICIENCY	14	16	17	47
LACK OF CAPABILITY	9	10	21	40

Figure 1–4: Linkage Facilitators



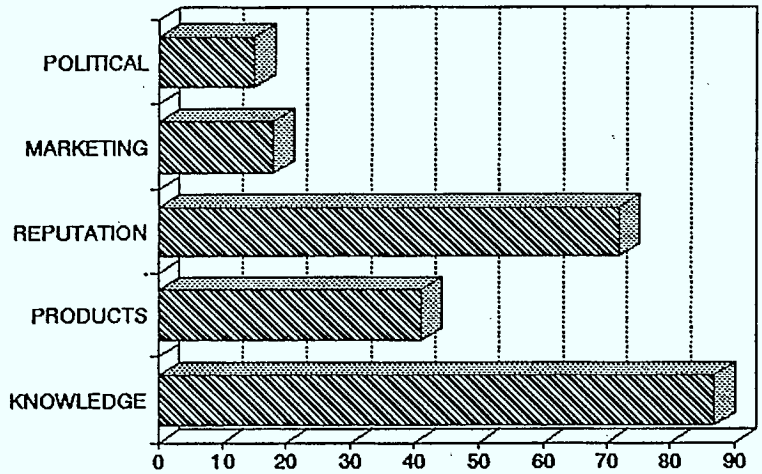
4.1.5 Reasons For Linkages

The reason most often cited for other organizations forming links with the study unit is knowledge; other parties are seeking people within the study unit with specific knowledge and a highly technical skills set. Once again the trend is very similar through all three sectors. The second most important reason is reputation which is closely related to the knowledge factor. Political reasons are the least important reason for linking which is consistent with the common perception of the scientific community.

Table 1–5: Reasons for Linkages

	Telecom.	Environ.	Alberta	All
KNOWLEDGE	25	30	32	87
PRODUCTS	13	11	17	41
REPUTATION	22	25	25	72
MARKETING	6	3	9	18
POLITICAL	5	5	5	15

Figure 1–5: Reasons for Linkages



4.2 LINKAGE DESCRIPTION

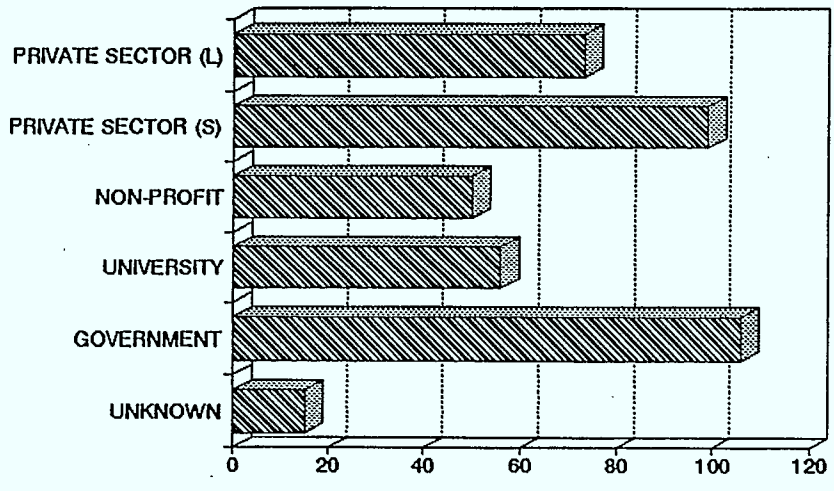
4.2.1 Linked Unit Organization Type

Most linkages occur with government, which is a trend that was to be expected. The second most important type of unit linked with is small, private sector organizations which is consistent with the structure of Canada's R&D community. It is misleading to conclude that non–profit organization are the least popular type of organization to link with as they comprise the smallest category. The three sectors are not as similar in this area but there are not particularly strong trends differentiating them either.

Table 2–1: Linked Unit Organization Type

	Alberta	Environ.	Telecom.	All
UNKNOWN	11	1	3	15
GOVERNMENT	40	51	15	106
UNIVERSITY	20	25	11	56
NON-PROFIT	24	17	9	50
PRIVATE (S)	29	39	31	99
PRIVATE (L)	36	18	19	73
ALL	160	151	88	399

Figure 2–1: Linked Unit Organization Type



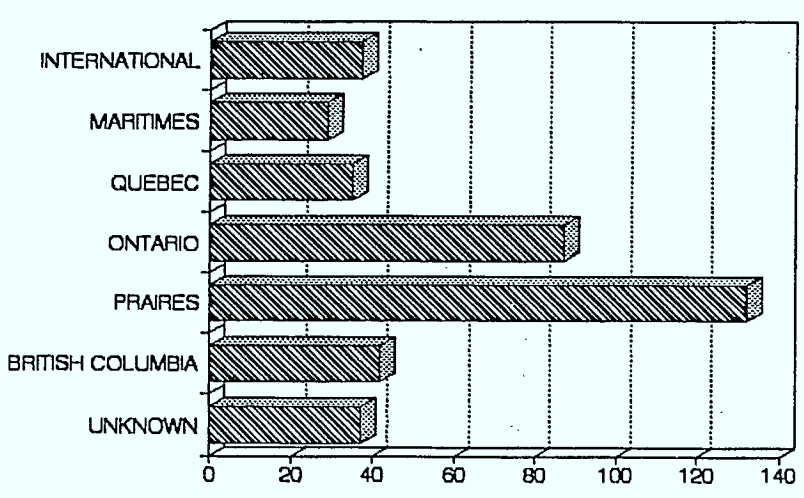
4.2.2 Linked Unit Region

Since most linkages are with organizations which are geographically close, the linked unit region is heavily influenced by the number of study units surveyed in each region. This is especially true for the praires because of the large number of organizations surveyed in Alberta. In spite of this, it is evident that Ontario plays a more significant role in linkages than the other regions.

Table 2-2: Linked Unit Region

	Alberta	Environ.	Telecom.	All
UNKNOWN	17	11	9	37
BRITISH COLUMBIA	5	26	11	42
PRAIRES	96	19	17	132
ONTARIO	16	42	29	87
QUEBEC	3	21	11	35
MARITIMES	2	20	7	29
INTERNATIONAL	21	12	4	37
ALL	160	151	88	399

Figure 2-2: Linked Unit Region



4.2.3 Number of People

The number of people from the Study unit involved in the linkage falls most predominantly in the 2 to 5 people range. The trend is consistent across all sectors. A similar trend exits for the number of people in the Linked unit involved in the linkage but it is not quite as strong. The 20+ range is more predominant which may indicate that the study unit feels it has access to more people and interacts with a larger group than it itself has involved in the linkage.

Table 2–3: Number of People

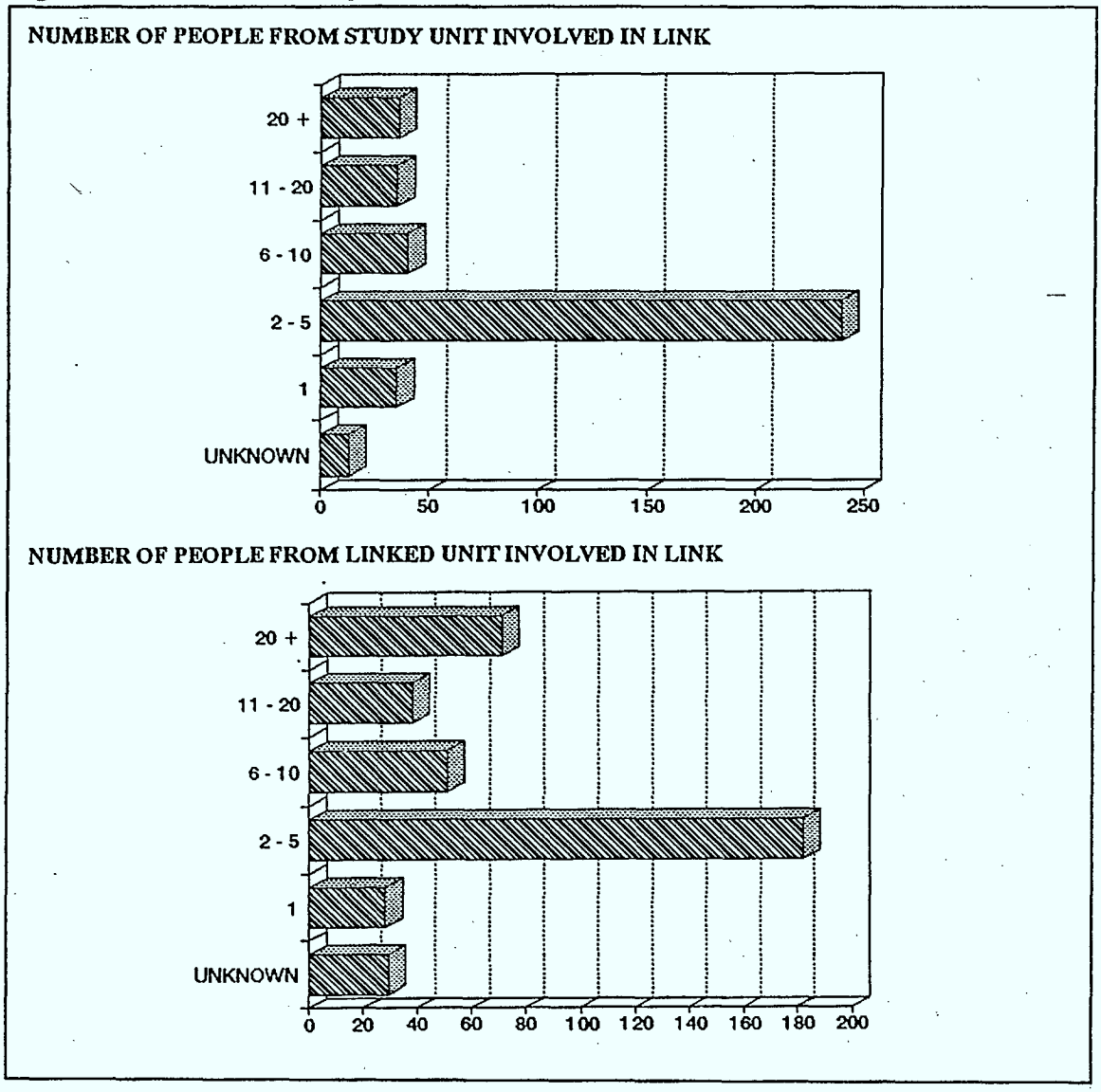
NUMBER OF PEOPLE FROM STUDY UNIT INVOLVED IN LINK

	Alberta	Environ.	Telecom.	All
UNKNOWN	4	6	3	13
1	17	7	11	35
2 - 5	91	95	54	240
6 - 10	18	17	5	40
11 - 20	18	13	4	35
20 +	12	13	11	36
ALL	160	151	88	399

NUMBER OF PEOPLE FROM LINKED UNIT INVOLVED IN LINK

	Alberta	Environ.	Telecom.	All
UNKNOWN	12	13	4	29
1	13	8	7	28
2 - 5	66	69	47	182
6 - 10	17	23	11	51
11 - 20	16	13	9	38
20 +	36	25	10	71
ALL	160	151	88	399

Figure 2–3: Number of People



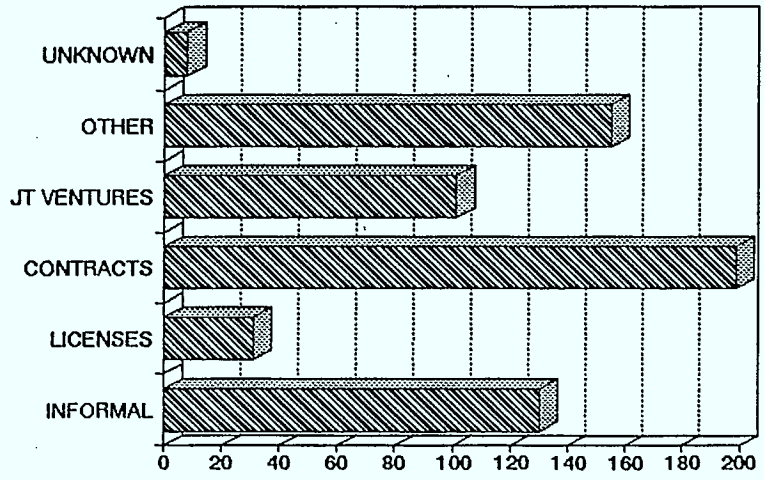
4.2.4 Linkage Type

Contracts are the important type of linkage arrangement. In the "other" category, the most frequent explanation given was funding. MOU's, Board of Directors memberships, and teaching were frequently mentioned in the "other" category.

Table 2–4: Linkage Type

	Alberta	Environ.	Telecom.	All
INFORMAL	45	59	26	130
LICENSES	14	8	9	31
CONTRACTS	83	79	37	199
JT VENTURES	38	49	14	101
OTHER	33	80	42	155
UNKNOWN	4	1	3	8
NUMBER RESPONSES	160	151	88	399

Figure 2–4: Linkage Type



4.2.5 Linkage Importance

A large majority of respondents feel that linkages are presently very important to their operations. This is consistent with all other study findings. Also, a large number of respondents feel that the future importance of reported linkages will increase or remain the same. Very few feel that there importance will decrease.

Table 2–5: Linkage Importance

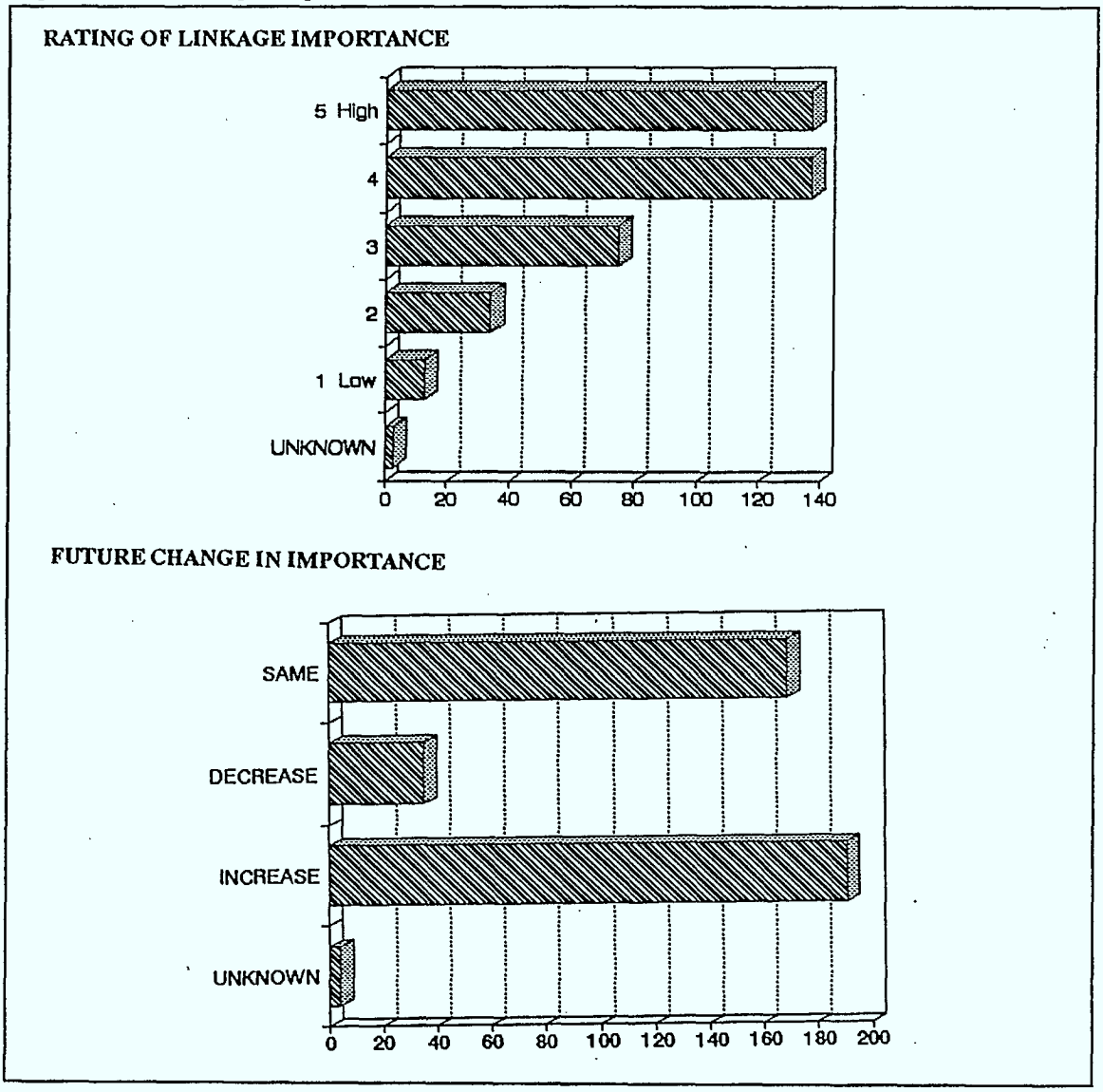
RATING OF LINKAGE IMPORTANCE

	Alberta	Environ.	Telecom.	All
UNKNOWN	0	2	1	3
1 Low	5	5	3	13
2	12	13	9	34
3	41	24	10	75
4	49	53	35	137
5 High	53	54	30	137
ALL	160	151	88	399

FUTURE CHANGE IN IMPORTANCE

	Alberta	Environ.	Telecom.	All
UNKNOWN	0	2	2	4
INCREASE	79	72	40	191
DECREASE	21	11	3	35
SAME	60	66	43	169
ALL	160	151	88	399

Figure 2–5: Linkage Importance



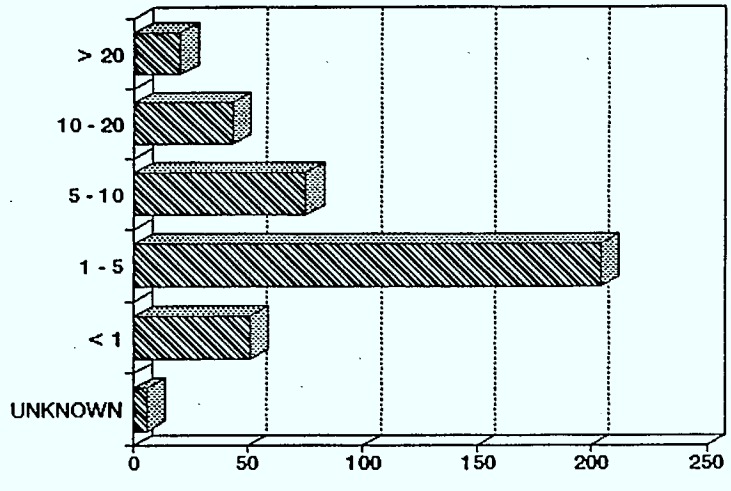
4.2.6 Linkage Duration

The majority of linkages tend to have been in existence for a duration of 1 to 5 years. This is true for all three sectors with Telecommunications having a large number of new linkage i.e. less than one year. This may be indicative of the extreme competitiveness of the telecommunications industry and the need to constantly form new linkages to remain competitive in the market place.

Table 2-6: Linkage Duration (years)

	Alberta	Environ.	Telecom.	All
UNKNOWN	1	3	2	6
< 1	20	11	20	51
1 - 5	73	74	57	204
5 - 10	28	42	5	75
10 - 20	28	13	2	43
> 20	10	8	2	20
ALL	160	151	88	399

Figure 2-6: Linkage Duration (years)



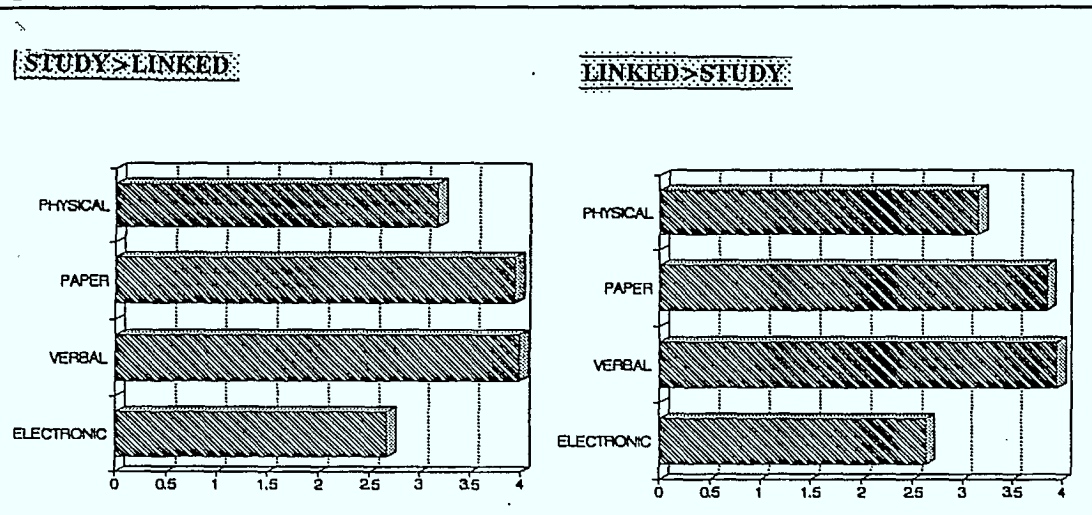
4.2.7 Exchange Mechanisms

For both directions of exchange (study>link and link>study) the most important mechanism by which the exchange occurs is verbal with the second most important being paper. These finding correlates to the item exchanged i.e information and the topic of exchange which in most cases would be research findings. The least important mechanism is electronic. These trends are consistent for all three sectors.

Table 2-7: Exchange Mechanisms

	Alberta	Environ.	Telecom.	AVG
STUDY>LINKED				
ELECTRONIC	2.8	2.6	2.7	2.7
VERBAL	4.0	4.0	4.0	4.0
PAPER	4.0	4.0	3.9	3.9
PHYSICAL	3.2	2.9	3.4	3.2
LINKED>STUDY				
ELECTRONIC	2.7	2.6	2.6	2.6
VERBAL	3.8	4.0	4.0	3.9
PAPER	3.8	4.0	3.8	3.8
PHYSICAL	3.1	3.0	3.4	3.1

Figure 2-7: Exchange Mechanisms



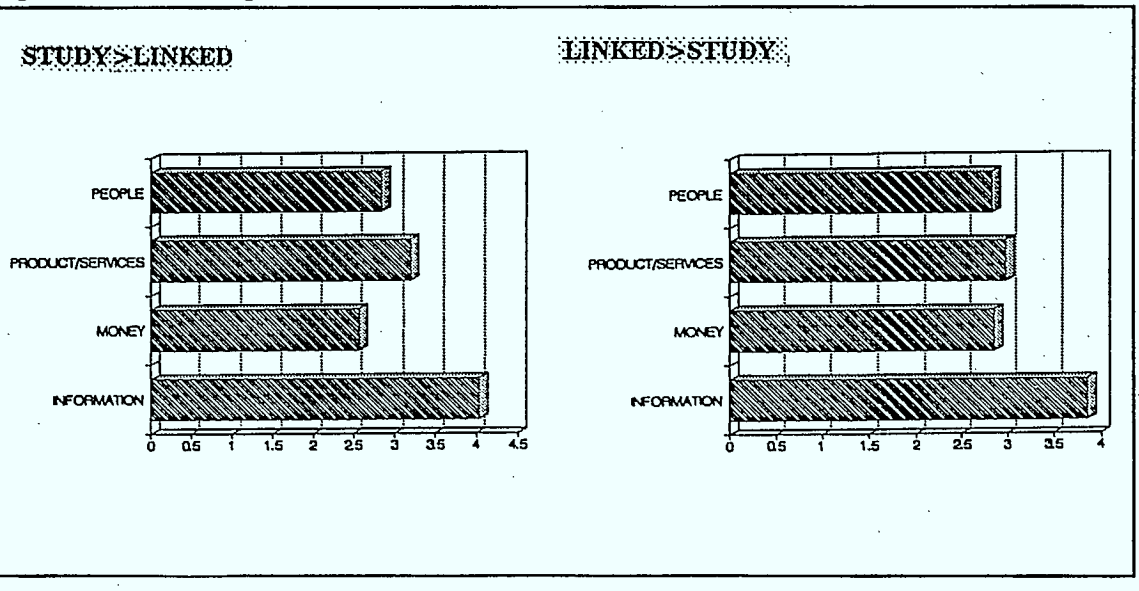
4.2.8 Exchanged Items

For both directions of exchange (study>link and link>study) information is the most important item exchanged. This is consistent in all sectors and is not a surprising result considering the type of organizations that participated in the survey.

Table 2-8: Exchanged Items

	Alberta	Environ.	Telecom.	AVG
STUDY>LINKED	0	0	0	0
INFORMATION	4.0	4.1	4.0	4.0
MONEY	2.5	2.4	2.8	2.6
PRODUCT/SERVICES	3.2	3.4	2.9	3.2
PEOPLE	2.9	2.8	2.8	2.8
LINKED>STUDY	0.0	0.0	0.0	0.0
INFORMATION	3.7	4.0	3.8	3.9
MONEY	2.9	2.6	3.0	2.9
PRODUCT/SERVICES	3.0	3.0	3.0	3.0
PEOPLE	2.8	2.8	2.8	2.8

Figure 2-8: Exchanged Items



4.2.9 Contact Frequency

Of the linkages that were reported, interaction between parties tends to occur most often on a monthly or weekly basis. It is rare for a linkage interaction to only take place on an annual basis. Yearly interaction may not be frequent enough for many organizations to consider it an important linkage. Again, this finding is consistent over all three sectors.

In the majority of cases the frequency of contact with a linked unit will stay the same or increase.

Table 2-9: Contact Frequency

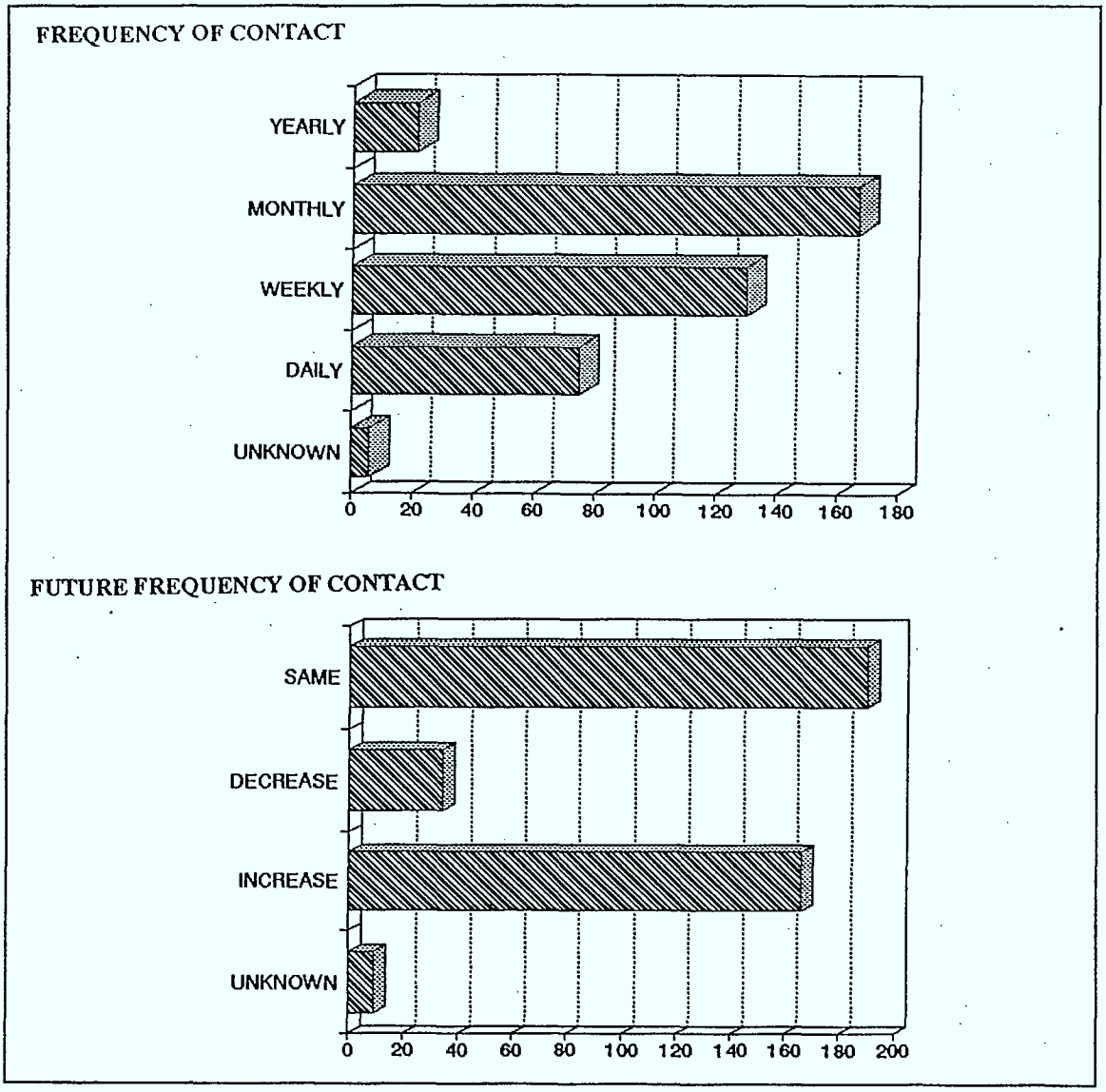
FREQUENCY OF CONTACT

	Alberta	Environ.	Telecom.	All
UNKNOWN	1	5	0	6
DAILY	35	22	18	75
WEEKLY	49	52	29	130
MONTHLY	68	66	33	167
YEARLY	7	6	8	21
ALL	160	151	88	399

FUTURE FREQUENCY OF CONTACT

	Alberta	Environ.	Telecom.	All
UNKNOWN	3	5	1	9
INCREASE	76	54	36	166
DECREASE	23	7	4	34
SAME	58	85	47	190
ALL	160	151	88	399

Figure 2–9: Contact Frequency



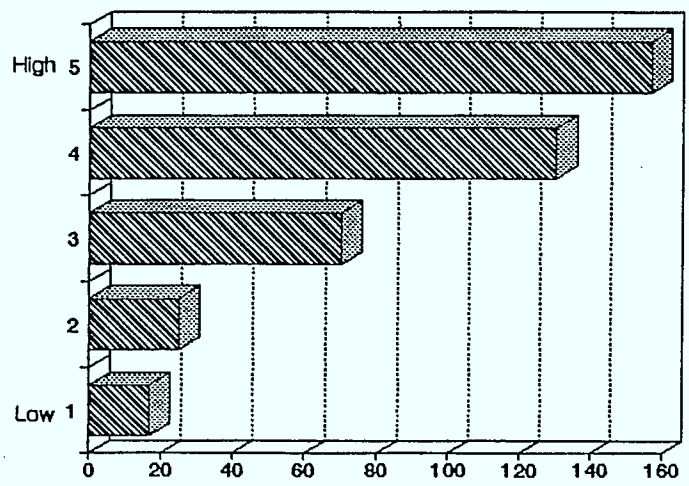
4.2.10 Benefit

In the majority of cases the benefit derived from a linkage is high. This trend is similar for all three sectors. Note that participants may only have responded for linkages that they derive a beneficial outcome from.

Table 2–10: Benefit

	Alberta	Environ.	Telecom.	All
1 Low	8	5	4	17
2	11	7	7	25
3	32	24	14	70
4	55	48	27	130
5 High	54	67	36	157
ALL	160	151	88	399

Figure 2–10: Benefit



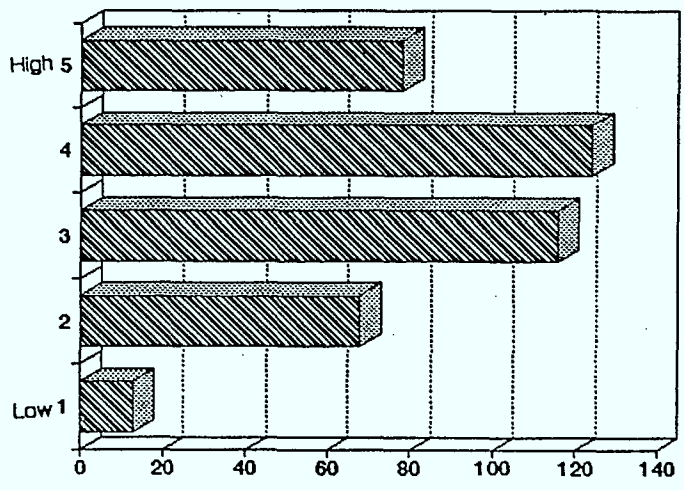
4.2.11 Effort

Most linkages require a reasonable amount of effort.

Table 2–11: Effort

	Alberta	Environ.	Telecom.	All
1 Low	4	5	4	13
2	26	22	20	68
3	45	47	24	116
4	53	45	26	124
5 High	32	32	14	78
ALL	160	151	88	399

Figure 2–11: Effort



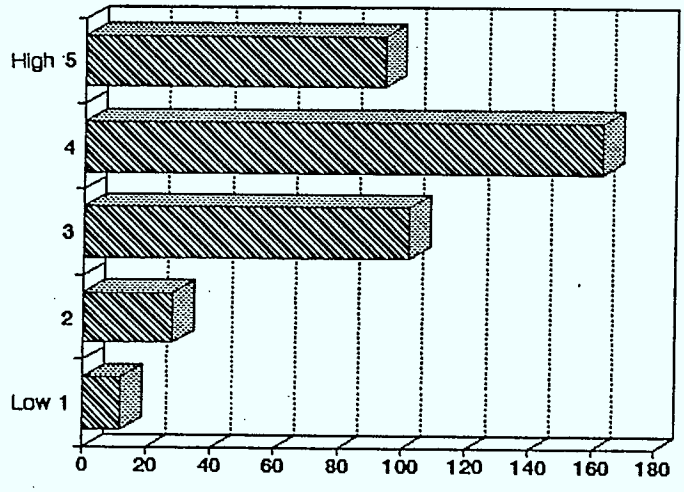
4.2.12 Satisfaction

Most linkages received a relatively high satisfaction rating. This again may be related to the fact that respondents may have only report linkages that they were satisfied with. There also seems to be a correlation between the level of effort and benefit and the level of satisfaction obtained.

Table 2–12: Satisfaction

	Alberta	Environ.	Telecom.	All
1 Low	8	2	2	12
2	16	7	5	28
3	50	32	20	102
4	61	62	40	163
5 High	25	48	21	94
ALL	160	151	88	399

Figure 2–12: Satisfaction



4.3 OTHER

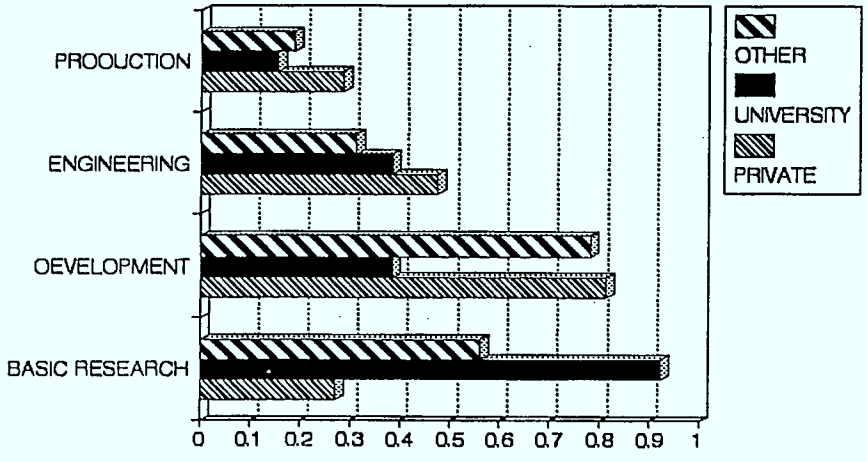
4.3.1 Research Stage versus Organization Type

As was expected, most university respondents report performing basic research versus only approximately 25% of the private sector respondents. The private sector and other category (non–profit and government) responses indicate an emphasis on developmental research. The low response for production research can be attributed to the bias imposed by the selection of respondents from research centres of organizations. Had the interviewees been selected from organization's engineering or production departments, it is expected that these results would be different.

Table 3–1: Research Stage versus Organization Type

	PRV	UNV	OTH
BASIC RESEARCH	27%	92%	56%
DEVELOPMENT	81%	38%	78%
ENGINEERING	47%	38%	31%
PRODUCTION	29%	15%	19%

Figure 3–1: Research Stage versus Organization Type



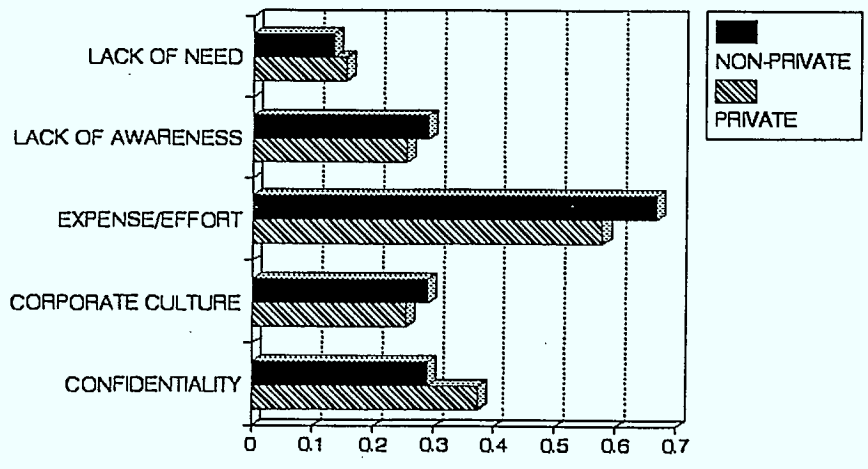
4.3.2 Linkage Barriers versus Organization Type

The most often reported barrier by both private and non–private organizations was expense/effort. This reflects the amount of effort that is required to establish and maintain linkages. Confidentiality was the second most often mentioned barrier, slightly higher for private sector organizations. Lack of need was the lowest barrier for all types of organizations, indicating the respondents' perception of the importance of linkages.

Table 3–2: Linkage Barriers versus Organization Type

	PRV	NON-PRV
CONFIDENTIALITY	37%	29%
CORPORATE CULTURE	25%	29%
EXPENSE/EFFORT	58%	67%
LACK OF AWARENESS	25%	29%
LACK OF NEED	15%	13%

Figure 3–2: Linkage Barriers versus Organization Type



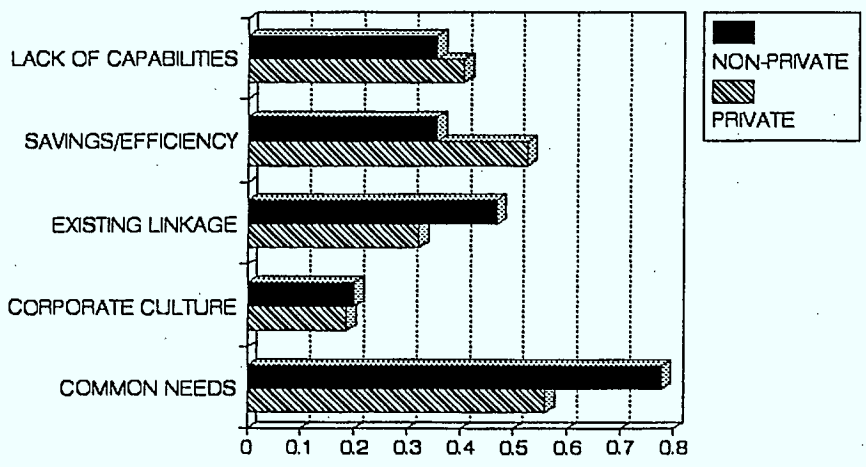
4.3.3 Linkage Facilitators versus Organization Type

Common needs was the most often reported facilitator for both private and non-private organizations. It is interesting to note that while corporate culture and lack of capability were reported as facilitators by roughly the same percentage of both private and non-private organizations, existing linkages and savings efficiency were not. Existing linkages prove to be more of a significant facilitator for non-private sector organizations. This could reflect a long term, rigid approach to linkages by government, universities and non-profit organizations. Savings/efficiency was reported as a facilitator by over half of the private sector respondents and only 36% of the non-private. Thus, private sector organizations tend to gain a competitive advantage through linkages as linkages result in increased efficiency.

Table 3-3: Linkage Facilitators versus Organization Type

	PRV	NON-PRV
COMMON NEEDS	56%	78%
CORPORATE CULTURE	19%	20%
EXISTING LINKAGE	32%	47%
SAVINGS/EFFICIENCY	53%	36%
LACK OF CAPABILITIES	41%	36%

Figure 3-3: Linkage Facilitators versus Organization Type



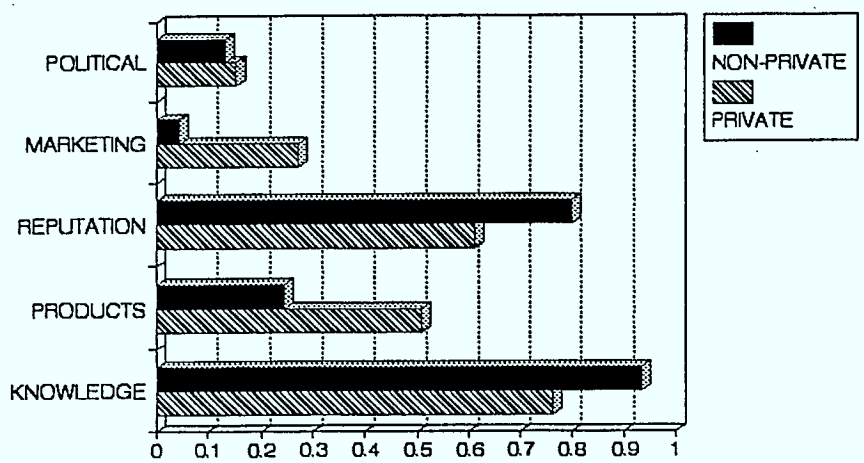
4.3.4 Linkage Reasons versus Organization Type

Knowledge and reputation were the most frequently reported reasons that private and non–private organizations gave as to why others formed linkages with them. It is interesting to note that these two factors were reported more frequently by non–private (universities, government and non–profit) than private sector organizations. While products was ranked third, it is not surprising it was a more important reason for private sector organizations. Similarly, very few non–private sector organizations reported marketing as a reason that others link with them.

Table 3–4: Linkage Reasons versus Organization Type

	PRV	NON-PRV
KNOWLEDGE	76%	93%
PRODUCTS	51%	24%
REPUTATION	61%	80%
MARKETING	27%	4%
POLITICAL	15%	13%

Figure 3–4: Linkage Reasons versus Organization Type



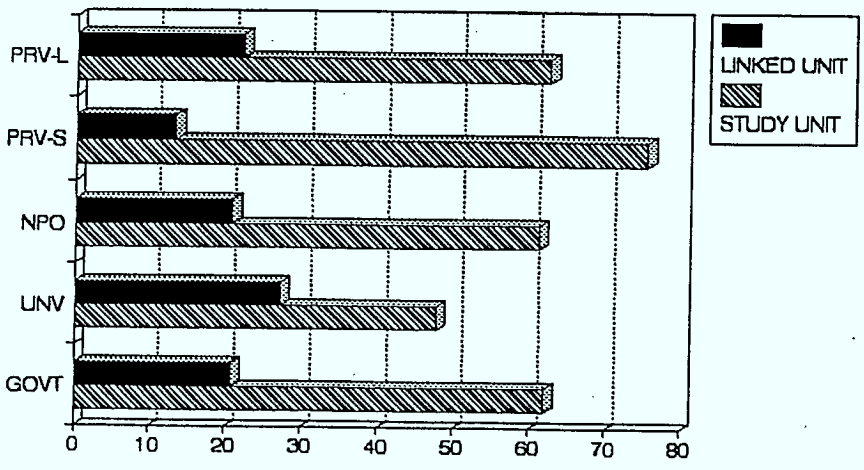
4.3.5 Linkage Initiator versus Organization Type

It was to be expected that the majority of reported linkages were initiated by the study unit. Respondents reported their most important linkages and thus it was confirmed that linkages initiated by the study unit are viewed as the most important to their work. Very few organizations reported third party or mutual initiation. One significant discovery is that universities show a higher level of linked unit and mutual initiation than do the other organization types. This is consistent with other study findings that show universities as not particularly pro–active in initiating linkages with the outside world.

Table 3–5: Linkage Initiator versus Organization Type

	GOV	UNV	NPO	PRV-S	PRV-L	ALL
UNKNOWN	3.26	4.55	7.46	0	1.92	3.01
STUDY UNIT	62	47.7	61.2	75.6	62.5	63.4
LINKED UNIT	20.7	27.3	20.9	13.3	22.1	20.3
THIRD PARTY	3.26	4.55	7.46	10	10.6	7.52
MUTUAL	3.26	15.9	2.99	0	0.96	3.26
STUDY + THIRD	1.09	0	0	0	0.96	0.5
THREE PARTIES	3.26	0	0	1.11	0.96	1.25
ALL	100	100	100	100	100	100

Figure 3–5: Linkage Initiator versus Organization Type



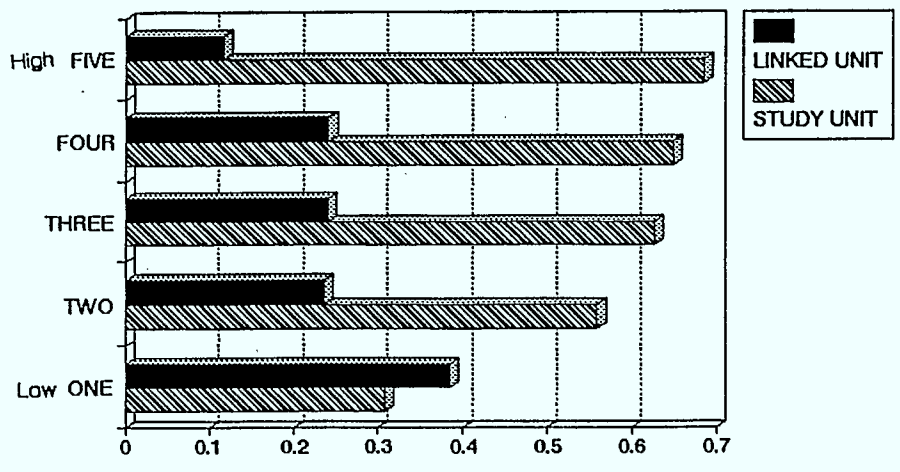
4.3.6 Linkage Initiator versus Linkage Importance

This graph illustrates the relationship between the reported importance of linkages and initiator. With the exception of the linkages with an importance ranking of "1", the vast majority of linkages, regardless of importance, were initiated by the study unit. The likelihood that a linkage was initiated by the linked unit increases as the importance ranking decreases. Linkages that were initiated by the study unit tend to be viewed as more important.

Table 3–6: Linkage Initiator versus Linkage Importance

	UNK	ONE	TWO	THREE	FOUR	FIVE
UNKNOWN	67%	0%	6%	3%	1%	5%
STUDY UNIT	0%	31%	56%	63%	65%	69%
LINKED UNIT	33%	38%	24%	24%	24%	12%
THIRD PARTY	0%	15%	12%	8%	4%	9%
MUTUAL	0%	15%	0%	3%	2%	4%
STUDY + THIRD	0%	0%	3%	0%	1%	0%
THREE PARTIES	0%	0%	0%	0%	2%	1%
ALL	100%	100%	100%	100%	100%	100%

Figure 3–6: Linkage Initiator versus Linkage Importance



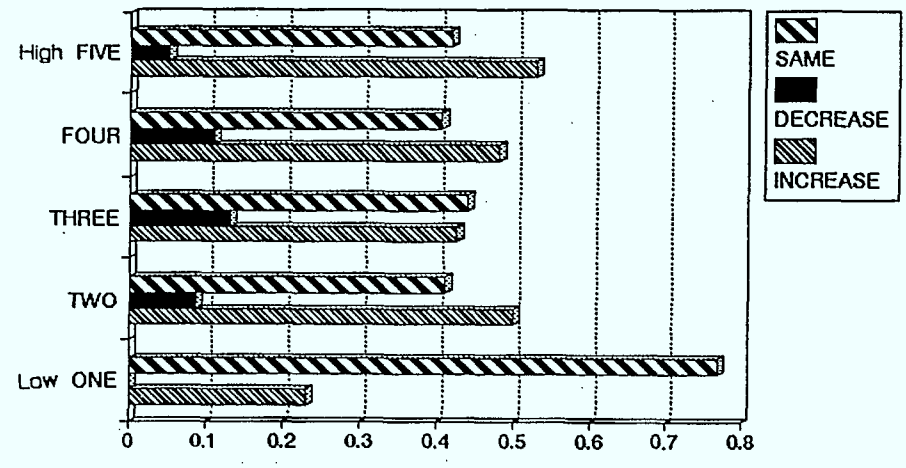
4.3.7 Linkage Importance versus Importance Change

In general, respondents did not anticipate a future decrease in importance for many of their current linkages. With the exception of linkages whose current importance is ranked very low (1), the importance of linkages, regardless of current importance, is equally expected to increase or remain the same.

Table 3–7: Linkage Importance versus Importance Change

	INCR	DEC	SAM	ALL
ONE Low	23%	0%	77%	100%
TWO	50%	9%	41%	100%
THREE	43%	13%	44%	100%
FOUR	48%	11%	41%	100%
FIVE High	53%	5%	42%	100%

Figure 3–7: Linkage Importance versus Importance Change



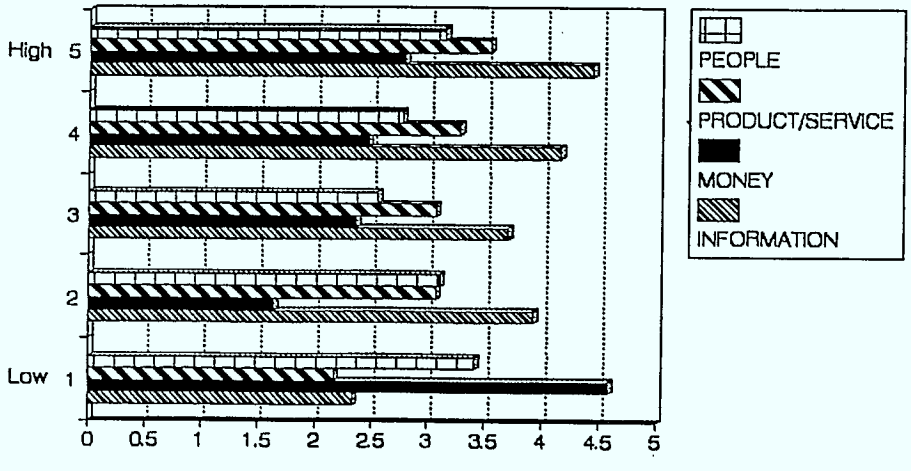
4.3.8 Importance of Linkage Items versus Linkage Satisfaction

This table shows, for each level of satisfaction (1 through 5), the average reported importance of each item exchanged. The most significant observation is that the satisfaction with linkages increases with the importance of information exchanged (in both directions). Also note that money is viewed as important in linkages that are less satisfactory. This supports other study findings that indicate that the exchange of dollars does not necessarily constitute a rewarding linkage. Many do not even consider this form of exchange a linkage.

Table 3–8: Importance of Linkage Items versus Linkage Satisfaction

	1	2	3	4	5	ALL
STUDY>LINKED						
INFORMATION	2.3	3.9	3.7	4.2	4.4	3.7
MONEY	4.6	1.6	2.4	2.5	2.8	2.8
PRODUCT/SERVICE	2.2	3.1	3.1	3.3	3.5	3.0
PEOPLE	3.4	3.1	2.6	2.8	3.2	3.0
LINKED>STUDY						
INFROMATION	3.3	2.8	3.7	3.9	4.3	3.6
MONEY	2.2	2.9	2.4	2.8	3.4	2.7
PRODUCT/SERVICE	3.1	2.4	2.8	3.1	3.2	2.9
PEOPLE	3.8	2.2	2.8	2.7	3.0	2.9

Figure 3–8: Importance of Linkage Items versus Linkage Satisfaction



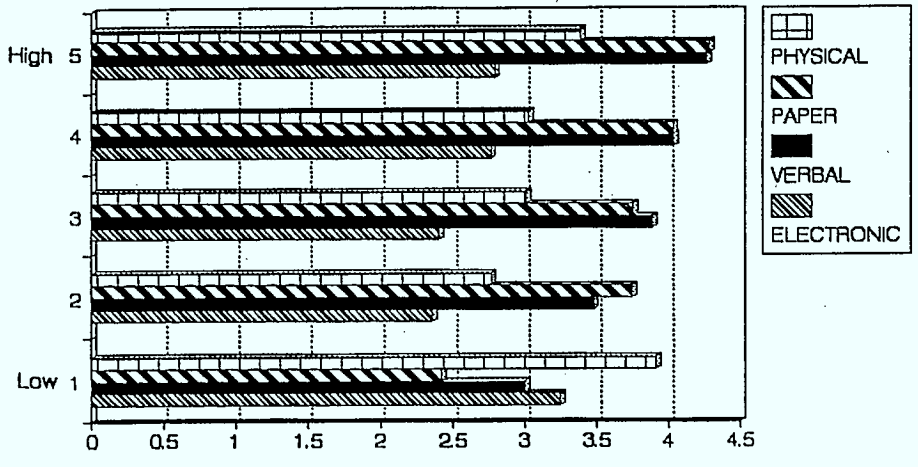
4.3.9 Importance of Linkage Mechanisms versus Linkage Satisfaction

This table illustrates, for each level of satisfaction (1 through 5), the average reported importance of each mechanism of exchange. Generally, higher levels of satisfaction come with an increased relative importance of verbal and paper exchange. The verbal exchange ranking is important as it corroborates the interview findings that successful linkages are characterized by face–to–face, or verbal exchanges. Higher levels of satisfaction were also generally characterised by an increased importance of electronic and physical exchange mechanisms, but at a lower relative level than verbal and paper exchange.

Table 3–9: Importance of Linkage Mechanisms versus Linkage Satisfaction

	1	2	3	4	5	ALL
STUDY>LINKED						
ELECTRONIC	3.3	2.4	2.4	2.8	2.8	2.7
VERBAL	3.0	3.5	3.9	4.0	4.3	3.7
PAPER	2.4	3.8	3.8	4.0	4.3	3.6
PHYSICAL	3.9	2.8	3.0	3.0	3.4	3.2
LINKED>STUDY						
ELECTRONIC	3.6	2.1	2.4	2.8	2.7	2.7
VERBAL	2.7	3.4	3.8	4.0	4.2	3.6
PAPER	2.9	3.5	3.7	3.9	4.2	3.6
PHYSICAL	4.3	2.7	2.9	3.1	3.4	3.2

Figure 3–9: Importance of Linkage Mechanisms versus Linkage Satisfaction



4.3.10 Study Unit Location versus Linked Unit Location

This table shows for each of the regional areas used for the study (B.C., Prairies, Ontario, Quebec and the Atlantic), the location of the linkages reported by the telecommunications and environment sectors. As was expected, the vast majority of reported linkages occur within the organization's regional area. This information is portrayed graphically on the following maps.

Table 3–10: Study Unit Location versus Linked Unit Location

	BC	PRA	ONT	PQ	ATL
BRITISH COLUMBIA	82%	6%	3%	3%	8%
PRAIRIES	3%	58%	6%	3%	5%
ONTARIO	12%	26%	70%	15%	10%
QUEBEC	0%	8%	6%	73%	2%
MARITIMES	0%	0%	3%	0%	63%
UNITED STATES	3%	0%	9%	0%	0%
EUROPE	0%	2%	2%	6%	12%
ALL	100%	100%	100%	100%	100%

Figure 3–10: Study Unit Location versus Linked Unit Location (British Columbia)

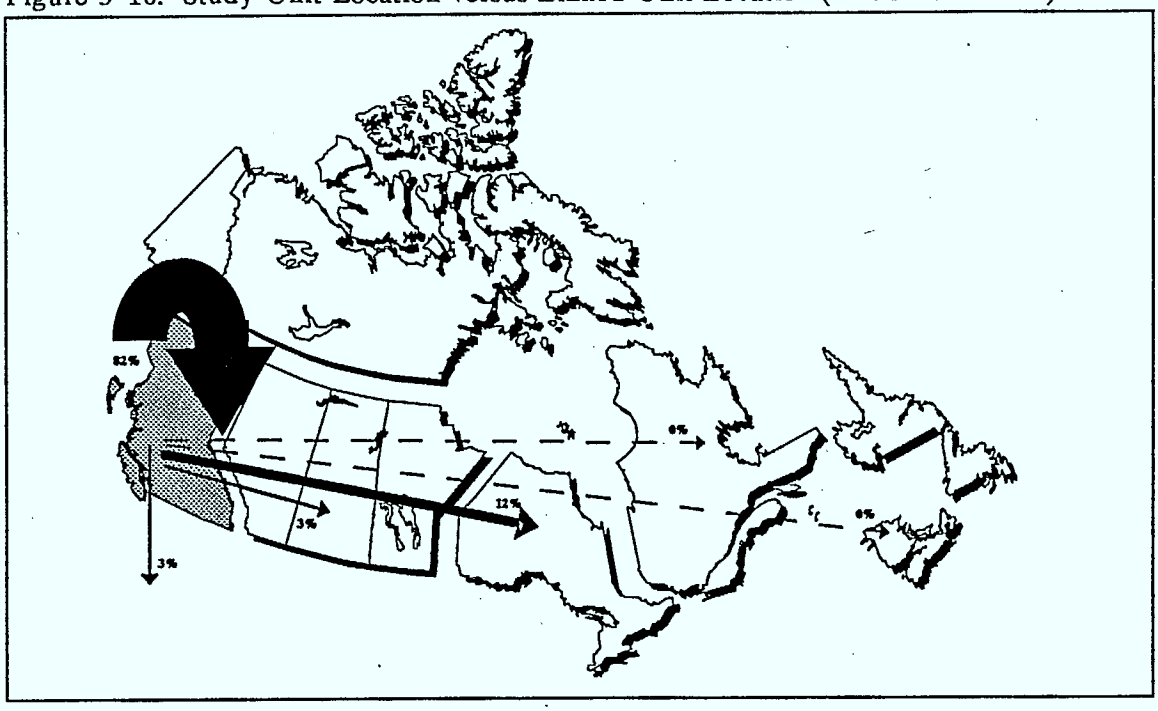


Figure 3–11: Study Unit Location versus Linked Unit Location (Prairies)

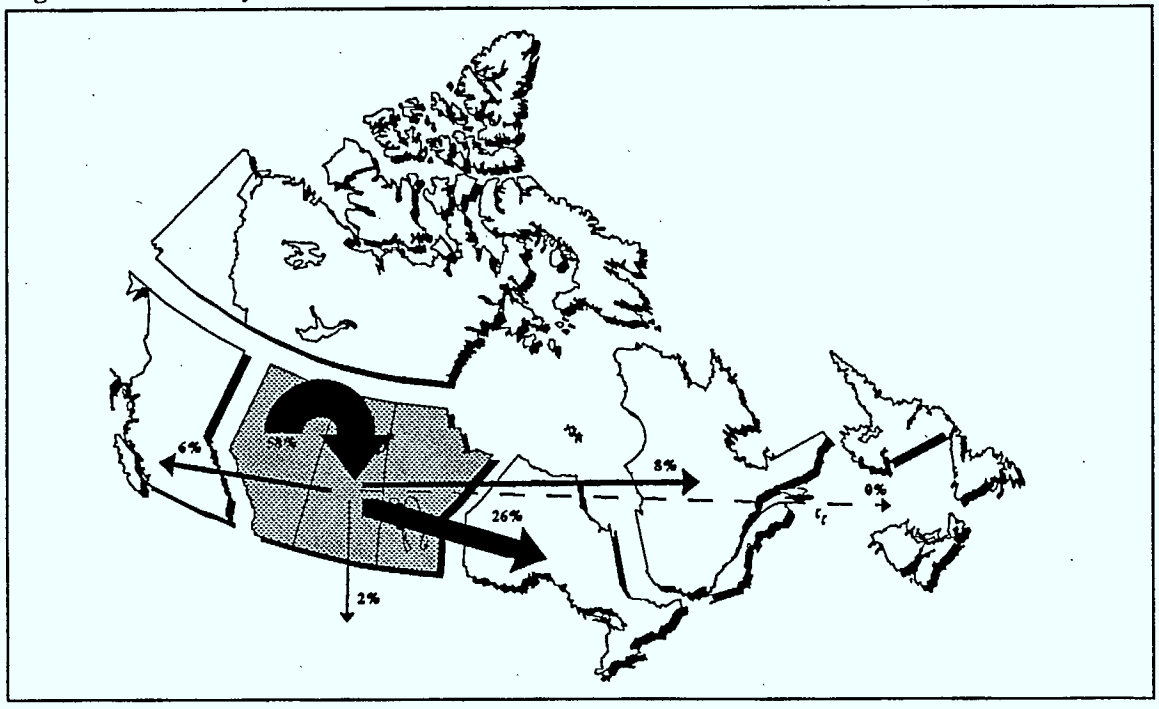


Figure 3–12: Study Unit Location versus Linked Unit Location (Ontario)

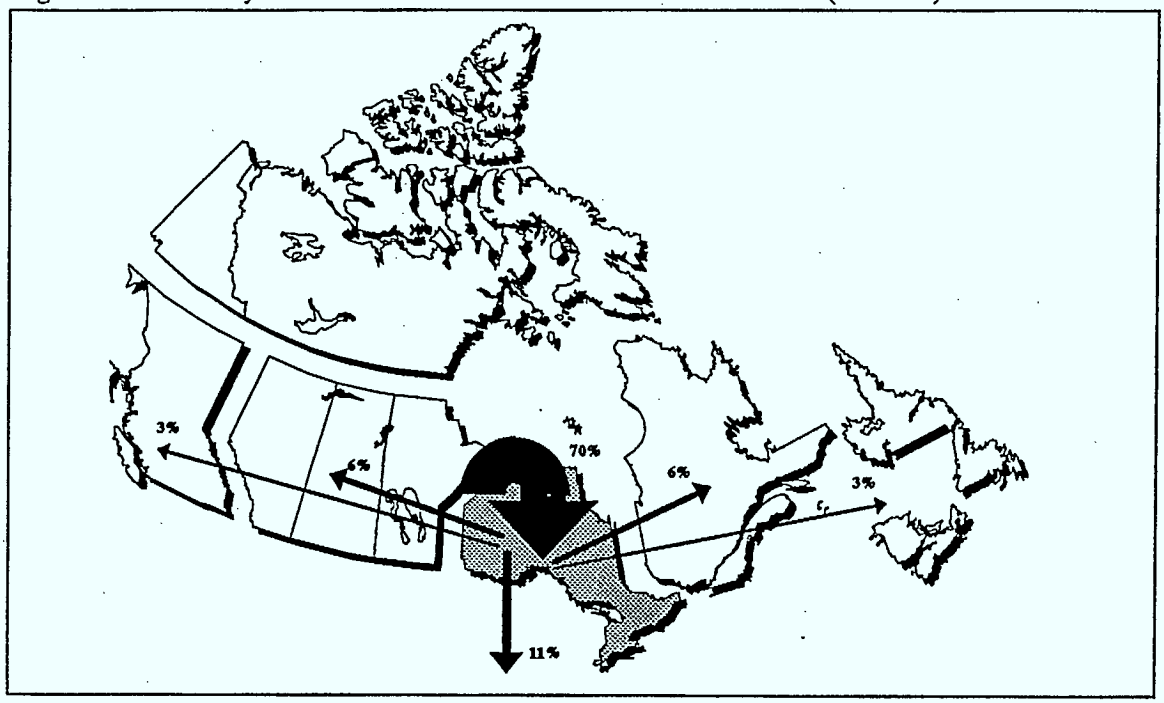


Figure 3–13: Study Unit Location versus Linked Unit Location (Quebec)

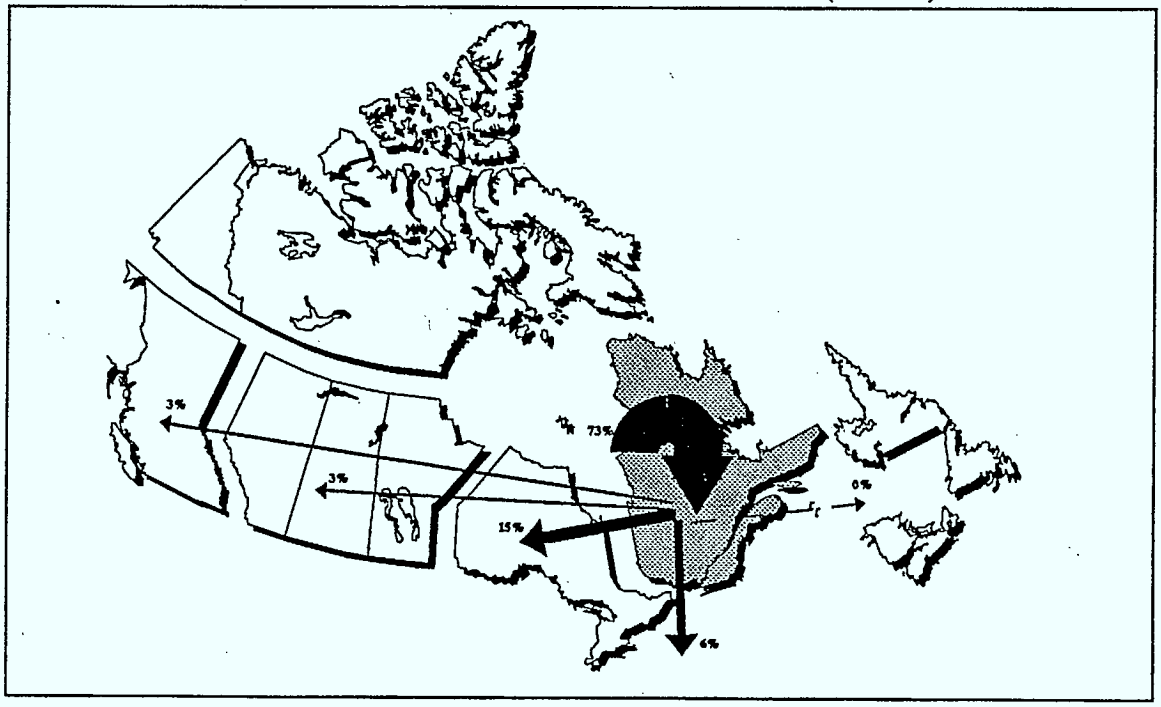


Figure 3–14: Study Unit Location versus Linked Unit Location (Maritimes)

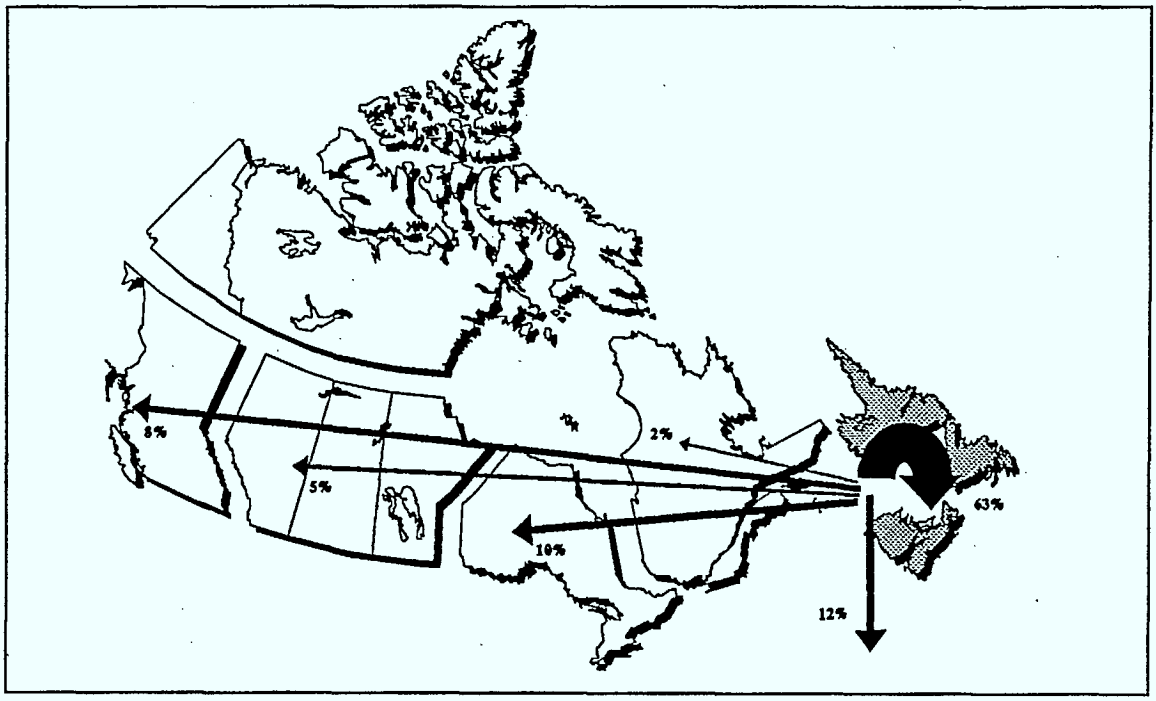


Figure 3–15: Study Unit Location versus Linked Unit Location (Alberta)

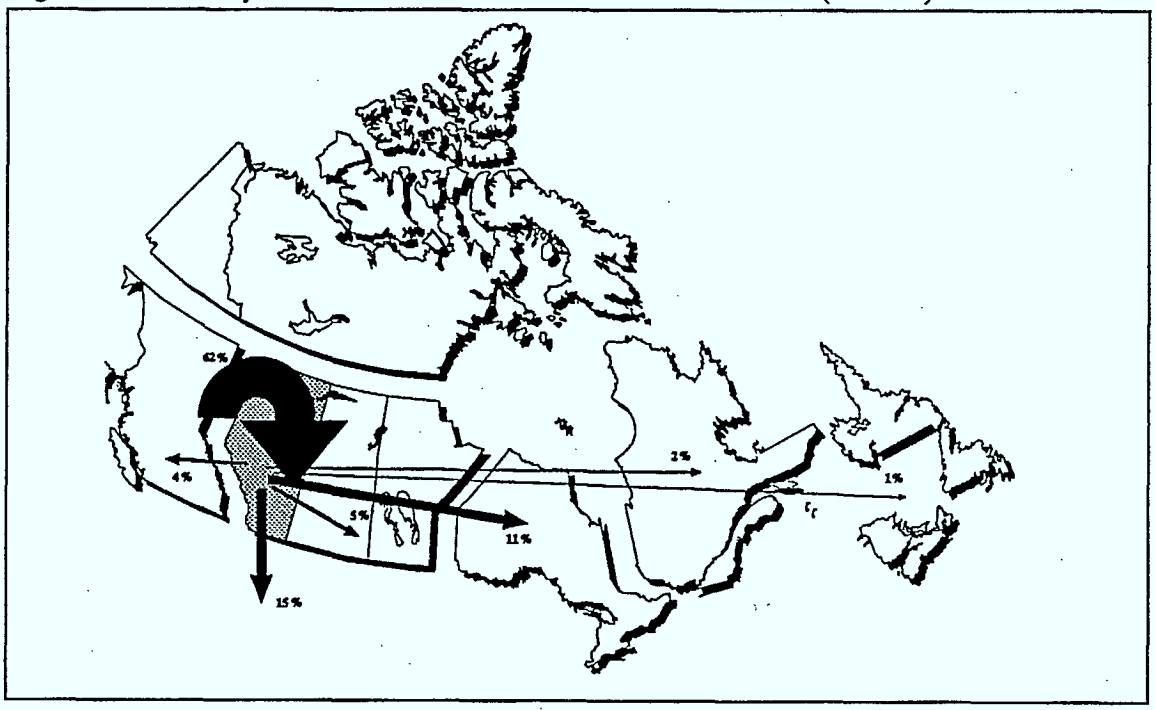


Figure 3-16: Linkage Locations (Environment)

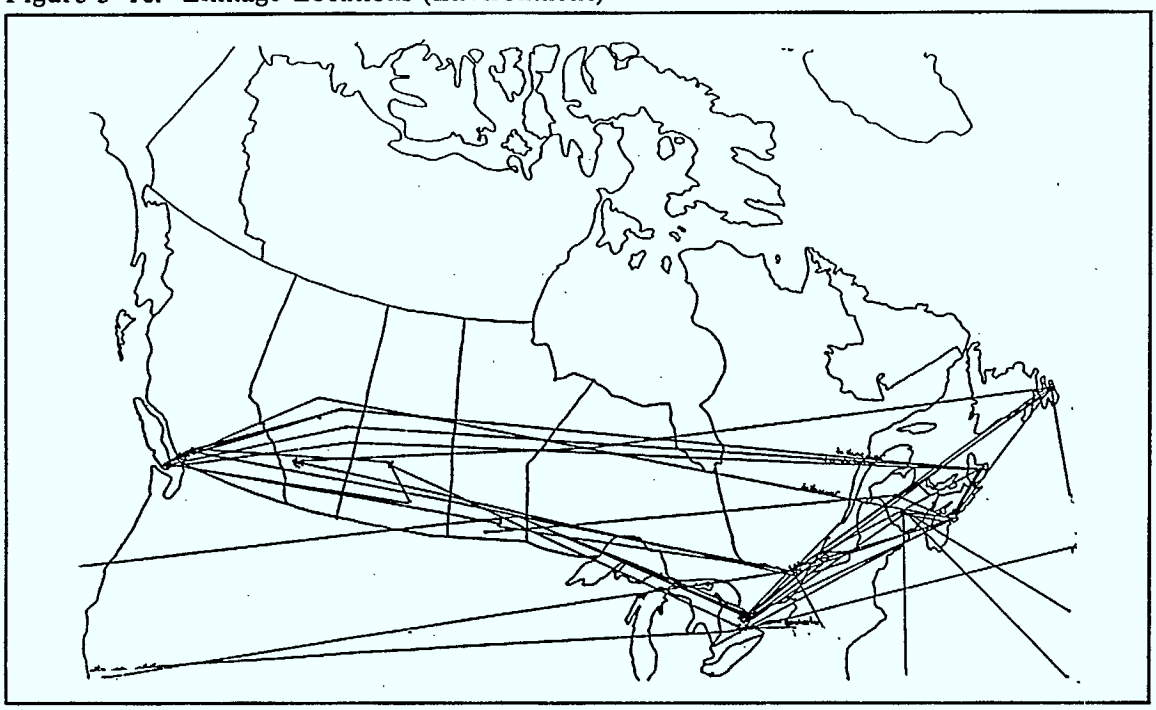


Figure 3-17: Linkage Locations (Telecommunications)

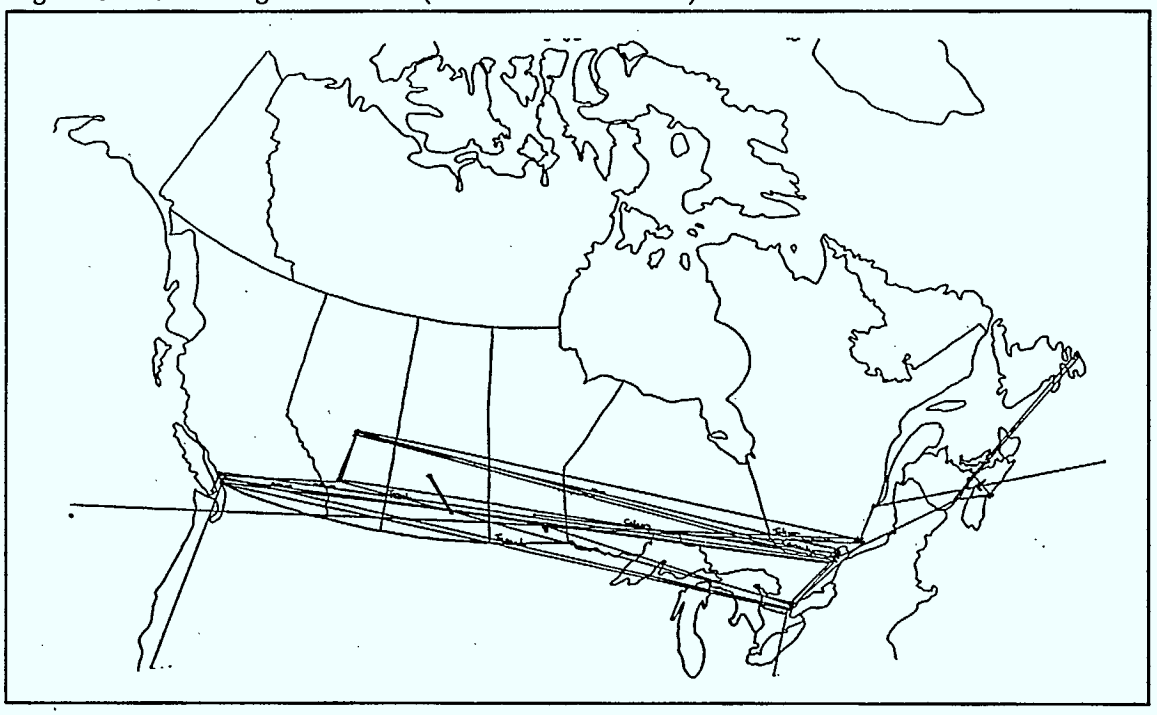
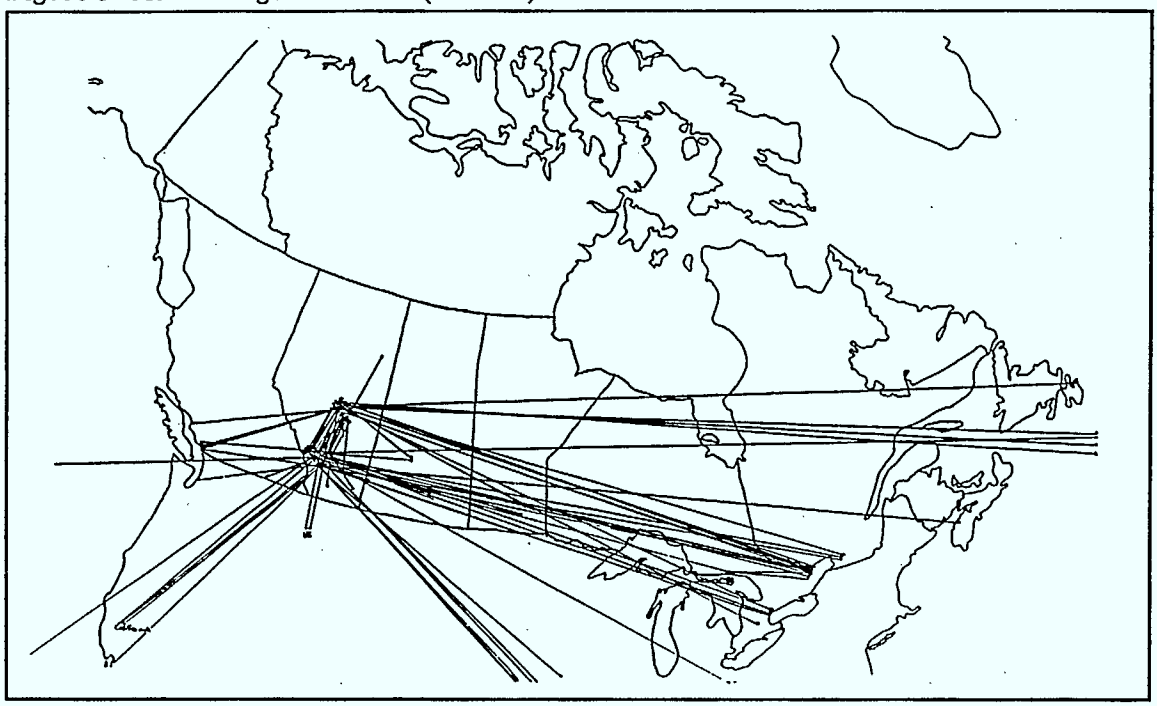


Figure 3-18: Linkage Locations (Alberta)



4.4 FEDERAL LABORATORIES

A seperate analysis was done of linkages involving federal government laboratories. For this analysis, unit types were re-coded to isolate federal government laboratories from other government and non profit organizations. Eight study units and 47 linked units were federal laboratories.

4.4.1 Linked Unit Location

With the exception of British Columbia, for which there was no data, approximately 43% of a population of 47 linkages with federal laboratories as the study unit were with Ontario-based organizations; international linkages corresponded to approximately 13%.

In general, there is a trend toward linkage clustering in the region where the federal laboratory study unit is located; however, this finding requires verification since the analysis is based on a very small linkage population for each region. Regional clustering was greatest for Ontario (63%) and Quebec (100%), and least for the Atlantic provinces (28%). The greatest number of international linkages was noted for federal laboratories in Ontario (21%).

Table 4-1: Linked Unit Location

	STUDY UNIT – FEDERAL LAB				
LINKED UNIT	BC	PRAIRIES	ONTARIO	QUEBEC	ATLANTIC
BC	ND	1 (9%)	0 (0%)	0 (0%)	3 (42%)
PRAIRIES	ND	4 (36%)	3 (13%)	0 (0%)	1 (15%)
ONTARIO	ND	4 (36%)	15 (63%)	0 (0%)	1 (15%)
QUEBEC	ND	1 (9%)	1 (4%)	5 (100%)	0 (0%)
ATLANTIC	ND	0 (0%)	0 (0%)	0 (0%)	2 (48%)
INTERNATIONAL	ND	1 (9%)	5 (21%)	0 (0%)	0 (0%)
TOTAL	ND	11 (100%)	24 (100%)	5 (100%)	7 (100%)

ND NO DATA

4.4.2 Linkage Importance

Over 76% of a total of 64 linkages with federal laboratories were considered to be above average in importance for the study unit.

Table 4-2: Linkage Importance

LINKAGE IMPORTANCE (%)

	OTHER	UNV	SMALL IND	LARGE IND	FEDERAL LAB	TOTAL
1 (LOW)	4	4	2	3	5	3
2	8	4	13	5	9	9
3	24	29	14	19	9	19
4	27	36	39	33	39	34
5 (HIGH)	35	27	32	40	38	34
TOTAL	100	100	100	100	100	100

4.4.3 Linkage Initiator

Federal laboratories were the linkage initiator in approximately 30% of the total number of linkages (64) for which they were a partner.

Table 4-3: Linkage Initiator

LINKAGE INITIATOR (%)

	PROV	UNV	NPO	SMALL IND	LARGE IND	FEDERAL LABS
STUDY UNIT	52	73	61	63	60	71
LINKED UNIT	21	11	20	25	25	16
THIRD PARTY	3	11	14	8	10	2
UNKNOWN	24	5	5	4	5	11
TOTAL	100	100	100	100	100	100

4.4.4 Linkage Quality

The quality of linkages as measured against "benefit", "effort to maintain", and "satisfaction" reported by the study units who linked with federal laboratories was above average to high.

Table 4-4: Linkage Benefit

	OTHER	UNIVERSITY	INDUSTRY
1 (LOW)	3	0	4
2	6	0	5
3	15	0	12
4	18	50	35
5 (HIGH)	58	50	44
TOTAL	100	100	100

Table 4-5: Linkage Effort

	OTHER	UNIVERSITY	INDUSTRY
1 (LOW)	9	0	0
2	16	25	4
3	15	25	48
4	24	50	23
5 (HIGH)	36	0	25
TOTAL	100	100	100

Table 4-6: Linkage Satisfaction

	OTHER	UNIVERSITY	INDUSTRY
1 (LOW)	6	0	4
2	0	0	4
3	15	25	36
4	29	75	36
5 (HIGH)	50	0	20
TOTAL	100	100	100

Figure 4-1: Linkage Benefit

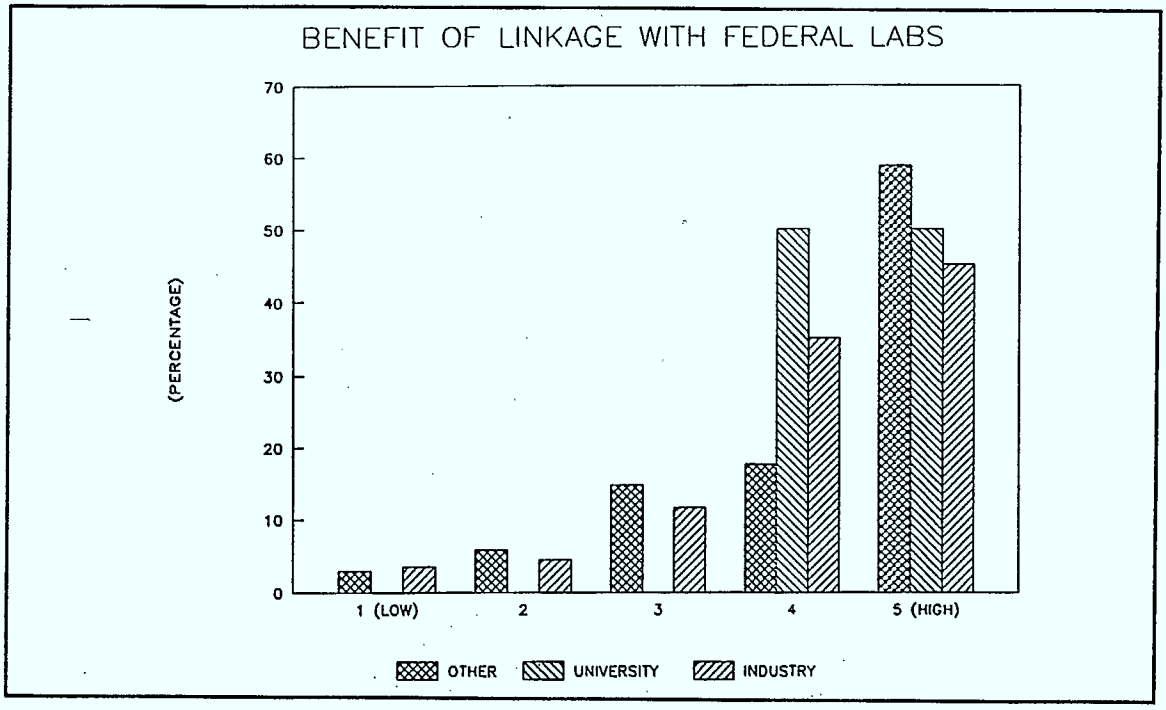


Figure 4-2: Linkage Effort

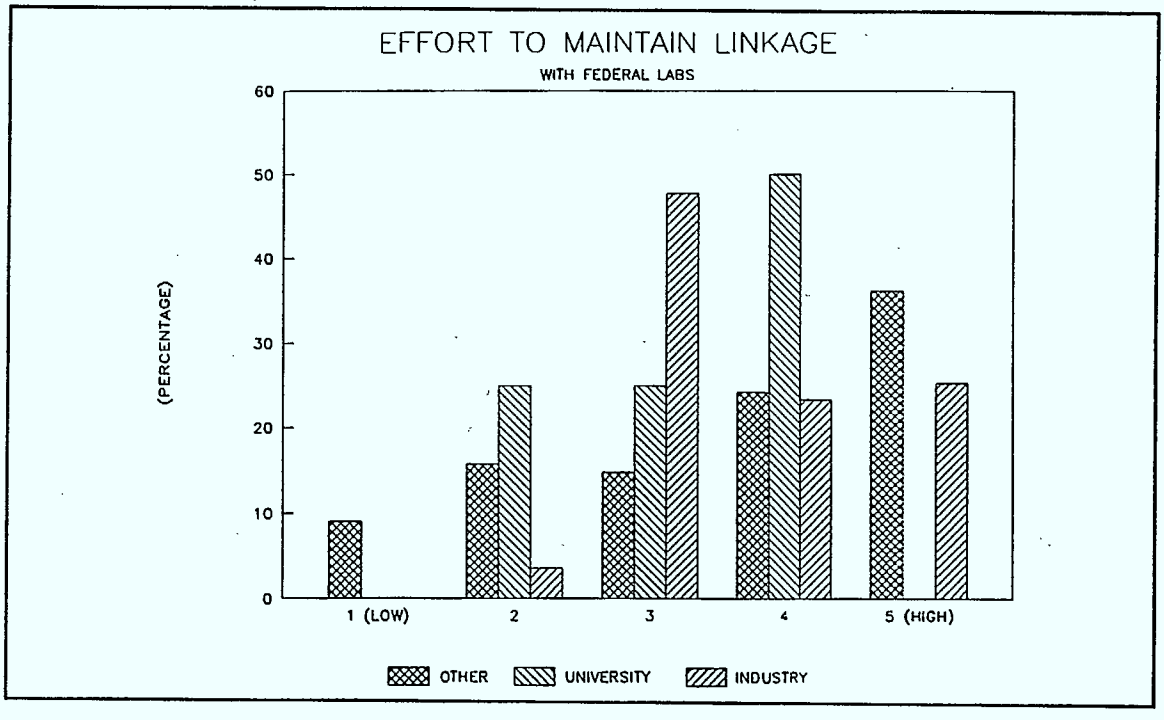
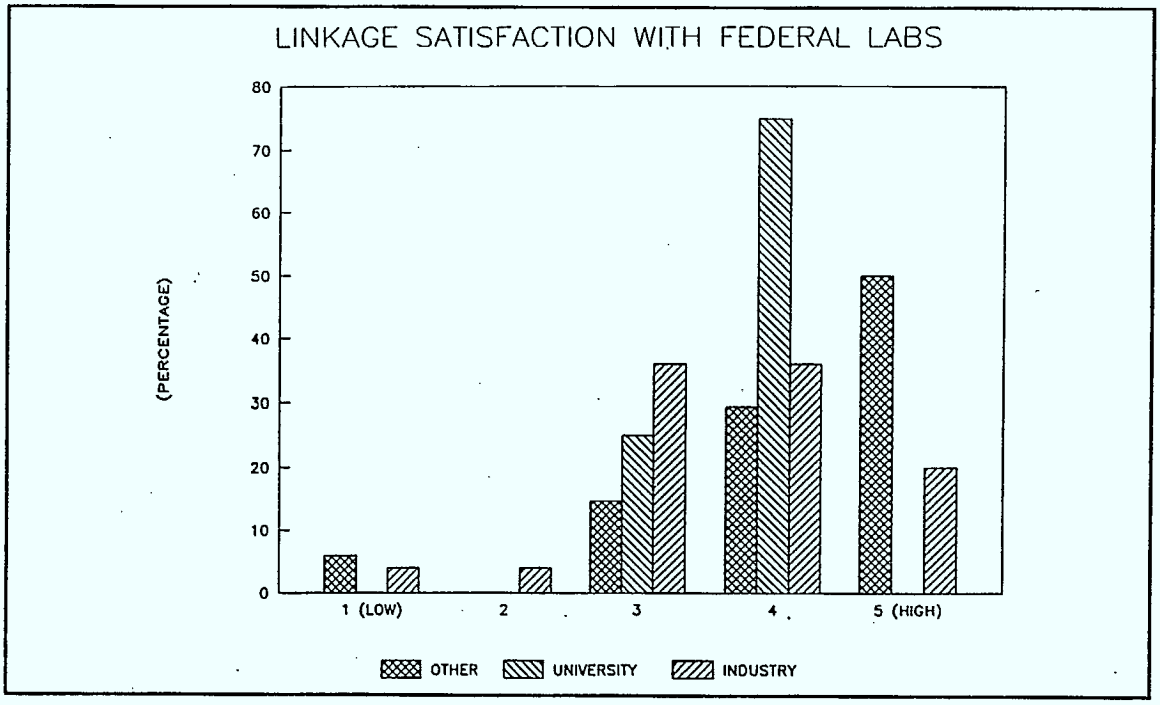


Figure 4-3: Linkage Satisfaction



4.4.5 Linkage Exchange Items

The most important linkage exchange item received by study units from federal laboratories was "information"; this corresponds to the most important traffic characteristics for all other organizations as well.

Table 4-7: Linkage Exchange Items

IMPORTANCE OF LINKAGE EXCHANGE ITEMS

	PROV	UNV	NPO	SMALL IND	LARGE IND	FEDERAL LABS	AVG
INFORMATION	4.2	3.9	3.7	3.9	3.8	3.9	3.9
MONEY	2.6	3.7	2.7	3.1	2.6	2.6	2.8
PRODUCT\SERVICES	3.2	3.2	2.8	3.1	3.0	2.6	3.0
PEOPLE	2.6	3.7	2.6	2.6	3.0	2.7	2.8

4.4.6 Linkage Type

The results show that informal linkages with federal laboratories are considered to be of equal importance to ther linkage types.

Table 4-8: Linkage Type

	OTHER	UNV	SMALL IND	LARGE IND	FEDERAL LAB	TOTAL
INFORMAL	98	53	87	61	59	358
LICENSES	91	45	79	57	56	328
CONTRACTS	101	51	87	65	59	363
JOINT VENTURES	95	46	81	60	57	339
OTHER	90	47	79	66	59	341
TOTAL	107	56	99	73	64	399

4.4.7 Linkage Duration

More than 50% of the linkages with federal laboratories are of a duration of one to five years. The next highest category is five to ten years (30%). This trend is consistent for all other S&T organizations in this study.

Table 3-19: Linkage Duration

LINKAGE DURATION (%)

	OTHER	FEDERAL LABS
LESS THAN 1 YEAR	13	12
1 TO 5 YEARS	51	52
5 TO 10 YEARS	17	30
10 TO 20 YEARS	12	5
OVER 20 YEARS	6	1
UNKNOWN	1	0
TOTAL	100	100

5. INTERVIEWS

5.1 IMPORTANCE OF LINKAGES

The general consensus among the science and technology organizations interviewed in the telecommunications and environment sectors and the province of Alberta is that linkages are very important. However, it was also reported that linkages can be very difficult to establish and maintain.

5.1.1 Industry Associations and Government

Linkages were viewed as critical by the government departments and industry organizations interviewed. Often the organization's reason for existence stems from the recognition of the importance and necessity for linkages. In these cases, linkages are viewed as one of the organization's main "products".

The importance of linkages to one government division was attributed in part to its size. Since they do not have the personnel required to carry out many projects they often work with private sector companies. This division's linkages change very frequently and their formation is often reactive; companies usually approach them for joint work. Linkages are formed to help stop the duplication of effort and get research performed in areas that the division feels are important. They are frustrated that often people in the field are unaware of what they do and that they do not have the time or resources to rectify this problem.

The importance of linkages to another government department results directly from their mandate to ensure that the expertise required to meet long term oil and gas industry research needs is developed and maintained within other agencies. The linkages that they establish to maintain this expertise are long-term and tend to be with other government agencies and, to a lesser extent, universities.

5.1.2 Universities/Centres of Excellence

Linkages are also extremely important to the Centres of Excellence contacted. Achieving the status of a Centre of Excellence allowed one institute to do more fundamental research and has increased the number of linkages that they are able to maintain. In the last three years, they have seen the importance of linkages increase, with the number of grads, employees and contracts, by approximately 50%. Part of the Centre of Excellence grant has been used for research infrastructure support and this has helped to promote linkages with other universities and industry.

One university feels that interaction with industry through both contracts and informal linkages is important; however, their most important linkages are usually with government sponsored bodies on the topic of funding. Another university department sees the importance of linkages increasing in light of shrinking research dollars. It was also mentioned that linkages at a university tend to be of a personal nature and are communication channels that a particular professor can turn on or off. There is no strong driving force to compel a professor to form linkages, beyond those required for funding.

5.1.3 Private Sector Companies

The importance of linkages formed by the private sector organizations interviewed varied depending upon the topic of exchange.

R&D linkages are less important to large companies who see research as the road to a competitive advantage. For example, two multi-national telecommunications companies interviewed do not maintain many linkages for the purpose of R&D due to the competitive nature of their work. The majority of their R&D is financed by profits and their linkages are amongst company owned R&D units.

Conversely, linkages were much more important to organizations that were trying to solve common problems through research that did not directly affect their competitiveness. Environmental research often fell into this category. For example, one large company doing non-competitive environmental research has important linkages related to long term research contracts. The linkages provides them with expertise that they can't maintain in-house.

The type of linkages that are important to a company vary depending on the nature and maturity of the company. One Alberta company commented that during initial R&D efforts, their primary linkages were with a university department and a university-based consulting company but more recently their R&D needs have led them to link with a hardware vendor.

Linkages with industry associations are important to many organizations and are used to stay informed of current research work. In this way they are able to benefit from other organizations' experience and expertise.

A telecommunications company that does the majority of their work with the government stated that these represent their most important and long term linkages. Given their close relationship with the government, they are able to use the basic research being done in government labs. This long term research is often complimentary to the company's requirements.

One large company interviewed felt that long-term collaboration never works well. Rather than maintaining on-going linkages, the interviewee was of the opinion that it is best to have short term objectives with a partner and start afresh with the next project. He felt that collaboration was easier in the environment because organizations are usually not competing; industry is able to work together and there is a lot of political interest.

Linkages were important to a small telecommunications company interviewed in terms of funding. To them, linkages translate directly into dollars. Given their size, they are often forced to link with other organizations for basic research and more specialized expertise (ie. at a nearby University).

5.2 CHARACTERISTICS OF A GOOD LINKAGE

The characteristics of a good linkages did not vary much amongst the types of organizations interviewed. Communication, trust, common objectives and the presence of complimentary skills most often characterized a good linkage. It was stressed by most organizations that the linkages that succeed the most are those that start out as informal linkages. These linkages tend to be natural, as opposed to forced.

5.2.1 Communication

Open and effective communications between the linked organizations was mentioned most frequently. Even for simple linkages, a clear understanding of what each parties' responsibilities and commitments are is essential to success. For more involved, long term linkages it is also important that each organization has a solid understanding of the other's goals, capabilities and what they expect from the linkage.

There was not a consensus on the types of linkages that are characterized by good communications. Some interviewees felt that communication was facilitated by a formal mechanism such as a Memorandum of Understanding while others believed that an informal linkage could be equally successful if each party had a clear understanding of the purpose and goals of the linkage.

5.2.2 Trust and Respect

Trust and a mutual confidence in, and respect for, each other's abilities and expertise was fundamental to the success of any linkage. Trust was mentioned most often by private sector companies. It was important to private sector telecommunications companies doing research with other organizations as many of the results are proprietary. For companies doing non-competitive environmental research, the need for trust is a result of the sensitivity of environmental issues and the client confidential nature of the work.

According to one large company, each party must earn the others' trust by demonstrating a respect for confidentiality. For large companies, trust in a linkage partner is often a product of the faithfulness that the organization shows. For example, if a telecommunications company links with Northern Telecom to attain access to complementary expertise, the linkage could not continue to be successful if the company also formed a linkage with one of Northern's direct competitors.

For one Environment Canada division, a mutual trust and a willingness of a company to work with government was essential. Some companies are hesitant to let Environment Canada personnel onto their premises for fear that an environmental problem will be identified. This fear of whistleblowing threatens the formation of linkages with private industry.

5.2.3 Linkage Champion/Infrastructure

Successful linkages need a champion to sustain them and an infrastructure to facilitate them. For example, one interviewee spoke of a research association which is designed to be an excellent forum for the development of linkages amongst universities, industry and government. However, the infrastructure to facilitate these linkages - directors, support staff, etc. - are not currently in place. These types of organizations need one to two people to keep the project alive and organized.

5.2.4 Flexibility

Flexibility was mentioned most often in connection with research done at Universities.

According to one large company interviewed, a good linkage with a university is characterized by a flexibility in terms of the research that is performed. This approach is successful because these linkages are for long term research which the company works closely on with the university. Thus, as discoveries are made the research direction can be easily modified. This sentiment was echoed by the interviewee at a Centre of Excellence who said that while research goals must be set, they must also remain flexible.

Flexibility was also mentioned as a desirable characteristic of a linkage by an Alberta university department . The interviewee felt that the constraints of linkages with industry is that they tend to be contract-based and do not allow the necessary flexibility to undertake appropriate research.

However, it is important to note that this phenomena of University researchers pursuing flexible research programs has also been termed by some "an inability to focus". As such, it is not a beneficial characteristic for some linkages.

5.2.5 Common Objectives

A linkage can be characterized by examining the factors that led to its formation. In general, the more problems and characteristics that the organizations have in common, the more successful the linkage. The presence of common objectives means that linkages will form naturally. It was mentioned several times that linkages are most successful if natural and not forced.

Contributing to the success of the linkages amongst the members of a steel research consortia is the presence of a common competitive threat. This helps the group to focus on common objectives and research priorities.

Another example is the linkages formed through the Atlantic Provincial Telephone Council. These are reported to be very successful and easy to manage because all members face the same issues which stem from a small, disperse population.

5.2.6 Complementary not competing skills

Two of the large telecommunication companies interviewed stressed the importance that the needs and skills of the two parties involved be complimentary and not competing. If each brings complementary skills to the linkage, members will be able to respect the others' expertise. There will be no fear of the others stealing their technical expertise and using it to erode their competitive advantage.

Linkages that involved synergy whereby each member contributes part of the answer were the most successful. If one party is simply receiving money for work performed the relationship will not be successful in the long term. Both parties must benefit in ways other than financial. This was noted by several small and large organizations. One large company said that this is reflected by the lower quality of research done through short-term contracts versus that done by researchers with whom the organization has a long-term linkage.

The success of one Alberta software company's many linkages is that the partnerships were formed to address particular market needs and the organizations involved brought different skills, expertise or products to the partnership.

5.2.7 Senior level commitment

One of the large companies interviewed said that linkages were most successful if they were maintained at a high level within the organizations. He believed that it was important for the companies involved to have a similar business strategy and philosophy. Linkages among high level executives were most effective if strategy and not technical issues was the topic of exchange.

5.3 BENEFITS DERIVED FROM LINKAGES

Linkages are generally viewed to be very beneficial and this is reflected by the number of benefits mentioned during the interviews. There was no difference amongst the environment, telecommunications and Alberta interviewees in terms of these perceived benefits.

5.3.1 Leverage

The benefit mentioned most often, by both private and public sector organizations, is leverage to undertake large projects. By linking with other organizations a critical mass capable of handling intricate and complex jobs may be obtained.

5.3.2 Enhances in-house expertise

Linkages can provide new capabilities or enhance in-house expertise. One benefit of linkages is that they allow for access to technical expertise and experience on an as needed, project specific basis. Also, additional knowledge and expertise can be gained from the linked unit. One project carried out by a Provincial Research Organization gave them a broad knowledge base in a particular area. The technology and advances developed through this program were later transferred by the PRO to the US and Czechoslovakia. Often the benefits seen from large projects with many linkages have long reaching effects.

5.3.3 Improve competitiveness

Linkages can lead to increased competitiveness. By linking with organizations with complementary skills, smaller companies can successfully bid against larger organizations which perhaps otherwise would dominate the market.

One company mentioned that its use of R&D linkages allowed it to develop a product more rapidly, with the expectation of bringing it to market more quickly than the organization's main competitors. As a consequence, a larger market share is anticipated.

One Alberta organization commented that R&D linkages had allowed the company to gain expertise in additional market sectors. Such diversification allowed the company to survive during the downturn in the oil and gas industry which affected so much of Alberta several years ago.

5.3.4 Future/spin-off benefits

There are also future benefits to be derived from current linkages. Experience with linkages facilitate future ones by providing a framework or mechanism which can be followed.

On a more global scale, there are spin-off economic benefits generated when a project with a large number of participants is undertaken. Large projects will enhance each participant's expertise and this knowledge can in turn be exploited in future projects.

The benefits of linkages formed as a result of a large research project with multiple stakeholders are numerous. The industry involved incurs lower research costs, universities obtain expertise with "real world" problems which they may then apply to other fields, and supplier companies stand to make profits when they develop new products. In addition, the government research institutes fulfil their mandate to maintain and improve the competitiveness of Canada's industry. Also, these projects can go a long way to dispelling the stereotypes that each type of organization holds about the others.

5.3.5 Availability of Funding

One benefit mentioned by all types of organizations, especially within the telecommunications field, was the increase in the availability of funding through government programs or contracts. By working together Canadian telecommunications companies can develop a strong resource/financial base. On this basis they may then approach government to match or contribute to funding for a joint research project. Generally there are more financial incentives available when organizations link.

5.3.6 Increase Responsiveness to Industry Needs

The government lab doing telecommunications work felt that by linking with industry, research and development is more practical, relevant and responsive to the needs of industry. The universities also mentioned that linkages allow them to become more aware of problems that industry is facing. This awareness can influence the general direction a professor's work will take and may lead to research that is oriented to solving practical problems. One Alberta software company feels that their linkages determined by market pull or needs allow them to remain close to the market and competitive.

5.3.7 Access to proprietary information/equipment

One Alberta company has established a linkage with a hardware vendor for the purpose of access to proprietary information that they require to develop their software.

R&D linkages that some organizations maintain allow them access to equipment which would otherwise be unavailable. Along with access to equipment comes access to associated expertise.

5.3.8 Risk Sharing

Especially for small companies, linkages provide confidence through risk sharing and can allow for more rapid advances in product or process development due to the sharing of ideas

and resources. A small company looks to linkages for funding and backup technical support that will help them to become more competitive. Also, small companies have problems taking the R&D output and integrating it into proprietary products. Linkages therefore become very important if the internal R&D group is not of a critical mass to put developments into operations.

5.3.9 Access to world markets

One company mentioned establishing linkages as a means of marketing on an international basis. By establishing a partnership arrangement with an international hardware vendor the software company was provided access to the European market.

5.4 IMPACT OF EXTERNAL ENVIRONMENT

Three main changes in the external environment were used to account for the increase in the importance of linkages: decreased budget available for R&D; increased global competition; and, an increase in the sophistication of the technology involved. In addition, for companies with environmental problems, increased emphasis on the environment and additional regulations have prompted the formation of linkages. It is important to recognize that many of the companies interviewed on the topic of environmental research do not compete on the basis of environmental technologies; rather, they view environmental issues as a threat. Therefore, an issue such as global competition does not impact this type of linkage (non-competitive environmental R&D) to the extent that it does linkages on more competitive issues.

5.4.1 Decreased Budgets for R&D

For all types of labs (university, government and private sector), the number of linkages that are formed is related to their funding levels. Currently the financial resources available are diminishing and the past level of activity is no longer affordable. As a result, government and industry must co-operate and work together or new projects will not be approved.

Government downsizing impacts linkages as it becomes impossible to keep the expertise in-house and they are forced to go to outside organizations for funding. Given that many government laboratory mandates are to maintain a long term perspective on industry's problems, they must maintain expertise in many areas.

5.4.2 Global Competition

The telecommunications Centre of Excellence reason for existence is the changes in the external competitive market and globalization of the market. As a result of these pressures, the government felt that companies were becoming too short term oriented. Therefore, the threat of foreign competition led to the formation of this organization to promote linkages and take on long-term, long-payback research projects for which one industrial player can no undertake on their own.

A small telecommunications company noted that international competition is becoming a very dominate issue for them and it is generally very difficult for a small company to compete in telecommunications. As a result, the life span of smaller and mid-size companies is becoming shorter. Also, when a small company starts getting too big or aggressive or starts to capture too much of a large firm's market, the bigger company tends to buy-out the small company and break it apart.

Within the steel industry, a large joint project which has been created reflects reaction to the competitive threats faced by this industry in Canada. It is a direct response to global competition which is a growing factor in the market place.

One Alberta company, with projects in the telecommunications area, stated that linkages allow them to compete against larger US-based corporations and give them access to both European and Asian markets.

5.4.3 Increased technological sophistication

Technology in many industries is becoming very specialized and it is difficult for a science and technology organization to be an expert in all areas. This leads to more linkages with sub-contractors.

5.4.4 Political Agendas

The political scene impacts heavily on the linkages that the government organizations form. For example, the signing of the Atlantic Accord means that one government department interviewed is no longer the sole regulator for oil operations off shore in the Atlantic. New agencies formed as a result of this accord must be included in the process of developing standards and this forces new linkages. Also, the organization is soon to become part of the National Energy Board and will move to Calgary. The effect of this move on current linkages remains uncertain. It may make some linkages more difficult to maintain given the distance (such as those with other government agencies in Ottawa) and facilitate those with private sector oil and gas companies in Calgary. This may lead to an increased number of Joint Industrial Projects.

One Environment Canada department has recently had its mandate changed. They are now encouraged to look outside for joint projects and must address landfill clean-up and contaminated sites. Given that they work to a mandate, many of their linkages are formed as a result of a directive to undertake a certain type of work.

5.4.5 Recession

The recession was mentioned most often by those organizations doing telecommunications R&D. During an economic slow down, fewer private sector telecommunication companies push R&D projects. They do not usually abandon them completely, but what would previously have taken several months to formalize may drag out to a year. Therefore, linkages may not be pursued as vigorously.

During recessionary times, more companies tend to look for funding from government sponsored R&D programs, however there are also fewer dollars available for grants. To universities, the availability of funding is always their greatest concern and any changes in

the external environment that affects this cash flow are important (eg. economic downturns, political agendas, etc.).

Two large telecommunications companies said that they were somewhat recession proof because the majority of their work comes from multi-million dollar, long term contracts.

5.4.6 Increase in Environmental Awareness/Regulations

For one large company, the regulatory environment increases the demand for their end products and drives their research. However, their operating environment remains competitive and this remains a barrier to the formation of R&D linkages.

The need for environmental services and R&D is increasing due to regulations. One division of a Provincial Research Organization has seen their business in this area grow by 50% a year for the last five years. This impacts their linkages significantly. Similarly, increased attention to the environment has led the Centre of Excellence to enhance their communications with national environmental groups.

Other companies who do not compete in the environmental industry noted that the regulatory environment impacts significantly the research that is conducted and in turn the linkages that are formed. Most companies doing non-competitive environmental research see a limited proprietary emphasis on the environmental research work that they do. There is more of an emphasis on the rapid exchange of this technology. One interviewee felt that people today realize that it is not worth hiding environmental issues and now organizations communicate more on this issue.

At the Environment Canada lab, public awareness and environmental emergencies impact the linkages formed by the organization. For example, the recent increased emphasis on oil and chemical spills world wide has led to increased R&D on oil spills on behalf of government agencies and industry in Canada and abroad. The result has been an increase in joint projects and an increase in the funds available for their work.

5.5 FUTURE IMPORTANCE

All organizations interviewed reported an increase in the importance of linkages. This increase is attributed to a wide variety of factors including downsizing, development of complex technologies, and competitive threats.

Government downsizing is causing the importance of linkages for government departments to increase as they are forced to look outside government for funding and expertise. This is a contributing factor to the growth in importance of Joint Industrial Projects (JIPs). This trend has been accompanied in some case by a formal change in a division's mandate with regard to joint projects. Given increased experience with JIPs and the leverage they give, one government department is finding that their approach to other linkages is changing. Projects (potential linkages) are now evaluated in part on the basis of how much the linked unit is willing to put into the project in terms of Person Years (PYs), computer time, etc.

At one of the telephone companies, the interviewee sees more of an effort being put into linkages with the US because "they are 8 - 10 years ahead of us". He felt the US telephone

companies, unlike other Canadian telephone companies, have a business philosophy and service strategy than aligns well with his organization.

Within telecommunications, according to a Centre of Excellence, the economic times and the speed at which technology changes are promoting the formation of larger consortiums. They perceive a move towards larger research projects that individual organizations (universities/industry/government) can not do on their own. They were of the opinion that loosely held linkages are remaining stable, they may even be declining, and that active linkages, rather than passive linkages, are becoming more important. In order for greater benefit to be derived from the Centres of Excellence, the interviewee felt that more funding and involvement was required from industry rather than government.

One of the large telecommunications companies interviewed said that linkages with the provincial governments are now becoming more important as the provinces become more active in promoting their companies and regional capabilities to the federal government.

One of the large telecommunications company's linkages with universities are also becoming more important. They say that their interaction with universities in the past has not been good because they, as does industry in general, tend to look at universities as providers of students and have not fully considered the potential for technology transfer. In the past they assumed that professors are tied up with students and will not be able to meet deadlines. However, it is now recognized that "there are good people in universities" and successful linkages are possible.

One oil and gas company feels that cooperation on research is increasing in the environment area, but not in others.

The importance of linkages to environmental research is due to the complexity of environmental issues such as acid rain, ozone depletion and global climate changes. To be able to address these issues partnerships become essential. Even in areas where organizations have the expertise to undertake a project on their own, most reported that it is advantageous to join forces with a university or government lab.

One company that competes in the area of environmental technology is trying to increase the linkages with customers. This will directly impact applications research and may affect basic/fundamental research.

5.6 HOW AND WHEN LINKAGES ARE FORMED

Linkages are formed most often to gain access to complimentary expertise. The linkages are usually initiated on an informal basis. The mechanics of how and when linkages were formed varied greatly, not only amongst the organizations interviewed but within each.

The formation of linkages by private sector organizations is often the result of the recognition of a common threat. In such cases, research is undertaken not for individual company's competitive reasons but to help maintain the competitiveness of the industry as a whole. Therefore, issues such as the environment often prompt linkages. Organizations will link to their advantage when the parties to the linkage are not competitors and have complimentary skills.

The majority of linkages formed by the organizations interviewed were initially established on an informal basis through personal contact at conferences, conventions, standards committees, trade shows, etc. One Alberta company which has linked successfully with government agencies saw this as a result of a senior managers's personal ability to network and make preliminary contacts. When linkages involve proprietary information more care is taken and linkages are formalized earlier.

Generally, interviewees thought that formal linkages were easier to maintain than informal. This is because the mechanisms which govern the flows over the linkages are in place once a contract is finalized. With formal linkages, regular meetings are held and information can be exchanged.

The government organizations interviewed tended to have more formal linkages than informal. Recently there has been an increased emphasis on linkages with industry through Joint Industrial Projects's which allow research dollars to be leveraged and gives the government labs access to large amounts of data. In the past JIPs were initiated by private sector companies; however, it is now increasingly a priority for government to look for these opportunities. One barrier to the formation of long term linkages through Joint Industry Projects is that they are driven by interests of the day and once the project is finished so is the reason for the linkage.

Government interviewee also noted that linkages with private sector companies tend to be transient and operate under formal agreements. Private sector organizations are often hired to do research or development work on a competitive bid basis. Once the contract is awarded, a hands-off approach is usually taken. It can be difficult to maintain a linkage once established if the original need for the linkage is terminated.

The types of linkages maintained by government departments reflect their mandates directly. For example, one government organization's mandate was to maintain expertise in important fields. Therefore, many of their linkages are long term in nature and tend to be with government agencies or universities where they see the expertise most concentrated. This type of linkage usually operates under a Memorandum Of Understanding.

At one Centre of Excellence, all linkages were reported to begin informally. Linkages with research sponsors, who are approached by the Centre to fund research projects, are formalized when an agreement is reached. The success of these linkages is attributed in part to the flexibility that is built into the agreements. Linkages that the Centre maintains with Universities tend to be informal, while those with industrial associates who licence technologies developed at the Centre are formal.

In general, private sector companies and universities linked with the government primarily to obtain funding. One interviewee from a large private sector organization believed that his organization would never link with the government for the purpose of research. His perception was that if the government supports R&D they usually want to "own" the results and thus there would be a loss of control of joint projects.

One large company doing environmental research commented that when undertaking long term, strategic research, linkages are often created with university and government labs. They join forces with universities for particular studies if they do not have the time or resources to build up the expertise in-house. This company tends to remain very involved with the research once the project begins. The close involvement means that the research work can be modified as the project progresses. Since the focus is not on short-term research to solve immediate operational problems, the flexibility is beneficial. On the other hand,

linkages that this company establishes with private consulting firms are not as satisfactory. The work produced, while on schedule, is usually at a minimum standard. The company tends to be less involved with these linkages.

Linkages formed by private sector organizations for the purpose of product development occur between companies which possess unique expertise. For example, telecommunications companies with complementary technologies may link on the topic of a product development which combines their technologies.

One company doing environmental research for the purpose of new product development is unable to interact with universities and competitors due to the nature of their work. The company has used the Technology Outreach Program to facilitate linkages with a lab in France. The money is used to defray travel and communication costs. The companies meet two to three times per year to share product information and ideas without giving away proprietary information. The companies deal with similar but not competing products. The company was initially linked with a Danish organization. This linkage was terminated when the Danish company was bought out by a consortium who owned a direct competitor.

Industry linkages with associations are established mainly to provide a forum for information exchange, to decrease duplication of effort and to decrease the cost of doing research. Several interviewees felt that research consortia, especially on environmental issues, are becoming increasingly important. One large telecommunications company said that they maintain strong links on technical subjects with American associations. They felt that for high tech industries in Canada there are very few good industry associations. There is both a lobbying and technical side to linkages with US industry associations.

5.7 BARRIERS

5.7.1 Lack of Resources (Time and Personnel)

It was often heard that effective linkages require a lot of effort to identify, establish and maintain. Freeing people from the immediate pressures of day-to-day operations to enable them to manage the linkages can be difficult. One large company felt that it is very important to do research into any organization they are interested in linking with to ensure that it will be a successful partnership. The administrative and coordination aspect of a linkage can be onerous and time consuming. Small organizational units felt that they were at a disadvantage because they simply can not put the same level of effort into linkages as large organizations.

One Environment Canada department felt that they face some barriers when trying to influence US or Canadian agencies to put money into projects that are important to their work. They do not have the resources to pursue as many linkages as they would like nor do they have a "bagman" to lobby on their behalf. In addition, they felt that others in the same field are not aware that they exist and yet they do not have the resources to make their expertise more visible.

At universities, the effort and time required to get large research programs with many linkages up and running act as a barrier. The start-up of large projects can represent a lot of a professors unpaid time. The lack of funding for the start-up of projects was mentioned several times by universities and non-profit organizations.

It was mentioned that private sector organizations also often underestimate the start-up time for multi-partner projects and do not allocate sufficient resources. They are therefore often in the untenable situation of launching the project while undertaking other coordination duties.

Conferences were often mentioned as a good linkage facilitator. However, one barrier to the formation of effective linkages via these events is that often the people that have the time to attend are not those that have the technical background required to benefit from the discussions.

5.7.2 Confidentiality/Competitiveness

Confidentiality can be a barrier to all types of linkages. On issues of a competitive nature such as telecommunications research, this was particularly important. Some companies felt they become vulnerable if they joining forces because today's collaborator can be tomorrow's competitor. Linkages between private sector companies are thwarted by proprietary information; it is often not possible for companies producing identical technologies to link. Therefore, vertically integrated companies do not link very well as the linkage will most likely duplicate an existing department.

For companies dealing with a client organization the need to protect proprietary information is of critical importance and sometimes will create a barrier to a linkage that may have otherwise been formed.

Confidentiality can also be an issue for non-competitive, environmental research. Leaked information can bring embarrassing results. Also, the government labs face some difficulty when dealing with private sector companies on environmental technologies. The fear of punitive action may stop some companies from allowing government personnel onto their property.

The need for confidentiality and protection of intellectual property was cited as a barrier to linkages between private sector organizations and universities. There is a fundamental difference between the work that these two types of organizations pursue. Universities pursue research work with the ultimate product being a published paper, while private sector organizations often wish to restrict dissemination of such results for proprietary reasons.

One barrier mentioned by a large Alberta corporation with extensive consortia linkages was the long validity period of some confidentiality agreements. The linkages which are currently in place have confidentiality agreements extending from one year to fifteen years. The corporation found the restrictions placed upon sharing information with affiliate organizations a major barrier and confidentiality agreements of more than three years were considered too lengthy.

5.7.3 Resistance to Change

A fundamental barrier to the formation of linkages is that change is usually resisted. This is especially true in large organizations where momentum can impede the formation of new linkages.

In addition, once one linkage is established, new ones become more difficult to form. One government department mentioned that if they give money to a particular government facility

each year for research, the organization may become dependent on this funding. To divert funds away from this linkage and direct them towards establishing a new linkage can lead to "career altering/terminating decisions".

5.7.4 Different Cultures

Organizations with dissimilar cultures often find it difficult to form linkages.

One PRO felt that they were not able to link as effectively with government organizations as others were because they "do not play the political game".

A Centre of Excellence felt that it is often difficult for a researcher to effectively interact with government bureaucrats because the two groups "speak different languages". Due to these cultural differences, they are unable to attain access to influential people in the policy arm of government. However, they realize that these linkages are important and must be developed if the low status afforded their research within the government is to be changed.

Another barrier to linkages between industry and government is the red tape. Some private sector companies also feel that the government places a heavy emphasis on control and stated felt that this is "stifling" to a technical person. As a result, some private sector organizations have concluded that the benefits to be derived from such linkages are not worth the effort.

It was mentioned that one barrier to the formation of more formal linkages within industry organizations is that the more power or stronger mandate the organization is given, the less direct control the involved government scientists have. It was thought that the culture that prevails within government labs results in a sense of fear on the part of the scientists that to support industry associations is to undermine their own efforts by directing a portion of their fixed budget to the outside organization.

The barrier to linkages at universities is a direct result of the organizations' priorities. Individuals doing research in universities are given a great deal of flexibility as to the type of research they pursue. Since the research is often not directed, it can be done very independently and therefore there is no real compulsion to link. One professor felt that the goals and overall philosophy of universities differed significantly from industry and this made the two difficult to mix.

A barrier to linkages with universities mentioned by one company is that frequently people in charge of projects and of overseeing the linkage are poor project managers. The different approaches taken to managing a project can prove frustrating for those involved.

An important barrier to linkages related to cultural differences, is the tendency for people within an organization to stereotype those in others. Private sector organizations generally perceive university researchers as having their "heads in the clouds" and research work well behind schedule. By those outside government, government labs are viewed as having a poor work ethic and their efforts are seen to concentrate on projects with little application to current industrial problems. Universities and government see private sector companies as short-sighted and not interested in long-term research. All of these stereotypes form a barrier to linkages among different types of organizations.

5.7.5 Lack of Awareness

A mutual lack of awareness of what each party can contribute to the linkage can form a barrier.

A fundamental barrier mentioned by university contacts is that they are an unrecognized resource, often viewed as an "ivory tower". However, even though universities are aware of the importance of forming linkages with industry to support Canadian competitiveness, it is also generally felt that universities are not sufficiently pro-active in contacting Canadian industry. Most companies said that they were rarely approached by universities. In addition, several private sector and university interviewees felt that information dissemination from university departments is generally poor. The universities "industry liaison officers" in most cases are looking for funding and do not promote their expertise or R&D linkages.

Several private sector organizations in all sectors mentioned that they are unaware of appropriate government agencies with which they might wish to link.

5.7.6 Location

Location can be a barrier to linkages. Proximity to a research partner leads to more effective exchanges and promotes trust and dedication to the linkage. The distance and cost of travel can often play a role in determining the linkages formed.

One telecommunications company in New Brunswick felt that it was "difficult to see R&D here". In addition, the logistics for employee training courses and conferences, which can foster linkages, can become expensive since most are offered in Ontario or in the US.

Alberta private sector organizations see geographic location as a barrier when it comes to establishing linkages with federal government departments or research labs such as NRC. They would like to see government efforts made to "level the playing field".

5.7.7 Lack of Need

A lack of need for linkages on science and technology issues was perceived by a few large organizations who were able to maintain a lot of in-house expertise.

One large private sector organization noted that once a company sets priorities and agendas it becomes difficult to establish linkages outside this template. There can be a feeling of "we're the best" and if this is integrated into the culture of the organization, linkages will not be promoted.

More than one Alberta corporation commented on the perceived lack of need to form linkages with technology-suppliers such as government R&D laboratories or universities. They commented that there is a tendency within the given industry to be insular, not seeking out new technologies. They feel this is because industry has a short-term outlook and focuses on products for which there will be a market within a year and which could be developed within two years.

One interviewee mentioned that the government's insistence on formation of linkages for contract tams means that organizations "must scramble to form linkages". These forced

linkages are difficult to initiate and manage and discourage the organization from forming linkages independently.

5.7.8 Lack of Mechanism

Especially within the large organizations and government departments interviewed, the need for a formal mechanism over which a linkage could be established and maintained is very important. Within these organizations, difficulty is often encountered when trying to set up a mechanism to form linkages.

One government department felt that a barrier to the formation of linkages with industry through Joint Industrial Projects is that there is no mechanism to bring proposals from outside organizations to the two funding committees. The funds are not flexible enough to deal with such contracts.

Bureaucracy was seen as a barrier within universities, government and industry. One private sector interviewee felt that the university environment does not facilitate joint research with industry. It was perceived that the financial departments of the university are set up to receive grants, and that university administration is not familiar with the negotiation and administration of contracts.

Bureaucracy within industry is seen particularly when proprietary information is being exchanged. As this is an unusual type of linkage, corporations typically do not have established mechanisms by which to exchange the information.

Government bureaucracy was mentioned by several private sector interviewees. One large Alberta corporation mentioned an onerous amount of paperwork required in order to participate within a particular federal government cost-sharing program which deters such linkages.

Another mechanism barrier concerns legal obstacles. Many small corporations do not have expertise nor resources for formalizing their linkages. One suggestion which was proposed by several Alberta companies was to have the government provide guidelines for various types of linkages.

5.7.9 Personalities

The personalities of the individuals involved can pose a barrier to linkages. Conflict of personalities and professional pride can create a barrier to joint work. If researchers arrive at different conclusions and are unable to discuss their results, linkages break down. Also, it was felt that many scientists often want to work on a project to perfection before sharing it with linked organizations. This forms a barrier to on-going communications required for a successful linkage.

5.7.10 Canadian Research Culture

One interviewee felt that it can be difficult to establish research linkages in Canada because not many people are willing to invest in a long shot. Canadians are not risk takers and are not cultured in technology.

5.8 FACILITATORS

5.8.1 Common Needs

The presence and recognition of a common problem is seen to be the most important linkage facilitator. If a problem requires a wide range of expertise to solve organizations are forced to link. One private sector telecommunications company expressed this as "the pain that causes the common concern".

A sense of urgency to find a solution to a complex problem will prompt the formation of linkages. This was especially true for those organizations researching solutions to common environmental problems.

A government telecommunications lab felt that it is becoming increasing difficult to make a competitive product completely in-house due to complexity and sophistication of the many technologies involved, the learning process is long and expensive. Therefore, it is advantageous to link with companies who have particular areas of expertise.

However, while linkages are initially prompted by common needs, they tend to be more successful when each organization brings a distinct area of expertise to the linkage.

5.8.2 Nature of the Industry

The nature of the industry involved and the research performed affects the ease with which linkages can be formed. Linkages are promoted or facilitated if the topic of exchange is non-competitive in nature. Environmental issues and new regulations pose a threat to many organizations and this facilitates R&D linkages in this area. Those who view the environment as an opportunity for new products or services tend not to have as many linkages.

The success of a joint steel industry project is attributed, by one member of the team, to the nature of the industry. Traditionally, this industry shares information and the tough economic times they face is prompting them to work more closely. While it was difficult to formalize the linkage, due to the many shareholders involved, their common needs and past history facilitated the process. The interviewee noted that now that a process or mechanism for arriving at agreements of this nature has been established, future linkages amongst the steel industry will be facilitated.

5.8.3 Resources - Money and Personnel

While the lack of needed resources prompts the formation of linkages, especially for private sector companies, the availability of some resources is needed to facilitate linkages (eg. time, people, mechanisms, information).

For example, one Centre of Excellence contacted had been operating as an institute up until its application was accepted. Since being formalized as a Centre of Excellence their increased funding has allowed them to direct funds towards improving their image and increasing others' awareness of their work. This has led to an increase in linkages. The funding also allows them to keep staff in between projects and this stability has resulted in stronger linkages. Funding helps them support travel for grad students and professors and allows them to produce two newsletters a year which are sent to a mailing list of 1000 government departments, consultants, and corporations. The interest generated by the newsletters often leads to more linkages.

In addition, funding allows university researchers to define projects more thoroughly. The funding for seed projects at the Centre of Excellence has allowed them to present better thought-out proposals which increases their success at forming linkages.

However, it is often the lack of resources (in-house expertise, equipment, money, etc.) that prompts an organization to look outside to enhance its capabilities and leverage its research dollars.

5.8.4 Culture

Corporate culture can facilitate or, as mentioned earlier, impede linkages. One interviewee observed that some companies prosper because of their unique ability to foster linkages while others can not form linkages because the characteristics required to maintain a strong and effective linkage are not part of their corporate culture.

Linkages are more successful if the goals and philosophy of the two organizations are similar. In general it was noted that like-people and organizations tend to form linkages among themselves. For example, researchers form more effective linkages with other researchers than with government bureaucrats.

Senior management support for linkages is an important facilitator. Some organizations, government and private sector, evaluate employees explicitly on their ability to communicate with outside organizations. A commitment to informal linkages can be shown through support for conferences and conventions.

To render R&D more efficient, one large telecommunications company began to decentralized their R&D operations in the early 1970s. Executives felt that they could get better results by moving both the fundamental and applied research to various divisions of the company where they would promote a greater interchange of ideas among researchers and development engineers. In this way, linkages were fostered within the organization.

5.8.5 Communication

Good, on-going, communication is seen as essential to facilitating the initiation and maintenance of linkages. Face-to-face meetings, on a regular basis, are the preferred method of communication. These in-person meetings are especially crucial at the time the linkage is initiated. Clearly documented requirements and expectations facilitate linkages, especially those that operate at a distance.

Associations can provide the mechanisms to stay in touch. For example, Telecom Canada was viewed by one private sector organization as an effective facilitator for further linkages.

A Centre of Excellence has found that offering short course or seminars is both a revenue generator and an effective way to foster linkages. Conferences heighten the Centre's profile, act as a technology transfer/communication vehicle, and lead to post-course interaction with those in attendance. The money generated by these courses is used to start new graduate courses, endow scholarship funds, and support travel.

The availability of funding to promote informal communications at conferences, trade shows and seminars, is very important to the fostering of linkages.

5.8.6 Location

The proximity of organizations can affect linkages. Face-to-face contact with potential collaborators is an important facilitator for establishing linkages. Generally, the closer the organizations are, the more frequently contact is made. This promotes trust and an increased awareness of the other's needs and areas of expertise. Therefore, most of an organization's important linkages tend to be with organizations in the same geographical area.

5.8.7 Experience

Experience with different types of linkages, both formal and informal, and with different types of organizations (government, private sector and universities) facilitates further linkages.

For example, one interviewee has attended seminars on consortia research which examined the advantages and disadvantages of linkages, and he has had first-hand experience with this consortia research dating back to the early sixties. This experience has helped facilitate additional linkages.

5.8.8 Government Policy

Several interviewees noted that mandatory requirements for regional distribution of funds on large government contracts facilitates or forces the formation of linkages.

One large telecommunications company said that since they do not yet qualify as a "Canadian" company according to government regulations they often must team with another industry player to meet mandatory Canadian content requirements.

5.8.9 Increased Awareness of Environmental Issues

Public interest in environmental issues increases private and public sector awareness and facilitates the formation of linkages.

5.9 FUTURE ACTION

Several interviewees mentioned that if linkages are to be facilitated, it is important that one recognize that formal linkages should not be established until there has been successful informal linkage demonstrated between the two parties. If the linkages is dictated by an external program, the ulterior motive can become dominant and the benefit from linking may be diminished. While linkages should be promoted as they are viewed to be beneficial it is necessary to recognize that the most successful linkages are initiated informally. This can pose a constraint on government policy and programs.

Many suggestions for government program or operational changes to help facilitate linkages were given. Government labs felt that they could better establish linkages if they had more personnel and more flexibility. Several suggestions were made as to how the approach to funding could be changed to promote linkages. Most of the suggestions given deal with

government's role, in terms of leadership and communication, in facilitating linkage formation.

5.9.1 Government-requested changes

In order to facilitate linkages, one government unit said that they need more exposure and better facilities. They need to be able to travel to conferences, especially in the US. This has been hindered by government constraints on foreign travel and the classification of travel to the US as "foreign". More resources, both people and dollars, would facilitate linkages.

Another government department said that in order to establish new directions and objectives with respect to linkages in an organization, fundamental organizational changes may be required. Such a shake-up would help overcome the natural barrier to change. For example, long-standing committees tend to set up attitudes of "this is my money" and actions become self-perpetuating. To make an impact on the types of linkages formed, the funding mechanism and project criteria must be completely revamped.

5.9.2 Funding

Several interviewees suggested that the government change their approach to funding to help foster research and linkages.

5.9.2.1 Program-related changes

It was suggested that funding programs be structured to encourage linkages and the formation of consortiums. For example, one type of linkage which was mentioned by two Alberta-based companies was the need for R&D corporations to link with consultants which can provide expertise in the areas of managing technology. When government is funding R&D projects, they should insist on such linkages if the company does not contain sufficient in-house expertise. Furthermore in-house expertise should be scrutinized. One interviewee went further and suggested that the government supply the project manager on large projects.

Two interviewees suggested that a company's ability and willingness to link should be used to evaluate proposals.

5.9.2.2 Up-front funding

Another suggestion was that government could facilitate linkages by funding research projects at the planning stage.

One interviewee believed that the government tends to underestimate the cost of start-up, during which time linkages are formed with collaborators. While the front-end of the project is viewed by many to be the most important stage during which linkages are formed there is no funding available for it. To establish linkages to make the research effort successful requires face-to-face meetings with potential collaborators and a lot of planning. Since there is no funding for this, this stage is usually rushed. To facilitate the formation of linkages and to better structure the research effort, money is need to defray the communication costs of travel and meeting.

It was suggested that one solution could be worked out whereby once the government receives and approves a letter of intent, that they fund the remaining research planning phase.

The importance of the availability of up-front research money is illustrated by a Centre of Excellence interviewed. Additional resources allow for "seed projects" to be done. These mini-projects allow the Centre to be more specific at the proposal stage and enables them to "go to bat with more saleable material."

5.9.3 Communication and Leadership - The Government's Role

Many suggestions were made in this category. Some address current programs and operations while others are suggestions for new programs.

5.9.3.1 Role of government labs

It was suggested several times that linkages with government could be facilitated if the roles of some government agencies were better defined. One interviewee mentioned that the Atmospheric Environment Service (AES) is involved in both basic research with a long term focus, and operational research. Although the AES has very competent scientists, it is difficult to address both types of research simultaneously. The interviewee commented that this is a problem with most organizations; it is a constant struggle to separate the two.

Another government department was viewed as having conflicting mandates where the goal of developing technologies to be licensed by the government agency is in direct conflict with their mandate to promote the sharing of ideas.

One telecommunications organization sees a conflict amongst the Federal Networks of Excellence, Provincial Centres of Excellence, Provincial Research Organizations, and Regional Institutions. Their mandates are not perceived as compatible as they all have different reporting requirements, drivers and initiatives. There is the perception that these programs are not logically coupled in a policy structure.

5.9.3.2 Clarification and simplification of current programs

Some organizations reported difficulty knowing which government department has funds and which to target with specific research proposals. Clarification, simplification and better communication of government services and programs is required. Several private sector companies said that they would be very interested in on-site visits by government personnel to explain programs and services they have to offer.

In terms of linkages with the government, one small telecommunication company's experience has not been successful. They said that small companies do not have the resources to sort through the information on grants, incentives, contracting procedures, programs, and regulations available from government offices. The number of publications, lists, and directories is overwhelming. They can not afford to maintain a government liaison officer dedicated to the task of sorting and categorize this information. Information needs to be short, concise and directly targeted to the needs of the particular company in question.

5.9.3.3 Address geographic barriers - Co-fund travel, workshops and trade shows

Alberta companies see geographic distance from Ottawa as a barrier and expressed the wish for the federal government to "level the playing field". In particular, they felt federal

departments were not cognizant of western companies' expertise. Such awareness would allow federal departments, granting agencies, etc to facilitate partnerships between organizations with complementary skills.

Several specific suggestions were given to remedy this situation. Federal government co-funded travel to Ottawa to establish better ties with federal departments and agencies was suggested. A second suggestion was the funding of a government RITE line to Ottawa. A third suggestion was the sponsorship of 2-day workshops during which government departments and Alberta organizations could present their expertise. In addition, materials could be made available which briefly outline such expertise, allowing participants to seek out appropriate counterparts for dialogues. The perception in the west is that the expertise of companies within the golden triangle of Ottawa, Toronto and Montreal and environs are better known to federal agents than the expertise of Western corporations.

A related suggestion was the development of trade shows at which small corporations including start-up companies and entrepreneur can display ideas. Expressed interest by other R&D organizations could later lead to R&D linkages.

It was also suggested that while there are usually many government people at conferences and trade shows, more of them should be presenters. They must let the public know what they have been working on rather than just acting as information gatherers.

5.9.3.4 Improve directories

Several Alberta-based organizations mentioned the need for directories of R&D companies. They seem unaware of the current directories that exist or feel the current ones are insufficient because they do not explicitly state company expertise. Improved dissemination of information is required. One Alberta interviewee used the patent office as an example of how poorly information is made available to corporations. The patent office could be a wealth of information but instead is viewed as a wasted resource because the information is not easily accessible. Corporations are interested in both new patents (potential linkages) and expiring patents (potential R&D applications).

5.9.3.5 Improve benefits from site visits

One small company in British Columbia said that while they are visited several times a year by government personnel and there is discussion on improving linkages with government to gain further benefits, nothing is ever followed up.

Several companies feel that the only way to form a successful linkage with the government is to link with a particular individual, a "champion" within a government department, to get relevant timely information. This type of linkage could be established through a site visit.

5.9.3.6 Federal office to facilitate links between private sector organizations

The possibility of a federal office to help link companies with complementary area of expertise (ie. a "dating service") was suggested several times. One interviewee mentioned that NRC was once an effective coordinator, but this is no longer true.

In facilitating linkages, the government should be assessing the capabilities of young technology-based corporations in the areas of financial management, sales capabilities and marketing capabilities, and pairing them with more mature corporations where these skills

are already established. Such linkages allow young corporations to acquire necessary skills, and allows more mature corporations access to new technologies.

The Alberta companies interviewed would like the Federal Government to facilitate linkages, particularly with corporations in other parts of Canada, by providing third party introductions.

5.9.3.7 Promote electronic networks

One large Alberta organization which already extensively uses electronic mail and has many R&D linkages within North America, mentioned the desirability of being able to communicate with other R&D corporations electronically. Electronic networks already exist for global communications and are extensively used by universities and government research laboratories. One suggestion is to facilitate the linkage of R&D organizations into such networks.

5.9.3.8 Government funded experts

Because certain technologies are changing rapidly, R&D corporations see the need to have access to individuals whose main responsibility is to stay current regarding certain technologies. In the computing area, the technologies mentioned include CASE tools, windowing systems and computer graphic tools. One might think that such expertise is resident within universities; this is not typically the case. Such expertise is typically acquired on an as needed or personal-interest basis and hence knowledgeable individuals are difficult to locate. The suggestion was that for certain key, rapidly changing technologies, the government fund individuals whose responsibility is to remain current and share information with industry. Such individuals would most likely be resident within government R&D organizations, with the beneficial result of also strengthening linkages between government and industry.

5.9.3.9 Joint research projects

Several interviewees believed that the private and public sectors should use industry associations to facilitate joint research. It was recognized that this is much more feasible for non-competitive research, such as many of the environmental studies. A lot of work is now being facilitate by industry associations which have a wide membership.

Large research projects are an effective way to foster linkages among various types of organizations. It was suggested that the government could organize large research projects, especially in the non-competitive side of environmental research. This would promote linkages and address some serious problems faced by a variety of industries. These project are also important to the research community in general as they generate interest in a large number researchers. The excitement created by these projects will help keep researchers in Canada. It was suggested that the government could assist in the grouping or linking of Canadian companies to form larger, well-rounded consortiums.

Several Alberta companies stressed the need for more pre-competitive research within Canada. Their fear is that otherwise Canadian industries will continue to duplicate effort and consequently will be relegated to technology importers rather than technology suppliers.

5.9.3.10 Exchange programs

Several interviewees believed that exchange programs would facilitate linkages by helping to dispel many of the myths and stereotypes that each type of organization holds of others. Government could sponsor a sabbatical program that would enable university and industry researchers to trade places. One association said they would be interested in sponsoring a sabbatical program if funding would be matched by government.

5.9.3.11 Academic placements

One suggestion from an Alberta company is that the government establish a program to encourage industry to hire new PhD graduates for a 2-year term. This would facilitate technology transfer, while exposing the graduate to skills not normally acquired within an academic setting, such as project management.

Another suggestion was a government program by which start-up companies could hire undergraduate and graduate students on work terms and to combined this with incubator programs for start-up companies. The suggestion was that such incubator programs should be either housed at universities or government R&D laboratories.

5.9.3.12 Publish guidelines for linkages

One suggestion proposed by several organizations was for the government to publish guidelines regarding licensing agreements, technology sharing, joint development ventures, joint marketing agreements which would help researchers gain insight into forming and managing various types of linkages. Such guidelines could also include a discussion of pitfalls as well as outlining typical obligations of each participant for each type of linkage.

6. FINDINGS

There were no significant differences found among the three sectors (Alberta, Environment and Telecommunications), in either the survey or interview findings, other than that the environmental field is often seen as working towards a common problem and therefore confidentiality is less of a barrier to the formation of linkages.

6.1 LINKAGES ARE VERY IMPORTANT

The importance of linkages to all types of organizations was highlighted in the survey results, interview findings and literature review. The importance of linkages stems from a recognition of the benefits to be gained. The increasing importance of linkages is explained by the effect that the changes in the external environment have on these benefits.

The literature findings showed that linkages are formed in order to adapt to a changing environment and thus are strategically important to an organization. Globalization, specialization, complexity of technology and competition are external changes that prompt organizations to form linkages. The benefits to be gained from linkages can lead to a competitive advantage for firms and hence nations. They include: access to expertise, facilities, and markets; risk reduction; leverage; and influence and control.

The survey respondents attach a high level of importance to their R&D linkages (see Table 1-2). The survey results indicate that the benefit derived from the reported linkages is quite high (see Table 2-5). In addition, the future importance of the vast majority of reported linkages is expected, at a minimum, to stay the same and in most cases increase (see Table 3-7). Much of the importance attached to linkages is a result of a direct benefit from the linkages (see Table 2-10).

The interview findings resulted in a long list of benefits to be gained from linkages. They included: leverage, improve competitiveness, access to world markets, increased access to funding and risk sharing. The reported changes in the external environment, including decreased budgets for R&D, global competition, and technological sophistication, made the benefits to be gained even more significant.

Conclusion

Given that linkages result in increasingly significant benefits, they should be supported by government actions.

6.2 LINKAGES ARE DIFFICULT TO ESTABLISH AND MAINTAIN

All three sources of information corroborate this conclusion. The barriers reported by the interviewees and survey respondents give insight into what aspects of linkages are difficult.

The literature findings show that while there is ample evidence of the value of cooperative research, the point is often made that extracting that value is not easy. There are often very strong deterrents and little motivation. The literature reported barriers include: organizational barriers, confidentiality, cost and inter-organizational barriers including both perceived and actual cultural differences.

The survey results show that the factors that most often inhibit the formation of linkages are the expense and effort involved in forming and maintaining the linkage (see Table 1-3). The second most frequently mentioned barrier is confidentiality. This ranking of barriers is not affected by the organization type (ie. private and non-private), see Table 3-2. Also, the effort that is put into linkages is reported to be quite high (see Table 2-11)

The barriers mentioned by interviewees included lack of resources, confidentiality, cultural differences, lack of awareness and location. The general comment was that most types of linkages require a lot of time, money and effort to establish and maintain and this inhibits their formation.

Conclusion

In order to facilitate linkages, Canadian organizations need to be more aware of various types of linkage opportunities and ways to simplify their formation and maintenance. Most are already convinced of their importance (ie. very few report lack of need as a barrier - Table 1-3). Published guidelines could help address these logistical barriers to effective linkages.

6.3 ROLE OF CULTURAL DIFFERENCES

For many of the barriers mentioned, an organization's culture plays a role, both explicitly and implicitly. Each organization tends to stereotype others and this inhibits the formation of successful, long term linkages among organizational types. In addition to perceived cultural differences, there are actual cultural differences that impact linkage formation. Organizations, such as in the government, have more rigid structures and policies to be followed. This degree of rigidity is reflect by the survey results which indicate that existing linkages can be a barrier to future ones. This degree of structure can be "stifling" for some private sector or university researchers and discourages some from seeking out linkages with the government.

One important difference amongst the universities, private and public sector is the initiator role. In general, it was reported by private sector organizations that they are rarely approached by universities. This relates back to the conclusion that cultural differences, real and perceived, affect linkage formation. Private sector organizations seem to feel that universities should be approaching them for research contracts, while the universities feel that if other organizations were made more aware of their capabilities, that they would be approached more frequently.

The universities reported a need for flexibility in the work that they do due to the type of research that they perform. This can be frustrating for some linkage partners who wish the university to perform their research to a formal, directed work plan.

Conclusion

There are some important cultural differences amongst industry, government and universities that can impact linkages. Government and universities in particular must work at improving their images.

6.4 DIFFERENCES BETWEEN TYPES OF LINKAGES: INFORMAL AND FORMAL

The literature review indicates that in the past emphasis has been on formal linkages. While informal linkages tend to be more valuable they are more difficult to help.

The survey results indicate that the most common type of linkage arrangement is a contract (see Table 2-4). However, the number of reported informal linkages is also significant. The low level of licensing arrangements may reflect a lack of understanding of this type of linkage.

During some interviews (mostly those with government) a need for a linkage mechanism was mentioned. These interviewees felt that linkages could be facilitated if there was a mechanism established, through a formal arrangement, which outlined how and when communication was to take place. Since communication is essential to the success of any linkage, the creation of such mechanisms is very important for some organizations.

It is also important to note that other interviewees saw a great deal to be gained from informal linkages, though they often reported that informal ones could be more difficult to manage. Informal linkages are also important because they provide organizations with much needed information that may not be gained through a more formal linkage.

Conclusion

Government programs should recognize and assist the formation of informal linkages.

6.5 LINKAGES ARE MORE SUCCESSFUL IF THEY BEGIN INFORMALLY

One main conclusion that can be drawn from the interview findings is that forced linkages do not work and linkages tend to be more successful if they are initiated informally. Informal linkages allow the linked units to develop an understanding of each others goals and strategies before the linkages if formalized. Thus, the formalization step will only occur if the units are well suited and thus the chance of success is increased.

Conclusion

Government programs concerning linkages should be aimed at facilitating natural linkages.

6.6 LINKAGES ARE MORE SUCCESSFUL IF THEY ARE MORE THAN FINANCIAL

The reasons for linkages mentioned in the literature review emphasize competitive advantage. The development of competitive advantage requires more than just the exchange of money. Both organizations must learn if the linkage is to be successful.

The survey results also support this finding. Table 3-8 shows that the satisfaction ranking of a linkage is directly correlated with information exchange in both directions.

The interviewees noted that organizations who link should have complimentary skills that can combine to form a competitive advantage for both. The difficulty with this is that if money is not a main item exchanged, then information must be, and thus confidentiality may become more of an issue.

Conclusion

Government programs will be more successful if they contribute more than just money. Government deparments must maintain technical capability and be able to provide input to projects.

6.7 INDUSTRY TYPE CAN IMPACT LINKAGE FORMATION

How quickly the technology is adapted and the competitiveness of the industry combine to impact the formation of linkages in both number and type. These two concepts, adaption and competitiveness, can be applied to any industry and used to draw inferences concerning linkages.

The nature of the industry affects the role that research consortia could play. Several interviewees saw an increasing need for research consortia to work towards solutions of a non-competitive nature. This was seen especially with respect to environmental research.

Conclusion

Government programs need to be tailored to the recipients.

6.8 IMPORTANCE OF COMMUNICATION

The importance of in-person contact to the success of a linkage was reflected in the survey results which show that the most important mechanism for exchange is verbal (see Table 2-8). In addition, there is a correlation between the success of a linkage and the degree to which exchanges are made verbally (see Table 3-9).

There is a need for face-to-face meetings, especially at the onset. This need affects the location preference for linked units. The vast majority of the reported linkages occur within the respondent's geographic area (see Table 3-10)

Conclusion

If linkages are to fostered across regional boundaries, infrastructure and support must be made available for travel and communications.

6.9 FEDERAL LABORATORIES

In the context of the relatively small database and the subject areas considered in the study, the findings indicate a large number of linkages for federal laboratories based in Ontario compared to those in the other regions. Although this result is not suprising because of the large concentration of federal laboratories in the National Capital Region (NCR), it highlights certain areas that require further examination since the general trend is for linkages to be clustered in the same region/province as the federal laboratory study unit.

Based on the 47 linkages with federal laboratories as the study unit, the findings indicate that there is general satisfaction about the effectiveness of linkages and that the exchange of "knowledge" is one of the major traffic items that potential partners look for in forming linkages with federal laboratories.

Conclusion

The findings support the importance of building and sustaining networks of linkages across Canada; therfore programs such as the Industrial Research Assistance Program (IRAP), which are designed to promote such networks, could be considered as possible models for strengthening existing federal laboratory networks. In addition, new initiatives may have to be considered to increase the number and effectiveness of regionally based linkages with government. There is potential for federal laboratories to play a more active role in forming linkages.

6.10 PERCEPTION OF GOVERNMENT POLICY

The interview findings and survey results lead to some observations on the perception of government policy in the science and technology area in general. This perception acts as a barrier to both linkages with government organizations as well as to their role as a linkage facilitator. A lack of communication between government and non-government organizations contributes to the current perception. The general feeling is that government:

- Poorly communicates science and technology policy
- Currently forces linkages, thus displaying a lack of sensitivity
- Poorly executes current programs, eg. little follow up on company visits, confusion related to overlapping programs

Conclusion

Government must improve its communications, both to make its programs more effective and to improve its image.

6.11 THE ROLE OF GOVERNMENT

The above conclusions help to focus the future role of the government in the area of linkages. The government plays two significant roles, as:

- a linkage participant - NRC, labs, etc., and as
- a linkage promoter or facilitator

Government must recognize its cultural differences and work towards minimizing their impact on linkages with private sector organization. As a linkage participant, red tape and program overlap must be reduced. The role of government laboratories and departments must be communicated more clearly to the private sector.

As a linkage promoter and facilitator, government can support linkages and their participants. Changes to current programs will help promote linkages of all types. In addition, additional program recommendations follow to further facilitate linkage formation.

7. RECOMMENDATIONS

7.1 COMMUNICATION

The full benefit of government programs is being limited by a lack of awareness and understanding, on the part of potential recipients, of linkages and available government support programs.

- Rationalize, simplify, and explain programs.

  There is a great deal of confusion within industry about the proliferation of government programs offered by different levels and departments. Government representatives typically are familiar with only their own programs. This means that industry, which does not differentiate well among government's many parts, must sift through many sources of information to identify a suitable program.

  Programs offered by different levels and departments of government are rarely rationalized. Overlaps and gaps in purposes further complicate the selection process.

  Once suitable government programs have been identified, industry perceives many as difficult and expensive to use, with the bother of the "red tape" exceeding the benefit derived.

  Site visits were identified as beneficial, however timely follow-up to the visits and a close, continuing relationship between the company and government contacts is essential.

- Communicate the advantages of linkages.

  Linkages between complementary organizations (such as strategic alliances) have received much attention. However, benefits can be obtained from other linkages, such as with suppliers, customers, and experts.

  The communication should strive to overcome the cultural barriers and prejudices which inhibit the creation of linkages among organizations which have not cooperated before. The benefits to industry of linkages with universities particularly needs to be stressed.

  Examples of communication methods include publications, seminars for organizations, as well as government and private sector brokers who interact with industry, universities, and government laboratories.

- Provide guidance on the creation and utilization of linkages.

  The difficulty in obtaining a net benefit from a linkage is usually associated with the learning process required by all participants to make the linkage work. Linkages will be more successful if the past experience of others can help create the necessary mechanisms and environment.

A government hot line and information clearing house on linkages will help to guide organizations with little or no experience. It would raise awareness, explain possible approaches, outline obligations, and discuss expectations.

A more powerful approach is to involve as many organizations as possible in linkages with government laboratories. This will provide them with "hands-on" experience which can then be applied in other situations.

7.2 FACILITATION AND COORDINATION

Ways in which government can promote linkages use different levels of intervention. At one end of the spectrum are procurement policies which stipulate that contractors shall have on their team, for example, representation from specified regions (eg. the Canadian Space Station MSS contract). At the other end are programs which respond to an industry request for assistance in creating linkages (eg. the telecommunications industry's Vision 2000). The Networks for Centres of Excellence is in between; government has specified that there shall be linkages, but participants have freedom in deciding whom to link with.

The findings of this study recommend that government policy should, where possible, support the formation of natural linkages. This means that, ideally, the creation of a linkage should be instigated by the participants to fulfil a requirement which they have. The emphasis should be on those organizations most receptive to linkages.

- Review existing programs for linkage benefits.

  Many government programs already promote the concept of linkages. Much can be learnt about ways to support linkages by examining the experiences of these programs.

  Also, as more is learnt about how best to promote and maintain linkages, the effectiveness of current and future programs may be improved.

- If the need for new initiatives is identified by the program review, create a Domestic Technology Linkage Program.

  This program would provide support to industry, universities, and government in the creation of linkages. It would be reactive to requests for assistance in a way similar to the unsolicited proposal program. It would be proactive on communication and education matters.

  Such a program would be responsible for the implementation and monitoring of most of the recommendations made here. It would provide financial assistance (especially for travel), information about the skills and capabilities of organizations looking for partners, and act as broker among organizations.

- Promote personnel exchange programs.

The findings of this study emphasize the need for personal interaction in the creation and maintenance of linkages. Personnel exchange programs are an excellent means of achieving this. They foster communications and breakdown barriers of culture.

Sabbaticals and executive interchange programs between government, universities and industry are examples of this approach. They do not, however, occur frequently enough, nor are they well advertised in terms of their potential benefits to both private and public sectors. Personnel exchanges are especially difficult for small and medium sized enterprises because of the cost and disruption involved; and yet it is these organizations which stand to gain the most.

7.3 RESEARCH AND ANALYSIS

It is important to continue this work. Government, the private sector, and universities have roles to play in the research; the work should be done through linkages among the three.

- Continue mapping sectors.

  This was a pilot study, and therfore covers only a small part of the Canadian science and technology base. Future work could broaden the outlook and attempt to obtain closure in the mapping of linkages. Closure means that all units in the linkage network are surveyed and all connections identified.

  It should be noted that linkages are transitory and that such a survey would provide only a snapshot in time. It is not felt that obtaining closure in the survey would change significantly the findings of this study. The information may be valuable in other ways. The effort and expense required to obtain closure, however, would be very significant. The tracing of linkage paths, described next, is a preferable means to obtain the same type of detailed information that closure would provide.

- Trace linkage paths.

  This study took a macro view of Canadian science and technology linkages. This approach was an excellent starting point. The next step, however, should be a detailed view a particular situation. Such a view will be an excellent complement to the existing data and is highly recommended.

  This can be achieved by mapping all of an organization's linkages, tracing these linkage paths to the next study unit, mapping its linkages, and so on. The process can be continued to the desired extent. The approach requires a high level of cooperation from the organizations involved, but the number of organizations is relatively small and so more time can be spent with each.

- Conduct case studies.

  In-depth studies of individual linkages, both successful and unsuccessful, would provide information not obtainable from a general survey of the type done in this study. Such information would be useful in determining guidelines for a successful linkage.

- Improve utility of the survey database.

  This study has been able to take only cursory look at the wealth of data contained in the survey database. The utility of the database could be improved by improving the software used to manipulate and analyze it. This will be especially important if the database is added to as a result of future work.

- Review models of linkages.

  Europe, Japan, the United States and others have valuable experience in forming linkages. In particular, some of their large research consortia (RACE, Sematech, Fifth Generation Computing, etc.) may be useful models, with appropriate modifications, in the Canadian context.

7.4 PARTICIPATION

These preceding recommendations concentrate on government's role in creating an environment conducive to linkages. It should be remembered that government also has an important role as a linkage participant through government laboratories and other organizations. However, for example, federal government laboratories were the initiator in only 30% of their linkages. There is potential for government to play a more active role in encouraging the creation of linkages between the federal laboratories and other science and technology organizations.

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APPENDIX A: SURVEY PARTICIPANTS

APPENDIX A: SURVEY PARTICIPANTS

A.1 ALBERTA

A.1.1 Government

Alberta Research Council
Oil Sands and Hydrocarbon Recovery
Edmonton

Alberta Forest Service
Forest Research Branch
Edmonton

The Alberta Laser Institute
Materials Processing R & D
Edmonton

Alberta Microelectronics Centre
Edmonton

Alberta Research Council
Manufacturing Technologies
Edmonton

Red Deer Hospital
Pharmacy, Pharmhand Project
Red Deer

A.1.2 Universities

University of Alberta
Dept. of Forest Science
Edmonton

University of Alberta
Dept. of Agricultural Engineering
Edmonton

A.1.3 Non-profit

Canadian Energy Research Institute
Calgary

Centre for Frontier Engineering Research
Edmonton

A.1.4 Private Sector - Small

Intera Technologies Ltd.
Technology Development Centre
Calgary

Austec Electronic Systems Ltd.
Edmonton

PLD Systems Ltd.
Calgary

SPI Synthetic Peptides Inc.
Edmonton

Sur-Flo Meters and Controls Ltd.

Western Research
Environmental Engineering
Calgary

Willowglen Systems Ltd.
Research & Development
Calgary

Beta Monitors and Controls Ltd.
Software Dept.
Calgary

Hycal Energy Research Labs Ltd.
Calgary

Agritrends Research Inc.
Calgary

Prairie Biological Research Ltd.
Edmonton

EDO Canada Ltd.
Research and Design Engineering
Calgary

Zard Aerospace
Calgary

Norac Group Inc.
Norac Technologies Inc.
Edmonton

Pulsearch Consolidated Technology
Pulsearch Navigation Systems
Calgary

Valmet Automation (Canada) Ltd.
Sage
Calgary

Microtech Well Logging Ltd.
R&D Deptartment
Calgary

Pelorus Navigation Systems Inc.
Calgary

A.1.5 Private Sector - Large

Westronic Inc.
Controls Division
Calgary

Norcen Energy Resources Ltd.
Research Group
Calgary

Schlumberger of Canada
Technical Department
Calgary

Chembiomed
Edmonton

Alta Genetics Inc.
Alta Genetics Division
Calgary

Canadian Foremost
Engineering
Calgary

Datap Systems
Calgary

Lakeside Feeders Ltd.
Lakeside Research
Brooks

Monenco
Power Division
Calgary

Esso Resources Canada Ltd.
Research & Technology Division
Calgary

Gulf Canada Resources Ltd.
Technical Services
Calgary

Northern Telecom
Business Products Division
Calgary

A.2 ENVIRONMENT

A.2.1 Government

Environment Canada
Emergencies Engineering Division
Ottawa

Research Branch of Agriculture Canada
Land Resource Research Centre
Ottawa

Deptartment of Environment
Technical Services Lab.
Winnipeg

Canada Oil Gas Lands Administration
Environmental Protection Branch
Ottawa

BC Environment
Contaminated Sites & Toxicology
Victoria

NRC Biotechnology Research Institute
Environmetal Engineering Group
Montreal

Deptartment of Environment - National Hydrology Research Institute
Environmental Science Division
Saskatoon

Newfoundland Dept. of Environment
Industrial Environmental Engineering
St. John's

Institute for Marine Biosciences
Analytical Chemistry Section
Halifax

A.2.2 Universities

University of Sherbrooke
Faculty of Applied Science
Sherbrooke

Waterloo Centre for Groundwater Research
Waterloo

Memorial University of Newfoundland
Centre for Cold Ocean Research
St. John's

A.2.3 Non-profit

Research and Productivity Council
Chemical and Biotechnical Section
Fredericton

Toxicology Research Centre
Saskatoon

Alberta Sulphur Research Ltd.
Industry Study Group
Calgary

Alberta Research Council
Environmental Research and Engineering Department
Edmonton

Ortech International
Ontario Waste Exchange
Mississauga

AECL Research
Equipmental Technologies Division
Pinawa

Nova Scotia Research Foundation Corporation
Environmental Chemistry Group
Dartmouth

A.2.4 Private Sector - Small

Integrated Environments Ltd.
Calgary

Tallon Metal Technologies, Inc.
Pointe Claire

CBR International Biotechnologies
Environment Services Division
Sidney

A.2.5 Private Sector - Large

British Columbia Research Corp.
Waste Management
Vancouver

ADI Ltd.
Environmental Engineering
Fredericton

McCain Foods Ltd.
Environmental Committee
Florenceville

Shell Canada Ltd.
Safety and Environment Corp.
Calgary

Ontario Hydro
Environment & Science Division
Toronto

Domtar Inc.
Packaging Research
Senneville

Zenon Environmental Inc.
R&D Division
Burlington

Union Carbide Canada Ltd., Linde Division
Technology and Research Centre
Mississauga

MacMillan Bloedel
MacMillan Bloedel Research
Burnaby

Noranda
Technical Centre
Pointe Claire

A.3 TELECOMMUNICATIONS

A.3.1 Government

Ontario Ministry Culture and Communications
Operations and Technology Office
Toronto

Communications Research Centre
Advanced Devices and Reliabity Directorate
Ottawa

Communications Research Centre, DOC
Mobile Satellite Communications
Ottawa

A.3.2 Universities

University of British Columbia
Distributed Systems Research
Vancouver

University of Victoria
Department of Electrical & Computer Engineering
Victoria

Laval University
Laboratoire de Radiocommunication
Quebec

University of B.C.
Communications Research Group
Vancouver

University of Saskatchewan
Centre for Communications Studies
Saskatoon

University de Montreal
Research Group "Teleinformatique"
Montreal

University of Ottawa
Comm. Research Group
Ottawa

University of Regina
Canadian Institute for Broadband and Information Network Technology
Regina

A.3.3 Non-profit

Centre Recherche Informatique Montreal
Montreal

Manitoba Research Council
Engineering Services
Manitoba

Telecommunications Research Institute of Ontario
Kanata

Centre de Recherche Industrielle du Quebec
Product Development (Communication)
Montreal

Ortech International
Macro Electronics
Mississauga

A.3.4 Private Sector - Small

DEES Communications Engineering Ltd.
DEES Communications Engineer
Delta

Microlynx
Calgary

DBA Communications Systems Inc.
Research & Development
North Vancouver

Millennium Microwave Corp.
Nepean

Applied Microelectronics Institute
Halifax

Catcom Systems Corp.
Woodbridge

Pointe Claire Electronics Ltd.
Pointe Claire

A.3.5 Private Sector - Large

Ericsson Communications
Development Group
Montreal

MPR Teletech Ltd.
Advanced Technology Divison
Burnaby

Sasktel R&D
Regina

Spar Aerospace Ltd
Satellite Communications Systems
Ste-Anne-de-Bellevue

Glenayre Electronics
Vancouver Operations
Vancouver

Alberta Government Telephone Ltd.
Research Development Dept.
Edmonton

SR Telecom Inc.
St. Laurent

Motorola Canada Ltd.
Development Engineering
North York

New Brunswick Telephone Co. Ltd.
Systems Planning
Saint John

APPENDIX B: SURVEY FORM

LINKAGES AMONG SCIENCE AND TECHNOLOGY ORGANIZATIONS

SURVEY FORM

(TELECOMMUNICATIONS RESEARCH)

PLEASE COMPLETE AND RETURN BY FEBRUARY 22, 1991

INDUSTRY, SCIENCE AND TECHNOLOGY CANADA

January, 1991

Statistics Canada Registration Number:
IST/IST-600-04202

SURVEY DESCRIPTION

BACKGROUND

There is a pressing need to improve the effectiveness of the Canadian scientific establishment, particularly in the face of the growing globalization of business and the increasing technological sophistication of our major trading partners and competitors.

An important strategy for improving this situation is the promotion of closer ties, or linkages, among industry, universities and government.

This survey is part of a study examining the state of linkages among science and technology organizations in Canada. The study is being conducted on behalf of Industry, Science and Technology Canada (ISTC) by Hickling Corporation.

A variety of organizations across Canada will be participating. This first phase concentrates on organizations doing environmental research, telecommunications research, or research in the province of Alberta.

The information obtained from this survey will be used by ISTC to help the federal government develop policies and programs which will strengthen Canada's competitiveness in science and technology.

DEFINITIONS

Research – This survey is being directed towards science and technology organizations which perform research. Research, however, is being given a very broad definition and includes work in basic research, development, engineering, and the production of both goods and services.

Organization – An organization is a company, government department, or university involved in science and technology, either internally or through a linkage with another organization.

Unit – A unit is a part of an organization with a defined purpose and boundary. An organization may be made of one or more units. The size and scope of a unit will depend on the circumstances of the organization. For example, a unit may be called a division, section, group, lab, or the unit and organization may be synonymous. It is important that the unit can be considered to be homogeneous, i.e. other organizations identify with and deal with the unit as a whole.

Linked Unit – A linked unit is a unit of another organization with which the unit being surveyed has a linkage. The linked unit need not be performing research themselves.

Linkage – A linkage is a connection between units and not individual people, although obviously people are necessary to conduct the transactions which occur over the linkage. The connection must exist over time and involve numerous transactions. Transactions must involve two-way flows, although the commodities flowing in each direction need not be the same nor simultaneous. The transactions must have some affect on research and development in the organization.

INSTRUCTIONS

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The questionnaire is in two sections. Section A is concerned with the description of the unit. Section A is filled ont once.

Section B is concerned with description of the unit's linkages with the outside world. Section B is filled out once for each of your seven major linkages. Please respond, where possible, for your most important linkage within each of five categories of linked units: government, universities, private sector suppliers, private sector customers, and private sector organizations doing similar or complementary work. Then, please respond for any two other important linkages.

Answers to the questions may take one of three forms. Some questions require a short written answer; the amount of space provided indicates the detail requested. Some questions are multiple choice; simply check the box which applies in your case. Some questions ask that you rate the importance of a subject on a scale of 1 to 5; in each case, 1 is the least important and 5 is the most important.

When you have finished filling out this survey please mail it in the enclosed postage paid return envelope or fax it to the number below.

Thank you for your cooperation and assistance.

FURTHER INFORMATION

If you wish further information on this survey or the study in general, please contact:

Christine Havey
Hickling Corporation
350 Sparks St., 6th Floor
Ottawa, Ontario, K1R 7S8
Phone:(613) 237-2220
Fax:(613) 237-7347

SECTION A: UNIT DESCRIPTION

1. BACKGROUND INFORMATION

1.1 Organization: _____
Unit Name: _____
Location: _____
What is your organization's name, the name of the unit you represent, and its location?

1.2 Contact: _____
1.3 Position: _____
1.4 Telephone: _____
1.5 Fax: _____
What is your name, title, telephone number, and fax number?

1.6 Unit Age: ☐ < 1 ☐ 1–5 ☐ 5–10 ☐ 10–20 ☐ >20 (years)
How long has your unit existed?

1.7 Ownership: ___ % Publicly Traded ___ % Employee ___ % Domestic Organizations ___ % Foreign Org.
What is the distribution of ownership (if applicable) of your organization?

1.8 Employees: Organization _____ Unit _____
What is the total employment of your organization and unit?

1.9 R&D: Organization _____ Unit _____
How much did your org. and unit spend on R&D last year?

2. UNIT PURPOSE

2.1 Mission: _____
What is your unit's mission or mandate?

2.2 Research: _____
In what areas does your unit conduct research? If possible, please forward supplemental information on your researeb facilities and capabilities.

2.3 Products: _____
What are the products and/or services that your unit supports?

3. UNIT CLASSIFICATION

3.1 Application: ☐ Transmission Equipment ☐ Transmission Services ☐ User Equipment ☐ User Services
Towards what type of equipment or services is your unit's research aimed?

3.2 Stage: ☐ Basic Research ☐ Development ☐ Engineering ☐ Production
The creation of a product or service involves several stages. At which stage is your research targeted?

4. UNIT LINKAGES

4.1 R&D: ☐ 1 (low) ☐ 2 ☐ 3 ☐ 4 ☐ 5 (high)
Production: ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Marketing/Sales: ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Rank the importance of external linkages to your unit for each area.

4.2 Barriers: ☐ Confidentiality ☐ Corporate Culture ☐ Expense/Effort ☐ Lack of Awareness ☐ Lack of Need ☐ Other(specify)_____
What are the major factors which inhibit the formation of external linkages by your unit?

4.3 Facilitators: ☐ Common Needs ☐ Corporate Culture ☐ Existing Linkages ☐ Savings/Efficiency ☐ Lack of Capability ☐ Other(specify)_____
What are the factors which prompt your unit to form external linkages?

4.3 Reasons: ☐ Knowledge ☐ Products ☐ Reputation ☐ Marketing ☐ Political ☐ Other(specify)_____
What are the reasons that other organizations form linkages with your unit?

SECTION B: LINKAGE DESCRIPTION

1. BACKGROUND INFORMATION

1.1 Linked Unit: Organization Name _____
Linked Unit Name _____
Location _____
Refer to the introduction to this questionnaire for definitions of linked organizations and units.

1.2 Your Unit: ☐ 1 ☐ 2–5 ☐ 6–10 ☐ 11–20 ☐ 20+ (people)
Linked Unit: ☐ 1 ☐ 2–5 ☐ 6–10 ☐ 11–20 ☐ 20+ (people)
How many people are directly involved in this linkage in your unit and in the linked unit?

2. LINKAGE CHARACTERISTICS

2.1 Purpose: ☐ R&D ☐ Production ☐ Marketing
For what purposes is your unit participating in the linkage?

2.2 Type: ☐ Informal ☐ Licenses ☐ Contracts ☐ Joint Ventures ☐ Other(specify)_____
What types of arrangement has your unit with the linked unit?

2.3 Importance: ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
How important is this linkage to your unit?

2.4 Future: ☐ Increase ☐ Decrease ☐ Same
How will the importance of this linkage change?

2.5 Initiator: ☐ Your Unit ☐ Linked Unit ☐ Third Party
Who initiated this linkage?

2.6 Duration: ☐ < 1 ☐ 1–5 ☐ 5–10 ☐ 10–20 ☐ >20 (years)
How long has this linkage existed?

3. TRAFFIC CHARACTERISTICS

3.1 Topic: _____
What is the topic of your exchanges with the linked unit?

3.2 Your Unit ---> Linked Unit

Information:	☐ 1 (low)	☐ 2	☐ 3	☐ 4	☐ 5 (high)	Rate the relative importance of the items exchanged over the linkage from your unit to the linked unit.
Money:	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	
Product/Services:	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	
People:	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	
Electronic:	☐ 1 (low)	☐ 2	☐ 3	☐ 4	☐ 5 (high)	Rate the relative importance of the mechanisms by which the exchanges occur over the linkage from your unit to the linked unit.
Verbal:	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	
Paper:	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	
Physical:	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	

3.3 Linked Unit ---> Your Unit

Information:	☐ 1 (low)	☐ 2	☐ 3	☐ 4	☐ 5 (high)	Rate the relative importance of the items exchanged over the linkage from the linked unit to your unit.
Money:	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	
Product/Services:	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	
People:	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	
Electronic:	☐ 1 (low)	☐ 2	☐ 3	☐ 4	☐ 5 (high)	Rate the relative importance of the mechanisms by which the exchanges occur over the linkage from the linked unit to your unit.
Verbal:	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	
Paper:	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	
Physical:	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	

3.4 Frequency: ☐ Daily ☐ Weekly ☐ Monthly ☐ Yearly
How often does your unit have contact with the linked unit?

3.5 Future: ☐ Increase ☐ Decrease ☐ Same
How will the frequency of contact change?

4. QUALITY

4.1 Benefit:	☐ 1 (low)	☐ 2	☐ 3	☐ 4	☐ 5 (high)	Rate the relative benefit to your unit from this linkage.
4.2 Effort:	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	Rate the relative level of effort required for this linkage.
4.3 Satisfaction:	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	Rate your unit's relative level of satisfaction with this linkage.

LINKAGES AMONG SCIENCE AND TECHNOLOGY ORGANIZATIONS

SURVEY FORM

(ENVIRONMENTAL RESEARCH)

PLEASE COMPLETE AND RETURN BY FEBRUARY 22, 1991

INDUSTRY, SCIENCE AND TECHNOLOGY CANADA

January, 1991

Statistics Canada Registration Number:
IST/IST–600–04202

SURVEY DESCRIPTION

BACKGROUND

There is a pressing need to improve the effectiveness of the Canadian scientific establishment, particularly in the face of the growing globalization of business and the increasing technological sophistication of our major trading partners and competitors.

An important strategy for improving this situation is the promotion of closer ties, or linkages, among industry, universities and government.

This survey is part of a study examining the state of linkages among science and technology organizations in Canada. The study is being conducted on behalf of Industry, Science and Technology Canada (ISTC) by Hickling Corporation.

A variety of organizations across Canada will be participating. This first phase concentrates on organizations dning environmental research, telecommunications research, or research in the province of Alberta.

The information obtained from this survey will be used by ISTC to help the federal government develop policies and programs which will strengthen Canada's competitiveness in science and technology.

DEFINITIONS

Research – This survey is being directed towards science and technology organizations which perform research. Research, however, is being given a very hroad definition and includes work in hasic research, development, engineering, and the production of both goods and services.

Organization – An organization is a company, government department, or university involved in science and technology, either internally or through a linkage with another organization.

Unit – A unit is a part of an organization with a defined purpose and boundary. An organization may be made of one or more units. The size and scope of a unit will depend on the circumstances of the organization. For example, a unit may be called a division, section, group, lab, or the unit and organization may be synonymous. It is important that the unit can be considered to be homogeneous, i.e. nther organizations identify witb and deal with the unit as a whole.

Linked Unit – A linked unit is a unit of another organization with which the unit being surveyed has a linkage. The linked unit need not be performing research themselves.

Linkage – A linkage is a connection between units and not individual people, although obviously people are necessary to conduct the transactions which occur over the linkage. The connection must exist over time and involve numerous transactions. Transactions must involve two–way flows, although the commodities flowing in each direction need not he the same nor simultaneous. The transactions must have some affect on research and development in the organization.

INSTRUCTIONS

This survey should be directed to a unit within the organization which is responsible for some aspect of environmental research. It should be completed hy someone who is familiar with the interactions of the unit with the outside world. Typically this would be the manager of the unit.

The questionnaire is in two sections. Section A is concerned with the description of the unit. Section A is filled out once.

Section B is concerned with description of the unit's linkages with the outside world. Section B is filled out once for each of your seven major linkages. Please respond, where possible, for your most important linkage within each of five categories of linked units: government, universities, private sector suppliers, private sector customers, and private sector organizations doing similar or complementary work. Then, please respond for any two other important linkages.

Answers to the questions may take one of three forms. Some questions require a short written answer; the amount of space provided indicates the detail requested. Some questions are multiple choice; simply check the box which applies in your case. Some questions ask that you rate the importance of a subject on a scale of 1 to 5; in each case, 1 is the least important and 5 is the most important.

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Thank you for your participation and assistance.

FURTHER INFORMATION

If you wish further information on this survey or the study in general, please contact:

Tina Birkenheier
Hickling Corporation
350 Sparks St., 6th Floor
Ottawa, Ontario, K1R 7S8
Phone:(613) 237–2220
Fax:(613) 237–7347

SECTION A: UNIT DESCRIPTION

1. BACKGROUND INFORMATION

1.1 Organization: _____
Unit Name: _____
Location: _____
What is your organization's name, the name of the unit you represent, and its location?

1.2 Contact: _____
1.3 Position: _____
1.4 Telephone: _____
1.5 Fax: _____
What is your name, title, telephone number, and fax number?

1.6 Unit Age: ☐ < 1 ☐ 1–5 ☐ 5–10 ☐ 10–20 ☐ >20 (years)
How long has your unit existed?

1.7 Ownership: ___ % Publicly Traded ___ % Employee ___ % Domestic Organizations ___ % Foreign Org.
What is the distribution of ownership (if applicable) of your organization?

1.8 Employees: Organization _____ Unit _____
What is the total employment of your organization and unit?

1.9 R&D: Organization _____ Unit _____
How much did your org. and unit spend on R&D last year?

2. UNIT PURPOSE

2.1 Mission: _____
What is your unit's mission or mandate?

2.2 Research: _____
In what areas does your unit conduct research? If possible, please forward supplemental information on your research facilities and capabilities.

2.3 Products: _____
What are the products and/or services that your unit supports?

3. UNIT CLASSIFICATION

3.1 Application: ☐ Regulation/Planning ☐ Process/Production ☐ Treatment of Output ☐ Waste Disposal
Solutions to environmental problems can be addressed at a number of points. Which points has your research targeted?

3.2 Stage: ☐ Basic Research ☐ Development ☐ Engineering ☐ Production
The creation of a product or service involves several stages. At which stage is your research targeted?

3.3 Problem: ☐ Water ☐ Air ☐ Solids ☐ Land
What type of environmental problem is addressed by your unit's research?

3.4 Industry: ☐ Manufacturing ☐ Resource ☐ Process ☐ Service ☐ Other _____
Which industries benefit from, or are impacted by, the environmental research that your unit performs?

SECTION A: UNIT DESCRIPTION (continued)

4. UNIT LINKAGES

4.1 R&D: ☐ 1 (low) ☐ 2 ☐ 3 ☐ 4 ☐ 5 (high)
Production: ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Marketing/Sales: ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Rank the importance of external linkages to your unit for each area.

4.2 Barriers:
☐ Confidentiality ☐ Corporate Culture
☐ Expense/Effort ☐ Lack of Awareness
☐ Lack of Need ☐ Other(specify)_____

What are the major factors which inhibit the formation of external linkages by your unit?

4.3 Facilitators:
☐ Common Needs ☐ Corporate Culture
☐ Existing Linkages ☐ Savings/Efficiency
☐ Lack of Capability ☐ Other(specify)_____

What are the factors which prompt your unit to form external linkages?

4.3 Reasons:
☐ Knowledge ☐ Products
☐ Reputation ☐ Marketing
☐ Political ☐ Other(specify)_____

What are the reasons that other organizations form linkages with your unit?

SECTION B: LINKAGE DESCRIPTION

1. BACKGROUND INFORMATION

1.1 Linked Unit: Organization Name _____
Linked Unit Name _____
Location _____
Refer to the introduction to this questionnaire for definitions of linked organizations and units.

1.2 Your Unit: ☐ 1 ☐ 2–5 ☐ 6–10 ☐ 11–20 ☐ 20+ (people)
Linked Unit: ☐ 1 ☐ 2–5 ☐ 6–10 ☐ 11–20 ☐ 20+ (people)
How many people are directly involved in this linkage in your unit and in the linked unit?

2. LINKAGE CHARACTERISTICS

2.1 Purpose: ☐ R&D ☐ Production ☐ Marketing
For what purposes is your unit participating in the linkage?

2.2 Type: ☐ Informal ☐ Licenses ☐ Contracts ☐ Joint Ventures ☐ Other(specify)_____
What types of arrangement has your unit with the linked unit?

2.3 Importance: ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
How important is this linkage to your unit?

2.4 Future: ☐ Increase ☐ Decrease ☐ Same
How will the importance of this linkage change?

2.5 Initiator: ☐ Your Unit ☐ Linked Unit ☐ Third Party
Who initiated this linkage?

2.6 Duration: ☐ < 1 ☐ 1–5 ☐ 5–10 ☐ 10–20 ☐ >20 (years)
How long has this linkage existed?

3. TRAFFIC CHARACTERISTICS

3.1 Topic: _____
What is the topic of your exchanges with the linked unit?

3.2 Your Unit ---> Linked Unit

Information:	☐ 1 (low)	☐ 2	☐ 3	☐ 4	☐ 5 (high)	Rate the relative importance of the items exchanged over the linkage from your unit to the linked unit.
Money:	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	
Product/Services:	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	
People:	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	
Electronic:	☐ 1 (low)	☐ 2	☐ 3	☐ 4	☐ 5 (high)	Rate the relative importance of the mechanisms by which the exchanges occur over the linkage from your unit to the linked unit.
Verbal:	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	
Paper:	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	
Physical:	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	

3.3 Linked Unit ---> Your Unit

Information:	☐ 1 (low)	☐ 2	☐ 3	☐ 4	☐ 5 (high)	Rate the relative importance of the items exchanged over the linkage from the linked unit to your unit.
Money:	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	
Product/Services:	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	
People:	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	
Electronic:	☐ 1 (low)	☐ 2	☐ 3	☐ 4	☐ 5 (high)	Rate the relative importance of the mechanisms by which the exchanges occur over the linkage from the linked unit to your unit.
Verbal:	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	
Paper:	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	
Physical:	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	

3.4 Frequency: ☐ Daily ☐ Weekly ☐ Monthly ☐ Yearly
How often does your unit have contact with the linked unit?

3.5 Future: ☐ Increase ☐ Decrease ☐ Same
How will the frequency of contact change?

4. QUALITY

4.1 Benefit: ☐ 1 (low) ☐ 2 ☐ 3 ☐ 4 ☐ 5 (high)
Rate the relative benefit to your unit from this linkage.

4.2 Effort: ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Rate the relative level of effort required for this linkage.

4.3 Satisfaction: ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Rate your unit's relative level of satisfaction with this linkage.

LINKAGES AMONG SCIENCE AND TECHNOLOGY ORGANIZATIONS

SURVEY FORM

(ALBERTA)

PLEASE COMPLETE AND RETURN BY FEBRUARY 22, 1991

INDUSTRY, SCIENCE AND TECHNOLOGY CANADA

January, 1991

SURVEY DESCRIPTION

BACKGROUND

There is a pressing need to improve the effectiveness of the Canadian scientific establishment, particularly in the face of the growing globalization of business and the increasing technological sophistication of our major trading partners and competitors.

An important strategy for improving this situation is the promotion of closer ties, or linkages, among industry, universities and government.

This survey is part of a study examining the state of linkages among science and technology organizations in Canada. The study is being conducted on behalf of Industry, Science and Technology Canada (ISTC) by Hickling Corporation.

A variety of organizations across Canada will be participating. This first phase concentrates on organizations doing environmental research, telecommunications research, or research in the province of Alberta.

The information obtained from this survey will be used by ISTC to help the federal government develop policies and programs which will strengthen Canada's competitiveness in science and technology.

DEFINITIONS

Research – This survey is being directed towards science and technology organizations which perform research. Research, however, is being given a very broad definition and includes work in basic research, development, engineering, and the production of both goods and services.

Organization – An organization is a company, government department, or university involved in science and technology, either internally or through a linkage with another organization.

Unit – A unit is a part of an organization with a defined purpose and boundary. An organization may be made of one or more units. The size and scope of a unit will depend on the circumstances of the organization. For example, a unit may be called a division, section, group, lab, or the unit and organization may be synonymous. It is important that the unit can be considered to be homogeneous, i.e. other organizations identify with and deal with the unit as a whole.

Linked Unit – A linked unit is a unit of another organization with which the unit being surveyed has a linkage. The linked unit need not be performing research themselves.

Linkage – A linkage is a connection between units and not individual people, although obviously people are necessary to conduct the transactions which occur over the linkage. The connection must exist over time and involve numerous transactions. Transactions must involve two–way flows, although the commodities flowing in each direction need not be the same nor simultaneous. The transactions must have some affect on research and development in the organization.

INSTRUCTIONS

This survey should be directed to a unit within the organization which is responsible for some aspect of research. It should be completed by someone who is familiar with the interactions of the unit with the outside world. Typically this would be the manager of the unit.

The questionnaire is in two sections. Section A is concerned with the description of the unit. Section A is filled out once.

Section B is concerned with description of the unit's linkages with the outside world. Section B is filled out once for each of your seven major linkages. Please respond, where possible, for your most important linkage within each of five categories of linked units: government, universities, private sector suppliers, private sector customers, and private sector organizations doing similar or complementary work. Then, please respond for any two other important linkages.

Answers to the questions may take one of three forms. Some questions require a short written answer; the amount of space provided indicates the detail requested. Some questions are multiple choice; simply check the box which applies in your case. Some questions ask that you rate the importance of a subject on a scale of 1 to 5; in each case, 1 is the least important and 5 is the most important.

When you have finished filling out this survey please mail it in the enclosed postage paid return envelope or fax it to the number below.

Thank you for your participation and assistance.

FURTHER INFORMATION

If you wish further information on this survey or the study in general, please contact:

Jeffrey White
Alberta Research Council
3rd Floor, 6815 8 Street NE
Calgary, Alberta
Phone: (403) 297–2665
Fax: (403) 275–3003

SECTION A: UNIT DESCRIPTION

1. BACKGROUND INFORMATION

1.1 Organization: _____
Unit Name: _____
Location: _____
What is your organization's name, the name of the unit you represent, and its location?

1.2 Contact: _____
1.3 Position: _____
1.4 Telephone: _____
1.5 Fax: _____
What is your name, title, telephone number, and fax number?

1.6 Unit Age: ☐ < 1 ☐ 1–5 ☐ 5–10 ☐ 10–20 ☐ >20 (years)
How long has your unit existed?

1.7 Ownership: ___ % Publicly Traded ___ % Employee ___ % Domestic Organizations ___ % Foreign Org.
What is the distribution of ownership (if applicable) of your organization?

1.8 Employees: Organization _____ Unit _____
What is the total employment of your organization and unit?

1.9 R&D: Organization _____ Unit _____
How much did your org. and unit spend on R&D last year?

2. UNIT PURPOSE

2.1 Mission: _____
What is your unit's mission or mandate?

2.2 Research: _____
In what areas does your unit conduct research? If possible, please forward supplemental information on your research facilities and capabilities.

2.3 Products: _____
What are the products and/or services that your unit supports?

3. UNIT CLASSIFICATION

3.1 Stage: ☐ Basic Research ☐ Development ☐ Engineering ☐ Production
The creation of a product or service involves several stages. At which stage is your research targeted?

3.2 Industry: ☐ Manufacturing ☐ Resource ☐ Process ☐ Service ☐ Other (specify) _____
Which industries benefit from, or are impacted by, the research that your unit performs?

4. UNIT LINKAGES

4.1 R&D: ☐ 1 (low) ☐ 2 ☐ 3 ☐ 4 ☐ 5 (high)
Production: ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Marketing/Sales: ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Rank the importance of external linkages to your unit for each area.

4.2 Barriers: ☐ Confidentiality ☐ Corporate Culture ☐ Expense/Effort ☐ Lack of Awareness ☐ Lack of Need ☐ Other(specify)_____
What are the major factors which inhibit the formation of external linkages by your unit?

4.3 Facilitators: ☐ Common Needs ☐ Corporate Culture ☐ Existing Linkages ☐ Savings/Efficiency ☐ Lack of Capability ☐ Other(specify)_____
What are the factors which prompt your unit to form external linkages?

4.3 Reasons: ☐ Knowledge ☐ Products ☐ Reputation ☐ Marketing ☐ Political ☐ Other(specify)_____
What are the reasons that other organizations form linkages with your unit?

APPENDIX C: INTERVIEW GUIDE

APPENDIX C: INTERVIEW GUIDE

1. **Are linkages important to your organization/unit? What role do they play?**

   Interrelationship between your organization's goals and the types and number of linkages formed.

   Relative importance of linkages at the various stages of product or process development (ie. are linkages that impact basic research more important than those that affect development or engineering?)

   Characteristics of a good linkage. Benefits derived from linkages.

2. **How does the external environment impact the linkages your organization forms? Is this environment changing?**

   Impact of globalization, economic downturns, incentives, etc.

3. **Is the importance of linkages to your organization increasing or decreasing?**

   Types of linkages that are becoming more important/less important.

4. **How and when do you create linkages? What form do they take?**

   Type of organizations linked with most frequently (ie. suppliers, customers, competitors, etc.). Factors that lead to linkages with various types of organizations.

   Characteristics of the situations in which informal and formal linkages are established. Conditions under which informal linkages are formalized.

   Advantages and disadvantages associated with various types of linkages (licensing, joint venture, contract, informal). Importance of linkage types.

5. **What are the main barriers/facilitators to the formation of linkages?**

   Factors that act as a barrier to the formation of linkages. Examples of when these factors prevented the formation of a linkage.

   Factors that facilitate the formation of linkages. Examples of when these factors precipitated the formation of a linkage.

6. **What can be done to facilitate the formation of linkages/enhance the benefit derived from linkages?**

   a) at the unit (company/lab) level
   b) from a public policy perspective

   Actions to facilitate the formation of linkages and improve the results of linkages.

APPENDIX D: DATA ANALYSIS

APPENDIX D: DATA ANALYSIS

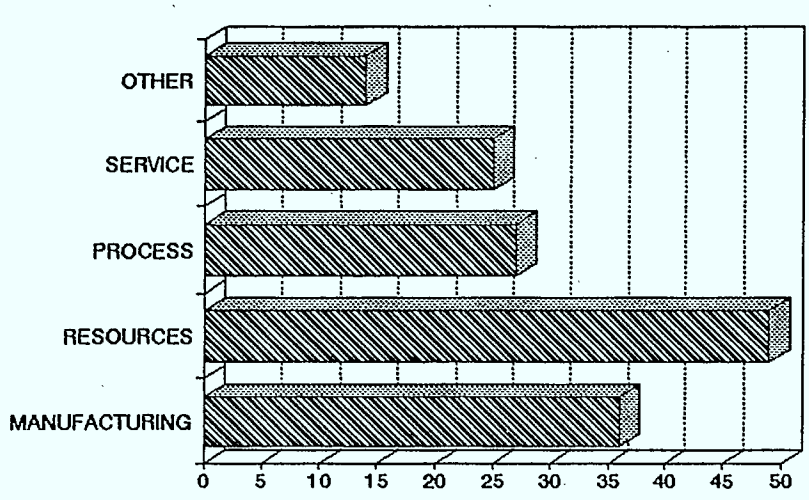
D.1 UNIT DESCRIPTION

D.1.1 Industries Impacted (Environment and Alberta)

Table 1–1: Industries Impacted (Environment and Alberta)

	Environ.	Alberta		All
MANUFACTURIN	19	17		36
RESOURCES	25	24		49
PROCESS	14	13		27
SERVICE	13	12		25
OTHER	6	8		14

Figure 1–1: Industries Impacted (Environment and Alberta)

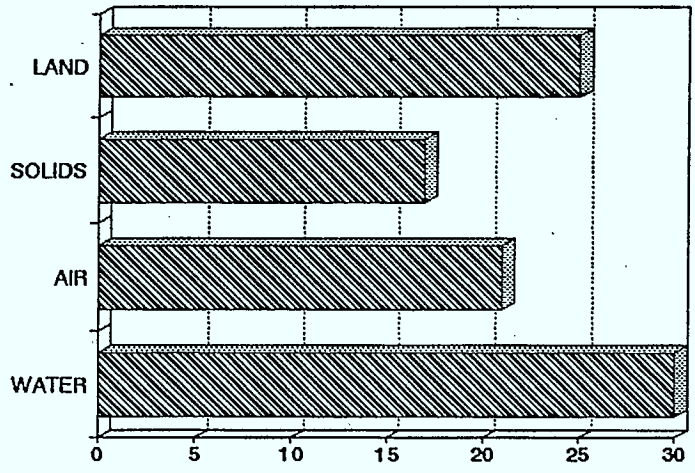


D.1.2 Problem Area Investigated (Environment)

Table 1–2: Problem Area Investigated (Environment)

	Environ.
WATER	30
AIR	21
SOLIDS	17
LAND	25

Figure 1–2: Problem Area Investigated (Environment)

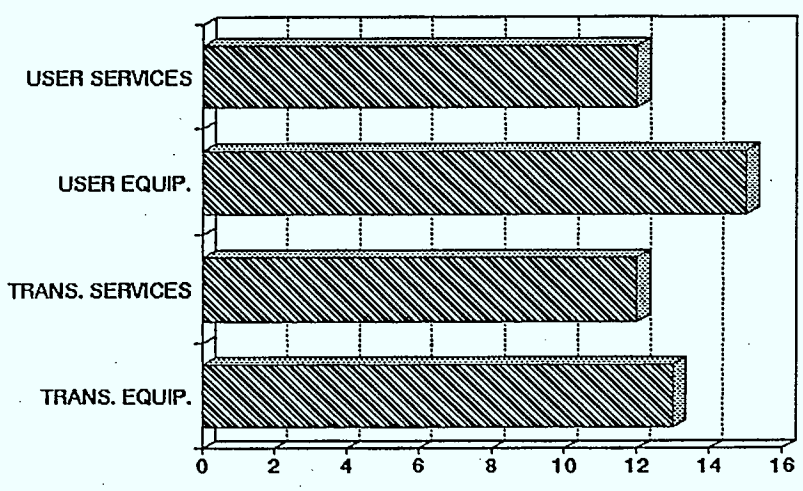


D.1.3 Application Area (Telecommunications)

Table 1–3: Application Area (Telecommunications)

	Telecom.
TRANS. EQUIP.	13
TRANS. SERVICES	12
USER EQUIP.	15
USER SERVICES	12

Figure 1–3: Application Area (Telecommunications)

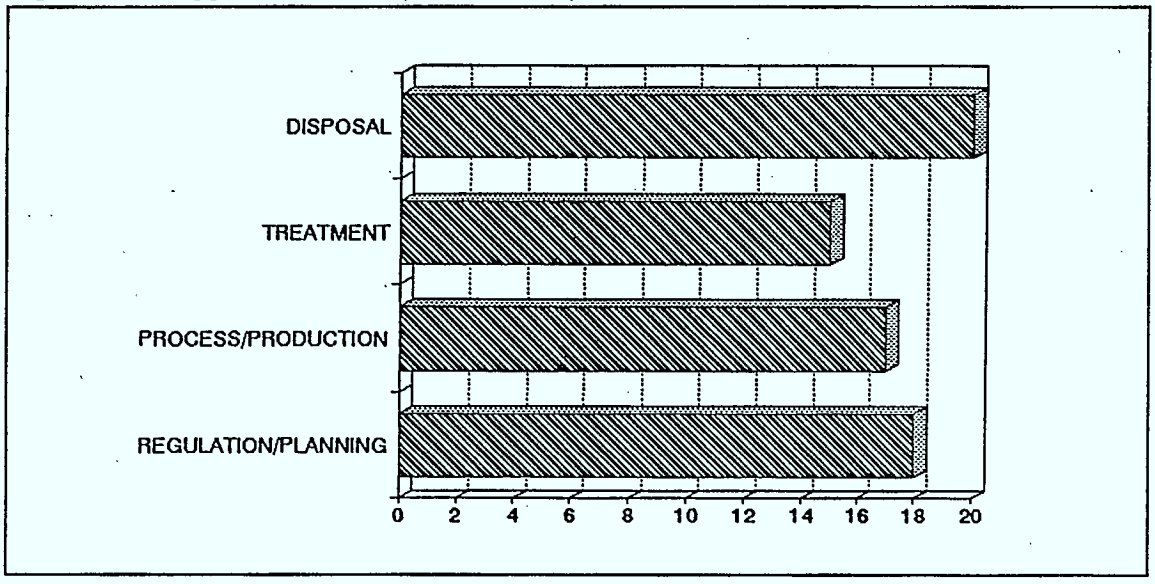


D.1.4 Application Area (Environment)

Table 1–4: Application Area (Environment)

	Environ.
REGULATION/PLA	18
PROCESS/PRODU	17
TREATMENT	15
DISPOSAL	20

Figure 1–4: Application Area (Environment)

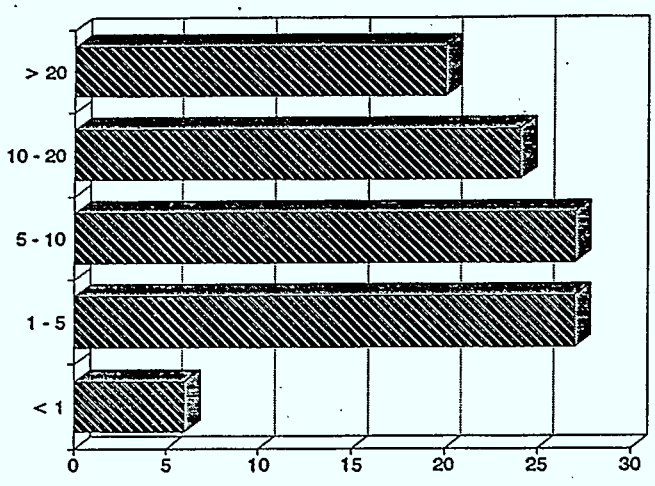


D.1.5 Unit Age

Table 1–5: Unit Age

	Telecom	Environ.	Alberta	All
< 1	0	4	2	6
1 - 5	11	7	9	27
5 - 10	11	6	10	27
10 - 20	6	6	12	24
> 20	4	9	7	20
ALL	32	32	40	104

Figure 1–5: Unit Age

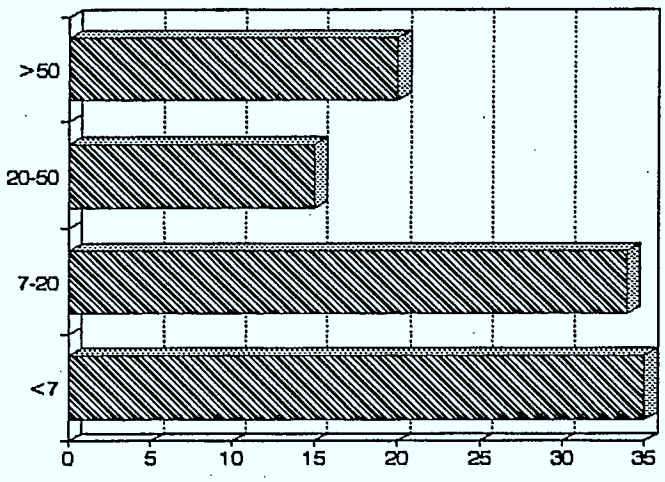


D.1.6 Number of Employees (Study Unit)

Table 1–6: Number of Employees (Study Unit)

	Telecom	Environ.	Alberta	All
<7	11	9	15	35
7-20	11	8	15	34
20-50	6	7	2	15
>50	4	8	8	20

Figure 1–6: Number of Employees (Study Unit)

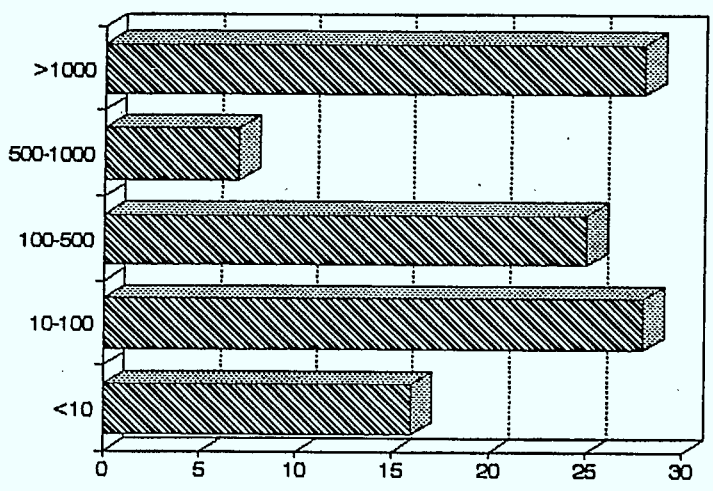


D.1.7 Number of Employees (Organization)

Table 1–7: Number of Employees (Organization)

	Telecom	Environ.	Alberta	All
<10	6	4	6	16
10-100	6	8	14	28
100-500	7	9	9	25
500-1000	2	1	4	7
>1000	11	10	7	28

Figure 1–7: Number of Employees (Organization)

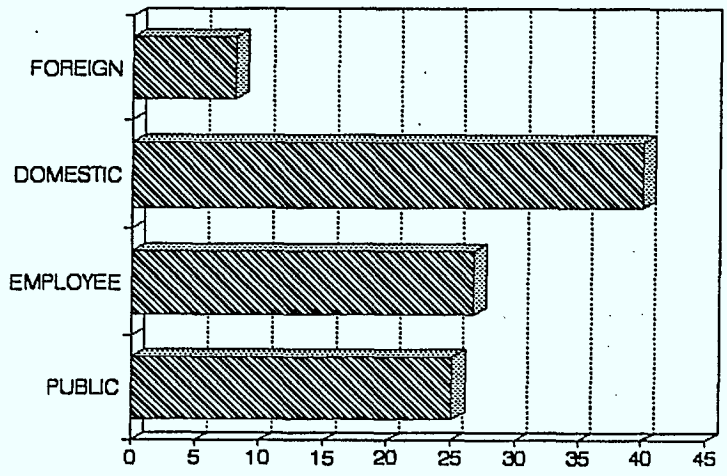


D.1.8 Ownership

Table 1–8: Ownership

	Telecom	Environ.	Alberta	All
PUBLIC	24.8	33.2	21.9	25.1
EMPLOYEE	17.5	36.4	28.5	26.8
DOMESTIC	51.5	18.2	42.2	40.0
FOREIGN	6.3	12.3	7.4	8.1
ALL	100.0	100.0	100.0	100.0

Figure 1–8: Ownership



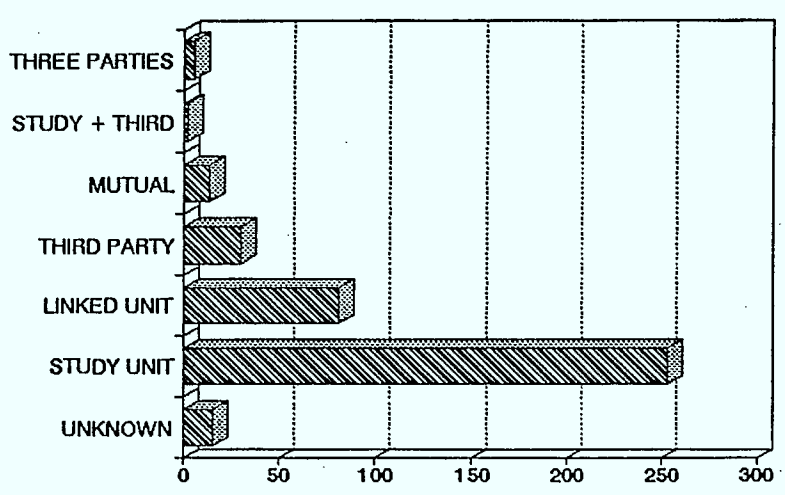
D.2 LINKAGE DESCRIPTION

D.2.1 Linkage Initiator

Table 1–9: Linkage Initiator

	Alberta	Environ.	Telecom.	All
UNKNOWN	4	6	5	15
STUDY UNIT	90	108	55	253
LINKED UNIT	33	29	19	81
THIRD PARTY	14	7	9	30
MUTUAL	12	1	0	13
STUDY + THIRD	2	0	0	2
THREE PARTIES	5	0	0	5
ALL	160	151	88	399

Figure 1–9: Linkage Initiator

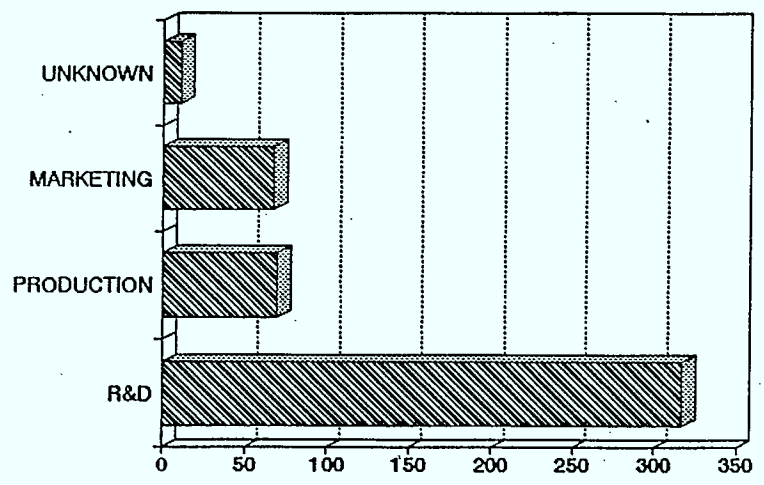


D.2.2 Linkage Purpose

Table 1–10: Linkage Purpose

	Alberta	Environ.	Telecom.	All
R&D	120	130	67	317
PRODUCTION	27	23	20	70
MARKETING	35	15	18	68
UNKNOWN	5	5	1	11
NUMBER RETURN	160	151	88	399

Figure 1–10: Linkage Purpose

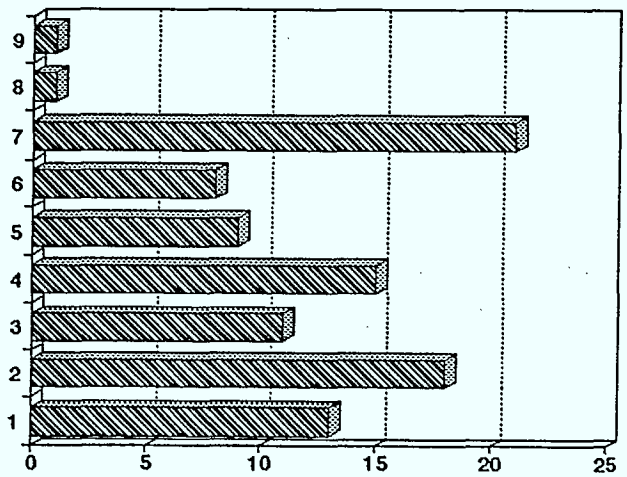


D.2.3 Number of Linkages Identified

Table 1–11: Number of Linkages Identified

	Alberta	Environ.	Telecom.	All
1	5	2	6	13
2	5	6	7	18
3	5	5	1	11
4	8	1	6	15
5	2	4	3	9
6	3	3	2	8
7	10	9	2	21
8	0	1	0	1
9	0	1	0	1
ALL	38	32	27	97

Figure 1–11: Number of Linkages Identified



APPENDIX E: LITERATURE SEARCH RESULTS

APPENDIX E: LITERATURE SEARCH RESULTS

File 49:PAIS INTERNATIONAL _ 76-90/AUG
(COPR.1990 PAIS INC.)

File 66:GPO MONTHLY CATALOG _ JUL 1976 TO SEP 1990

File 15:ABI/INFORM _ 71-90/SEP WEEK 1
(Copr. 1990 UMI/Data Courier)

File 90:FOREIGN TRADE & ECON ABSTRACTS _ 74-90/AUG

File 148:TRADE AND INDUSTRY INDEX_81-90/OCT
(COPR. 1990 IAC)

File 75:MANAGEMENT CONTENTS _ 74-90/SEP
(COPR. 1990 INFORMATION ACCESS CO.)

File 648:TRADE AND INDUSTRY ASAP_83-90/OCT
(COPR. IAC 1990)

File 6:NTIS - 64-90/ISSUE19
(COPR. 1990 NTIS)

File 13:INSPEC - 77-90/ISS19
(COPR. IEE 1989)

File 77:CONFERENCE PAPERS INDEX - 73-90/JUL
(C. CAMBRIDGE SCIENTIFIC ABS.)

File 1:ERIC _ 66-90/AUG.

File 7:SOCIAL SCISEARCH _ 72-90/WK34
(COPR. ISI INC.1990)

? s (linkage? and (research(w2)development or R(w2)D))/ti
S1 25 (LINKAGE? AND (RESEARCH(W2)DEVELOPMENT OR R(W2)D))/TI

1/3/1 (Item 1 from file: 49)
455510 861200245
Research and development: linkages to production in developing countries.
Silveira, Mary Pat Williams, ed.
'85 xvi+316p, tables charts
SERIES: United Nations science and tech. for development ser.;
ORDER INFO: Westview (LC 85-50985) (ISBN 0-8133-7073-6) pa $32

1/3/2 (Item 2 from file: 49)
356322 800901971
Agglomeration and intra-firm linkage in R & D location in the United States (clustering of industrial research and development laboratories in metropolitan areas).
Malecki, Edward J.
Tijdschrift voor Economische en Sociale Geografie (Leiden) 70:322-32 no 6 '79, bibl tables charts map

1/3/3 (Item 1 from file: 66)
1595261 ED 1.310/2-255765
A guide to linkages between vocational education and organized labor in the United States /.Robert E. Norton, James O. Belcher
Norton, Robert E.,1937-
Belcher, James O.
Corporate Source: National Center for Research in Vocational Education (U.S.) United States. Office of Vocational and Adult Education.
Columbus, Ohio : National Center for Research in Vocational Education, Ohio State University, 1984. viii, 162 leaves : ill. ; 28 cm.
Publication Date(s): 1984

LCCN: gp 88018228
Place of Publication: Ohio GPO Item No.: 466-A-3 (microfiche)
Stock No.: ED 255765; ERIC

1/3/4 (Item 2 from file: 66)
0196832 ED 1.310/2-205568
Regional exchanges of information through intermediate linkages affiliated with SEAs : The Research and Development Exchange (RDx) and the SEDL/Regional Exchange : one component of an emerging effort to disseminate the outcomes of educational research and development /.by Preston C. Kronkosky
Kronkosky, Preston C.
Corporate Source: Southwest Educational Development Laboratory. American Educational Research Association. Meeting (1981: Los Angeles, Calif.) National Institute of Education (U.S.)
Austin, Tex. : Southwest Educational Development Laboratory, [1981] 9 leaves ; 28 cm.
Publication Date(s): 1981
LCCN: gp 84006617
Place of Publication: Texas GPO Item No.: 466-A-3 (microfiche)
Stock No.: ED 205568; Educational Resources Information Center

1/3/5 (Item 1 from file: 15)
88034799
R&D/Marketing Linkage and Innovation Strategy: Some West Germa n Experience
Brockhoff, Klaus; Chakrabarti, Alok K.
IEEE Transactions on Engineering Mgmt v35n3 PP: 167-174 Aug 1988
ISSN: 0018-9391 JRNL CODE: IEE
AVAILABILITY: ABI/INFORM

1/3/6 (Item 2 from file: 15)
84017621
Linking R&D with Business Needs: R&D Linkages in a Multi-Industry Corporation
Westwood, Albert R. C.
Research Mgmt v27n3 PP: 23-26 May/Jun 1984
ISSN: 0034-5334 JRNL CODE: RMG
AVAILABILITY: ABI/INFORM

1/3/7 (Item 1 from file: 90)
7488527 800500527
Agglomeration and intra-firm linkage in R and D location in the United States
Malecki, E.J
EDITION: 11p. A4
Tijdschrift voor economische en sociale geografie, Amsterdam, (70), nr. 6, 1979, p. 322). , Graphs.Maps. Ref. Tabs CATALOG NO.: TEG-6-1979 R

1/3/8 (Item 1 from file: 148)
06801316 DIALOG File 148: TRADE & INDUSTRY INDEX
R&D-marketing linkage and innovation strategy: some West German experience.
Brockhoff, Klaus; Chakrabarti, Alok K.
IEEE Transactions on Engineering Management v35 p167(8) Aug, 1988
SOURCE FILE: TI File 148

1/3/9 (Item 2 from file: 148)
04359362 DIALOG File 148: TRADE & INDUSTRY INDEX
R&D linkages in a multi-industry corporation. (case study: Martin Marietta Corp.)
Westwood, Albert R.C.
Research Management v27 p23(4) May-June, 1984
SOURCE FILE: TI File 148

1/3/10 (Item 3 from file: 148)
02643188 DIALOG File 148: TRADE & INDUSTRY INDEX
Use Format 9 for FULL TEXT

Forging linkages for discovery and innovation. (research-and-development communication between science and business)
Lee, Edward P., Jr.
Industry Week v216 p13(1) Feb 21, 1983
SOURCE FILE: MI File 47
AVAILABILITY: FULL TEXT Online LINE COUNT: 00072

1/3/11 (Item 1 from file: 75)
133188 DIALOG Information Services, File 75: Management Contents
AMA7710526
INNOVATION LINKAGES BETWEEN MARKETING AND R & D.
TINSLEY, D.B.
AMERICAN MARKETING ASSOCIATION PROCEEDINGS, NO.41, 1977,P. 526.

1/3/12 (Item 1 from file: 648)
02643188 DIALOG File 648: TRADE & INDUSTRY ASAP
Use Format 9 for FULL TEXT
Forging linkages for discovery and innovation. (research-and-development communication between science and business)
Lee, Edward P., Jr.
Industry Week v216 p13(1) Feb 21, 1983
SOURCE FILE: MI File 47
AVAILABILITY: FULL TEXT Online LINE COUNT: 00072

1/3/13 (Item 1 from file: 6)
951130 PB83-132761
An Examination of Possible Linkages Between the National Science Foundation's Industrial R and D Data Set and Other Economic Data Bases (Final rept.)
Goodman, John A. ; Megna, Elizabeth C.
Technical Assistance Research Programs, Inc., Washington, DC.
Corp. Source Codes: 056588000
Sponsor: National Science Foundation, Washington, DC. Div. of Science Resources Studies.
Report No.: NSF-SRS-80-17030
14 Apr 82 55p
Languages: English
Journal Announcement: GRAI8306
NTIS Prices: PC A04/MF A01

1/3/14 (Item 2 from file: 6)
251833 AD-735 122
CURV Linkage Manipulator
(Research and development rept. Jan-Dec 70)
Uhrich, R.
Naval Undersea Research and Development Center San Diego Calif
Corp. Source Codes: 404762
Report No.: NUC-TP-271
Nov 71 14p
Journal Announcement: GRAI7204
NTIS Prices: PC A02 MF A01

1/3/15 (Item 1 from file: 13)
3270809 B89000166
R&D/marketing linkage and innovation strategy: some West German experience
Brockhoff, K.; Chakrabarti, A.K.
Author Affil: Christian Albrechts Univ., Kiel, West Germany
Source: IEEE Trans. Eng. Manage. (USA) vol.35, no.3, pp.: 167-74
Publication Year: Aug. 1988
CODEN: IEEMA4 ISSN: 0018-9391
U. S. Copyright Clearance Center Code: 0018-9391/88/0800-0167$01.00

1/3/16 (Item 2 from file: 13)
1697374 B86043536, C86034357
US-Japan data linkage for fusion energy research and development
Ogawa, M.; Adachi, M.; Takiguchi, T.

Author Affil: Fujitsu Labs., Japan
Source: Fujitsu (Japan) vol.36, no.7, pp.: 675-82
Publication Year: 1985
CODEN: FUJTAR ISSN: 0016-2515

1/3/17 (Item 1 from file: 77)
78056680 v6n7
Intrafirm linkage, government & agglomeration in R & D location
Malecki, E.J.
Univ Of Oklahoma.
Association of American Geographers 74th Annual Meeting 782 1051 New Orleans, Louisiana 9-12 Apr 78
Association of American Geographers
Papers planned, for information: AAG, 1710 16th St., N.W., Washington, D.C. 20009.

1/3/18 (Item 1 from file: 1)
ED255765 CE041313
A Guide to Linkages between Vocational Education and Organized Labor in the United States. Research and Development Series No. 252.
Norton, Robert E.; Belcher, James O.
Ohio State Univ., Columbus. National Center for Research in Vocational Education.
1984
162p.
Sponsoring Agency: Office of Vocational and Adult Education (ED), Washington, DC.
EDRS Price - MF01/PC07 Plus Postage.

1/3/19 (Item 2 from file: 1)
ED205568 TM810452
Regional Exchanges of Information through Intermediate Linkages Affiliated with SEAs: The Research and Development Exchange (RDx).
Kronkosky, Preston C.
Southwest Educational Development Lab., Austin, Tex.
13 Apr 1981
13p.; Paper presented at the Annual Meeting of the American Educational Research Association (65th, Los Angeles, CA, April 13-17, 1981); For a related document, see TM 810 451.
Sponsoring Agency: National Inst. of Education (ED), Washington, D.C.
EDRS Price - MF01/PC01 Plus Postage.

1/3/20 (Item 1 from file: 7)
02096055 Genuine Article#: CW028 Number of References: 0
RESEARCH-AND-DEVELOPMENT LINKAGES FOR THE GAINFUL USE OF WASTELANDS ON FORAGE BASED FARM FORESTRY PROGRAM
YADAV IPS; HAZRA CR
INDIAN COUNCIL AGR RES,INDIAN GRASSLAND & FODDER RES INST,DIV RURAL ECON & BIOMETR/JHANSI/UTTARPRADESH/INDIA/; INDIAN COUNCIL AGR RES,INDIAN GRASSLAND & FODDER RES INST/JHANSI/UTTAR PRADESH/INDIA/
JOURNAL OF RURAL DEVELOPMENT, 1989, V8, N6, P673-680
Language: ENGLISH Document Type: ARTICLE

1/3/21 (Item 2 from file: 7)
01906094 Genuine Article#: P7224 Number of References: 33
R-AND-D MARKETING LINKAGE AND INNOVATION STRATEGY - SOME WEST-GERMAN EXPERIENCE
BROCKHOFF K; CHAKRABARTI AK
UNIV KIEL/D-2300 KIEL 1//FED REP GER/
IEEE TRANSACTIONS ON ENGINEERING MANAGEMENT, 1988, V35, N3, P167-174
Language: ENGLISH Document Type: ARTICLE

1/3/22 (Item 3 from file: 7)
01340703 Genuine Article#: SQ147 Number of References: 2
R-AND-D LINKAGES IN A MULTI-INDUSTRY CORPORATION
WESTWOOD ARC
MARTIN MARIETTA CORP,RES & DEV/BALTIMORE//MD/21227

RESEARCH MANAGEMENT, 1984, V27, N3, P23-26
Language: ENGLISH Document Type: ARTICLE

1/3/23 (Item 4 from file: 7)
00809818 Genuine Article#: HZ806 Number of References: 51
AGGLOMERATION AND INTRA-FIRM LINKAGE IN R AND D LOCATION IN THE UNITED-STATES
MALECKI EJ
UNIV OKLAHOMA/NORMAN//OK/73069
TIJDSCHRIFT VOOR ECONOMISCHE EN SOCIALE GEOGRAFIE, 1979, V70, N6, P 322-332
Language: ENGLISH Document Type: ARTICLE

1/3/24 (Item 5 from file: 7)
00600677 Genuine Article#: EX424 Number of References: 13
LINKAGE BETWEEN DISTRIBUTION OF R AND D ACTIVITIES AND INDUSTRY (WITH PARTICULAR REFERENCE TO UNITED-STATES)
POLOVITSKAYA MY
ACAD SCI USSR,INST GEOG/MOSCOW V-71//USSR/
SOVIET GEOGRAPHY REVIEW AND TRANSLATION, 1978, V19, N4, P244-252
Language: ENGLISH Document Type: ARTICLE

1/3/25 (Item 6 from file: 7)
00549127 Genuine Article#: ED098 Number of References: 3
LINKAGES OF R AND D SYSTEMS TO CONTEMPORARY SOCIETIES
BULLETIN OF THE ATOMIC SCIENTISTS, 1977, V33, N10, P26-27
Language: ENGLISH Document Type: NOTE

File 669:FEDERAL REGISTER_04 JAN 88 - 06 Sep 1990
(c) U.S. Govt Printing Office

File 148:TRADE AND INDUSTRY INDEX_81-90/OCT
(COPR. 1990 IAC)

File 16:PTS PROMT_- 72-90/September 11
(Copr. 1990 Predicasts)

File 621:PTS NPA _ 85-90/SEP WEEK 1
(Copr. 1990 Predicasts)

File 75:MANAGEMENT CONTENTS _ 74-90/SEP
(COPR. 1990 INFORMATION ACCESS CO.)

File 648:TRADE AND INDUSTRY ASAP_83-90/OCT
(COPR. IAC 1990)

File 13:INSPEC - 77-90/ISS19
(COPR. IEE 1989)

File 1:ERIC _ 66-90/AUG.

? s ((link or links) and between and (indust? and univ?))/ti
S1 8 ((LINK OR LINKS) AND BETWEEN AND (INDUST? AND UNIV?))/TI
1/3/2 (Item 1 from file: 148)
03879293 DIALOG File 148: TRADE & INDUSTRY INDEX
Use Format 9 for FULL TEXT
Europe aims to 'harness' tech potential. (to improve links between industry and universities)
Research & Development v27 p49(1) Aug, 1985
SOURCE FILE: MI File 47
AVAILABILITY: FULL TEXT Online LINE COUNT: 00019

1/3/3 (Item 1 from file: 16)
02288538
CADENCE INTERNATIONAL UNIVERSITY PARTNERSHIP PROGRAM STENGTHENS LINK BETWEEN UNIVERSITIES AND INDUSTRY WITH ACCESS TO LEADING ICDA TOOLS

News Release July 20, 1989 p. 1

1/3/4 (Item 1 from file: 621)
0232983
News Release
DATELINE: San Jose, CA July 20, 1989 WORD COUNT: 536

CADENCE INTERNATIONAL UNIVERSITY PARTNERSHIP PROGRAM STENGTHENS LINK BETWEEN UNIVERSITIES AND INDUSTRY WITH ACCESS TO LEADING ICDA TOOLS

1/3/5 (Item 1 from file: 75)
176032 DIALOG Information Services, File 75: Management Contents
PDI80C0070
THE FUTURE DEPENDS ON CLOSE LINKS BETWEEN THE UNIVERSITIES AND INDUSTRY.
ANON
PLANNED INNOVATION, VOL.3, NO.2, MARCH/APRIL, P. 70., JOURNAL.

1/3/6 (Item 1 from file: 648)
03879293 DIALOG File 648: TRADE & INDUSTRY ASAP
Use Format 9 for FULL TEXT
Europe aims to 'harness' tech potential. (to improve links between industry and universities)
Research & Development v27 p49(1) Aug, 1985
SOURCE FILE: MI File 47
AVAILABILITY: FULL TEXT Online LINE COUNT: 00019

1/3/7 (Item 1 from file: 13)

1867289 B87023240
Links between universities and industry
Thomas, D.B.
Author Affil: Imperial Coll. of Sci. & Technol., London, England
Source: Electron. & Power (GB) vol.33, no.1, pp.: 44-6
Publication Year: Jan. 1987
CODEN: ELPWAQ ISSN: 0013-5127

1/3/8 (Item 1 from file: 1)
EJ239251 SE528611
Forging New and Stronger Links between University and Industrial Scientists.
Kiefer, David M.
Chemical and Engineering News, v58 n49 p38-51 Dec 1980

File 6:NTIS - 64-90/ISSUE19
(COPR. 1990 NTIS)

File 1:ERIC _ 66-90/AUG.

File 7:SOCIAL SCISEARCH _ 72-90/WK34
(COPR. ISI INC.1990)

File 139:ECONOMIC LITERATURE INDEX _ 1969-90/JUL

File 66:GPO MONTHLY CATALOG _ JUL 1976 TO SEP 1990

File 37:SOCIOLOGICAL ABSTRACTS_63-90/AUG
(COPR. SOC. ABSTRACTS)

File 88:ACADEMIC INDEX_1976-90/AUG
(COPR. 1990 IAC)

File 93:U S POLITICAL SCIENCE DOCUMENTS _ 75-90/ISS 1

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S1 93 INDUSTR? AND GOVERNMENT? AND UNIVERSIT? AND LINK?

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93 S1
76974 DEVELOP
S3 7 S1 AND DEVELOP

3/3/1 (Item 1 from file: 6)
1094696 DE84016800/XAB
Federal Laboratories: Technology Resources and Transfer Champions
Stark, Jr, E. E.
Los Alamos National Lab., NM.
Corp. Source Codes: 072735000; 9512470
Sponsor: Department of Energy, Washington, DC.
Report No.: LA-UR-84-2712; CONF-840805-24
Aug 84 23p
Languages: English Document Type: Conference proceeding
Journal Announcement: GRAI8502; NSA0900
188. meeting of the American Chemical Society, Philadelphia, PA, USA, 26 Aug 1984.
NTIS Prices: PC A02/MF A01

3/3/2 (Item 2 from file: 6)
1094476 DE84016351/XAB
Five-Year Technology Transfer Plan, 1986-1990
Department of Energy, Washington, DC. Passive and Hybrid Solar Energy Div.
Corp. Source Codes: 052661328; 9518222
Report No.: DOE/CE-0099
Aug 84 12p
Languages: English
Journal Announcement: GRAI8502; NSA0900
NTIS Prices: PC A02/MF A01

3/3/3 (Item 3 from file: 6)
699521 PB-290 530/5
Alabama Research Forum, 1975 Theme: State Research Priorities. Proceedings of a Conference Held at Montgomery, Alabama on December 15-16, 1975
Auburn Univ., AL.
Sponsor: National Science Foundation, Washington, DC. Applied Science and Research Applications.
Report No.: NSF/RA/G-75/081
Dec 75 28p

Languages: English Document Type: Conference proceeding
Journal Announcement: GRAI7911
NTIS Prices: PC A03/MF A01

3/3/4 (Item 1 from file: 1)
ED301144 HE022082
For the full text of this Digest use Format 9.
Leadership in Higher Education. ERIC Digest.
McDade, Sharon A.
ERIC Clearinghouse on Higher Education, Washington, D.C.
1988
3p.
Sponsoring Agency: Office of Educational Research and Improvement (ED), Washington, DC.
EDRS Price - MF01/PC01 Plus Postage.

3/3/5 (Item 2 from file: 1)
ED284515 HE020645
For the full text of this Digest use Format 9.
Public Service in Higher Education: Practices and Priorities. ERIC Digest 85-2.
Crosson, Patricia H.
Association for the Study of Higher Education.; ERIC Clearinghouse on Higher Education, Washington, D.C.
1985
3p.; This digest is a summary of ED 239 569.
Sponsoring Agency: National Inst. of Education (ED), Washington, DC.
EDRS Price - MF01/PC01 Plus Postage.

3/3/6 (Item 3 from file: 1)
ED246746 HE017399
The Federal Role in Fostering University-Industry Cooperation.
General Accounting Office, Washington, D.C.
25 May 1983
67p.
EDRS Price - MF01/PC03 Plus Postage.

3/3/7 (Item 1 from file: 37)
2080755 89U4743
The Organizational Imperative in Science
Goldberg, Albert I.; Kirschenbaum, Alan B.
Faculty Industrial Engineering & Management Technion-Israel Instit Technology, Haifa 32000
Organization Studies 1988, 9, 2, 201-220. CODEN:ORGSDM
PUB. YEAR: 1988
COUNTRY OF PUBLICATION: Germany, West BRD
LANGUAGE: English
DOCUMENT TYPE: Abstract of Journal Article (aja)