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TECH CENTRE RESOURCE REVIEW

DETAILED VOLUME

(VOLUME II)

Canada

TECH CENTRE RESOURCE REVIEW

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(VOLUME II)

AUGUST 19, 1985

Acknowledgements

This report has been the result of intensive efforts on the part of a highly motivated and enthusiastic study team. This team collected, analysed and reported an extraordinary amount of information from the population of technology centres in Canada, within three months. A 93% response rate was achieved, and this over a vacation season. The public servants and consultants who participated in this monumental task will never be fully compensated for the 80, 90, and in some cases 100 + hour work weeks they put in over this period, but the least that can be done is to name the participants.

Team leadership was provided by Ed Hahn of DRIE Program Evaluation Branch. Project management was undertaken by Steve Montague, also of DRIE PEB, who was assisted during the early phases of the study by Bob McDonald and Yvan Bedard in this regard. Verne Chant led an expert team of consultants including Jim Cousens, Marc Rosenberg and Luc Van Baaren who provided particular assistance in the design, collection and analysis phases. Extra interviewing assistance was provided by Roland Lussier, Guy Galant and Louise Williamson of the DRIE Office of Industrial Innovation. Bruce Stewart, Marie-Josée Thivierge and Kim Barton provided invaluable interviewing coordination and computer support in this regard.

Special thanks should be reserved for the dedicated group of secondments to this study team whose contribution truly made this achievement outstanding. These people are, in alphabetical order:

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Yuri Daschko	-	MOSST
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Paul Latour	-	NSERC
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SUMMARY

1. INTRODUCTION

1.1 Background (Vol II s 1.1)

Cabinet directed in May 1985 that MOSST undertake a study on ways and means to rationalize the federal government's investment in technology centres. Duplication of services was identified as one of the key problems with federal support for those centres, and self-sufficiency was recognized as a desirable component of future federal involvement. As a result, MOSST was directed to bring forward, by August 19, 1985:

a) A plan for a national system of technology centres; and

b) a strategy to redeploy existing resources that will rationalize and consolidate the existing centres.

1.2 Mandate (Vol II s 1.1.5)

A Technology Centre Review Team was struck by MOSST to fulfill its obligations in this regard. The sub-group responsible for preparing this report was mandated to gather and report background information on currently-existing technology centres in order to provide a factual base in support of the above requirements.

1.3 Approach (Vol II s 1.2)

1.3.1 Questions

The study approach was driven by the following two sets of questions:

i) What is the level and nature of federal investment in technology centers; and

ii) with regard to technology centers is/are there:

a) undue overlap or duplication;

b) proliferation/fragmentation;

c) lack of coordination;

d) strains on the availability of skilled human resources; and

e) obstacles to financial self-sufficiency

1.3.2 Definition of Tech Centre (Vol II s 1.2.1, s 1.2.2)

The first step in understanding the questions raised about technology centers was to define the entity to be studied.

At a meeting of the Technology Centres Advisory Group comprised of representatives from MOSST, NRC, NSERC, Statistics Canada, and DRIE, the following was agreed to as a definition of technology centres for the purposes of the study at hand:

> "Organizations sustained (through grants contribution or contracts) or operated by the federal government and which were designed or now function predominantly in support of industry needs for new technology or specific technical skills."

This definition excluded most departmental laboratories which operate primarily as performers of mission-oriented R&D, (e.g., DND laboratories), while including those with direct industry support objectives. Where it was unclear whether an internal (federally managed) institution's activity should be included or not, an opinion was solicited from the responsible department. External organizations were identified by examining lists and data from many sources and by determining through extensive follow-up if they met the definition. Over 600 organizations were studied in this way, and in the end almost 300 were identified. This group formed the study's "operational universe".

1.3.3 Selection and Interview Process (Vol II s 1.2.2, 1.2.3)

Based on a combination of objective criteria and expert knowledge, the operational universe was split into two groups for follow-on data collection purposes. Approximately half the universe, consisting of the larger, more diversified institutions which were most likely to perform technology centre functions, was designated for surveying by in-depth personal and telephone interviews, while the other half of the universe (the smaller and less-likely centres) was designated to be contacted for profile information.

The in-depth interview process generated quantitative information on each centre's organizational characteristics, human and financial resources, clients, and services, as well as qualitative information on the centre's services and human resources, the role of its funding agencies, and its interaction with other centres. The centres contacted for profile information provided data on services, clients, and human and financial resources.

Changes to the database were made as a result of information collected during the interview process, so that after a 93% response rate to the census of organizations within the operational universe, the study team was able to exclude nearly 100 which did not meet the technology centre definition. This left a maximum of 200 organizations which fit the technology centre definition. This group was further refined as will be described in section 2.

1.4 Analysis and Reporting (Vol II s 1.2.4)

The analysis for this report was divided into two parts. First, profile data on all centres was processed and interpreted to address the various questions relating to the nature of technology centres in Canada and to the federal investment in those centers. This analysis is covered in section 2 of this volume. Second, information pertinent to the major study questions about overlap, duplication, proliferation, coordination, skilled human resources, and funding/self-sufficiency was produced and analysed by question. This analysis is covered in section 3 of this volume.

2. PROFILE OF TECHNOLOGY CENTRES

2.1 Categories of Technology Centres

Technology centres may be described by using several different criteria such as size, region, or sponsor type (e.g., federally-sponsored, provincially- sponsored, university-sponsored, DRIE-sponsored, industry-sponsored, or other). The shortcoming in each of these methods of categorization is that they distinguish centres by their physical characteristics, or by who runs them, rather than by the nature of their activities. The most useful categorization method for the purposes of this study was found to be one which categorized centres by the degree to which they undertake technology centre activities of the type described in the previously-determined definition. (see s 1.3.2.).

2.2 The Special Case of Federal Laboratories (Vol II s 2.2, Appendix C)

Most federally operated laboratories are not considered technology centres for the purposes of this study. Several provide technical support more or less exclusively for their own departments' mission. Others devote a considerable amount of time to providing technical support for other departments without laboratories or to maintaining standards of measurements (e.g. time, length and mass). Many are also mandated to devote a significant part of their resources to high risk, medium- to long-term research of potential benefit to Canadian industry. Much of the technology transfer and diffusion resulting from this work occurs intra- or interdepartmentally, or between scientists at government laboratories and their counterparts in high-technology industries, without need for engaging in the kind of activities or services commonly associated with technology centres. Separate studies were being conducted in several departments, which were complementary to the present one and, in many cases, more detailed.

As a result of these factors, basic data on all likely federal technology centres was collected. About 110 laboratories were examined.

In the end, of 110 potential federal centres, only 27 were found to be full or partial technology centres by the study definition. (see s 2.3)

IRAP/PILP

These are two federal programs that engage in significant technology transfer activities, but do not match the definition of technology centres used in this study. These programs assist and partially fund companies in the translation of R&D results into processes and products of good commercial potential. Some of the IRAP/PILP funds provided to industry for further development work may end up being spent by the recipient at a technology centre -- more often they are spent on intramural development work -- but such funds arrive only indirectly at the technology centre, and so are not accounted for in this study as part of the direct federal grants and contributions to technology centres.

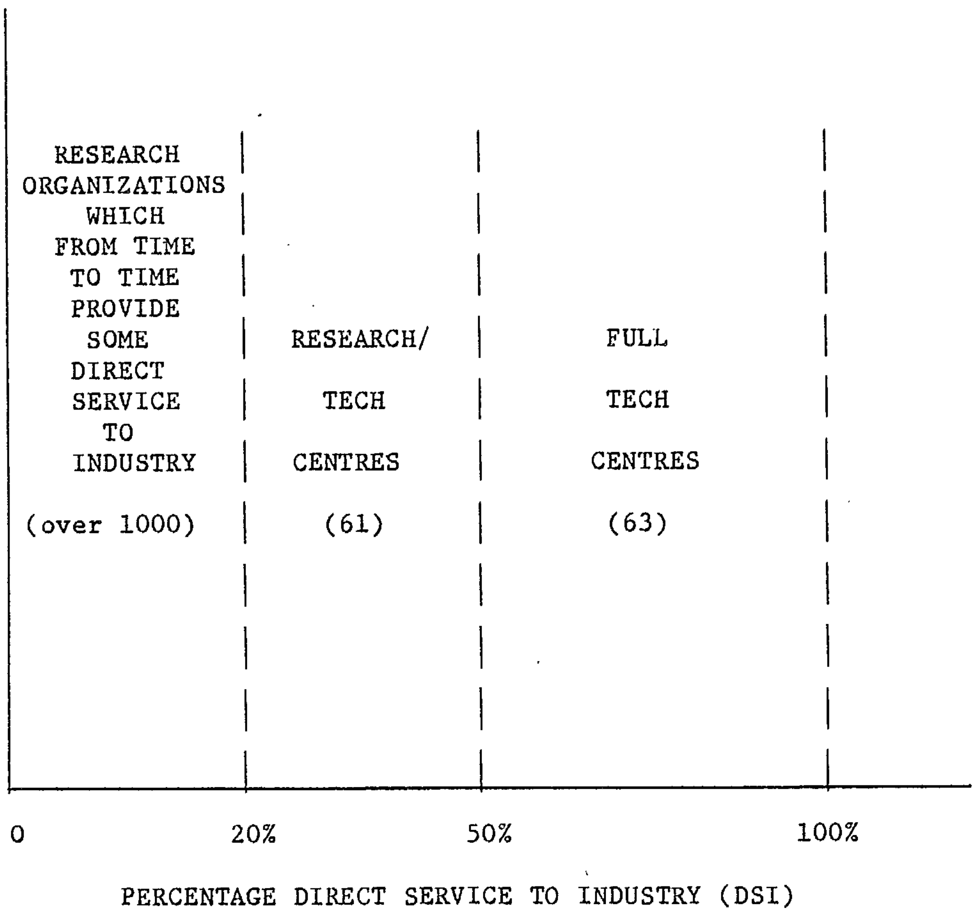
2.3 Definition of Direct Service to Industry

In order to categorize organizations by the degree to which they fit the definition of technology centres (i.e., the degree to which they provide direct, hands-on services to industry) it was necessary to derive a direct service to industry (DSI) index, based on technology centre responses to questions regarding the percentage of time and effort they devoted to direct technology support services to industry. "Technology support" in this context refers to the interaction that takes place between a centre and its client during those times when the centre is physically engaged in making the client aware of, and familiar with, a new technology, and is assisting the client with the adoption process.

The DSI index is used only to separate centres into various groups that have largely different mandates. As a purely descriptive variable the DSI index does not measure about the industrial relevance of a centre's work, nor its responsiveness to industrial needs, nor its effectiveness in fulfilling its mandate, nor the importance to Canada of the centre pursuing such a mandate.

Figure 1.

CATEGORIZATION OF ORGANIZATIONS BY PERCENTAGE DIRECT SERVICE TO INDUSTRY



The DSI index merely reflects the degree to which an organization is involved in outreach activities, for example, of the kind that tend to be needed in supporting Canada's large population of low technology companies. By contrast, centres involved in supporting Canada's high technology companies (who do not need a great deal of technical awareness-building and hand-holding, but who do benefit from short bursts of high-level coupling) tend to have a low DSI index because of the need for undertaking considerable background research. Two examples taken from the data base illustrate the meaning and limitations of the DSI index:

- A provincial CAD/CAM centre devotes nearly seven-eights of its time to training and educating its clients in the application and use of CAD/CAM systems and equipment. Its primary clients are manufacturers of machinery and equipment, auto parts, and miscellaneous electrical equipment, all of them medium to low technology sectors. Because of the high proportion of time spent in direct contact with clients which is in fulfilment of the centre's mandate, its DSI index is fairly high at 82%. It clearly is a technology centre.

- A federal materials and structures laboratory devotes three-quarters of its time to research and development, primarily in developing generic information about the performance properties of advanced metals, metal alloys, and composites under the design and service conditions prevalent in aircraft and space applications. Nearly 80 per cent of its industrial clients are manufacturers of aircraft and aircraft parts, an exceptionnaly high technology sector. Because most of the technology exchange with clients is in the form of brief, high-level information exchanges, only a small proportion of the centre's time is spent in direct contact with clients. Nevertheless the clients depend on the information received, and on the centre's fulfilling its mandate to conduct the necessary background research needed to generate this information. The centre's DSI index is (appropriately) low at 20%. It clearly is a research organization with associated technology activities.

FIGURE 2 PROFILE FINANCIAL DATA ON TECH CENTRES AND RESEARCH ORGANIZATIONS STUDIED

i) ORGANIZATIONS COMPUTED AS BEING EITHER TECH CENTRES OR RESEARCH/TECH CENTRES BY VIRTUE OF CALCULATED DSI INDEX > 20%

Group	No. of Centres	SOURCES OF FUNDING ($000) Federal Contracts	Federal Other	Other Contracts	Other Funding	Total
Federal	27	0	113,239	1,940	204	115,383
DRIE	13	2,780	3,047	5,921	4,126	15,874
Industry	13	3,145	4,116	4,170	21,853	33,284
Provincial	21	6,612	1,714	28,334	44,401	81,061
Other	50	2,886	11,175	8,930	11,742	34,733
TOTAL	124	15,423	133,291	49,294	82,327	280,335

ii) RESEARCH ORGANIZATIONS ORIGINALLY EXAMINED AS POSSIBLE TECH CENTRES BUT SUBSEQUENTLY FOUND TO PROVIDE LESS THAN 20% OF THEIR TIME AND EFFORT IN DIRECT SERVICE TO INDUSTRY

Group	No. of Research Organ-izations	SOURCES OF FUNDING ($000) Federal Contracts	Federal Other	Other Contracts	Other Funding	Total
Federal	82	-	324,978	209	-	325,187
DRIE	1	274	200	91	-	563
Industry	-	-	-	-	-	-
Provincial	5	552	275	8,312	9,045	18,183
Other	30	2,478	9,854	2,198	10,700	25,230
TOTAL (OF THE ORGANIZATIONS STUDIED)*	118	3,302	335,307	10,810	19,745	369,163

* NOTE: The research organizations in this second set (DSI < 20%) represent only a small sample of the organizations in the Canadian population which would fall into this category. Those organizations not represented include much of NRC, several sections of PROs, many Federal government labs, and others. (see s 2.2)

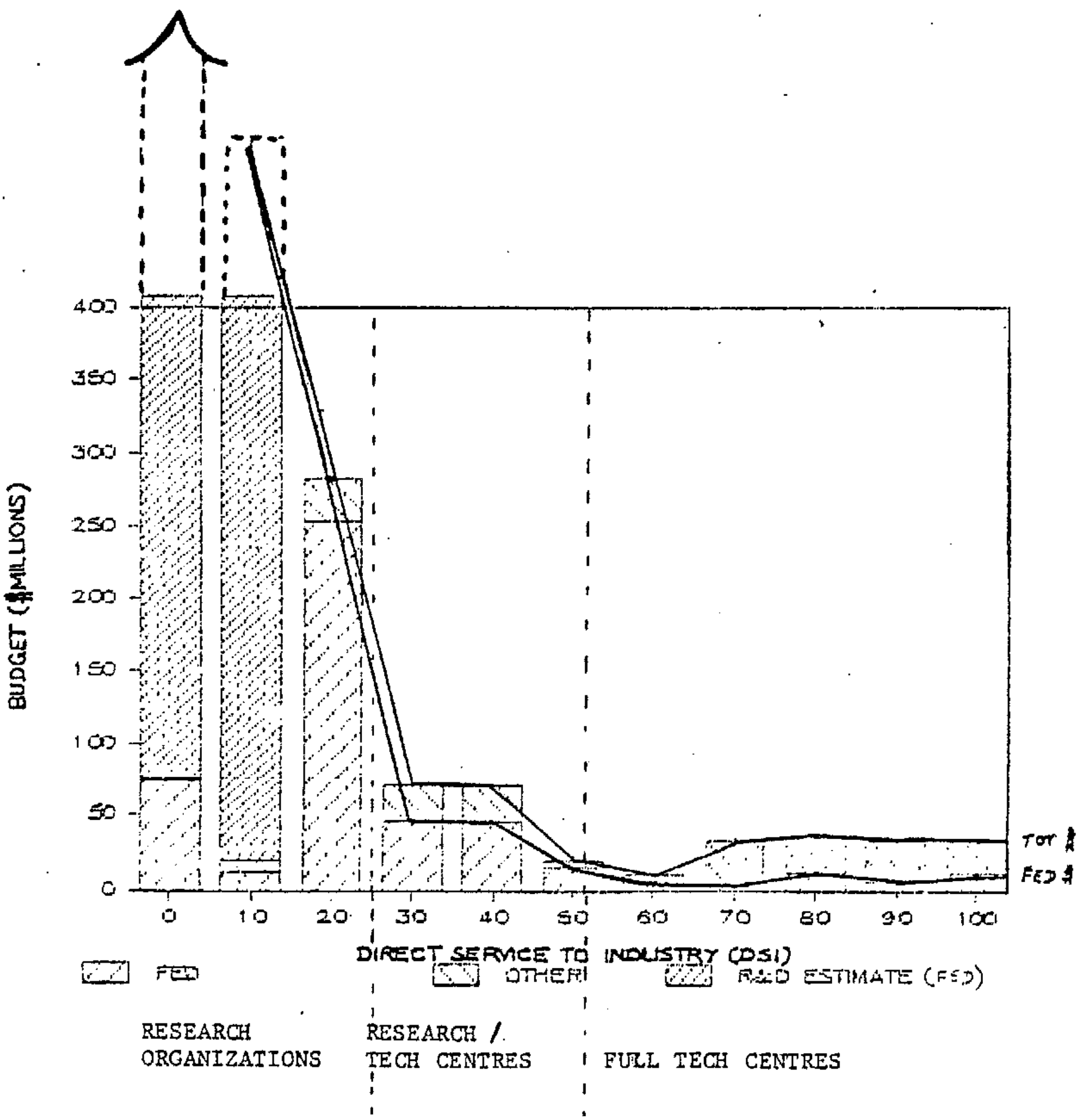
As shown in Figure 1, important distinctions can be made between centres which (a) spend over 50% of their time and effort in direct, hands-on service to industry clients (these centres are termed "full technology centres" or High DSI); (b) spend between 20% - 50% of their time and effort in the direct service of industry clients (referred to as "research/technology centres" or Low DSI); and (c) spend less than 20% of their time and effort on direct service to industry clients ("research organizations" which may do some work for industry or be involved with non-industry clients and objectives as mentioned). In this way the DSI index was used to distinguish technology centres from other centres. While some federal research organizations had been originally nominated as part of the study scope, further investigation revealed that they did not in fact fall into the technology centre category as reflected by the DSI categorization. (see Figure 2). A further discussion of federal laboratories is provided in section 2.1.1.

2.4 Technology Centre Characteristics

2.4.1 Groups

Industry-sponsored centres and DRIE centres are heavily represented in the full technology centre (high direct service to industry - HDSI) category. PRO and other centres show mixed classifications, and federal laboratories tend to be found in the low direct service to industry (20-50% DSI) category, or indeed are not technology centres at all.

FIGURE 3
TOTAL AND FEDERAL CANADIAN EXPENDITURES
ACROSS DIRECT SERVICE TO INDUSTRY CENTRE CATEGORIES
(1984)



2.4.2 Resources

As shown in Figure 3, funding decreases as direct service to industry increases, both in terms of total Canadian expenditures and, particularly, in terms of federal funding.

Of particular significance is the fact that there are only 63 full technology centres -- those with a DSI index of greater than 50% -- and a total of only 124 centres in the combined groups of full technology centres and research/technology centres, i.e., all those with a DSI index greater than 20%. The total Canadian investment in these 124 centres totals about $280 million annually, of which the total federal portion totals less than $150 million (only $37 million of which goes to centres spending over 50% of their time in direct service to industry). These expenditures contrast sharply with the federal investment in research organizations that spend less than 20% of their effort in direct service to industry, estimated at over two billion dollars annually.

In terms of human resources, technology centres tend to be small. The majority of technology centres retain fewer than 20 scientific/technical staff members, with the central tendency ranging between 5 and 25 scientific/technical staff members per centre. This tendency holds true for both high and low DSI groups.

2.4.3 Clients and Services

The size distribution of technology centre clients varies significantly from one centre to another. In general, while small firms (1 - 49 employees) tend to make up the majority of tech centre clients overall, very large firms (over 500 employees) are significantly over-represented compared to the

Canadian industrial population of firms. Also, while the central tendency for all categories of centre was to provide service predominantly to small firms, the full technology centres tended to service a greater number of medium sized clients than did the other centres.

In terms of serving their overall client base, centres attributed to industry a general lack of awareness of centre services, a lack of client technical sophistication, and a lack of industry funds as the most significant barriers to achieving greater outreach or market penetration.

2.5 Conclusions

There is no simple definition to separate technology centres from non-technology centres. In recognition of this shortcoming, an operational definition based on centre activities (not to be confused with value or relevance) had to be developed for the purposes of this study. Further investigation would likely enhance future efforts at categorization.

In terms of centres which spend most of their time and effort in the direct, hands-on service of industry clients, the number of full technology centres is small. Similarly, the federal investment in grants and contributions to these centres is small (less than $40 million annually). DRIE-sponsored centres represent an exception to the rule that the overwhelming majority of federal investment is tied up in the research rather than the diffusion end of the innovation and technological development spectrum.

3.1 **OVERLAP/DUPLICATION**

Issue/Description

MOSST had been given to understand that over 300 technology centres had been established by the separate activities of 11 government departments and agencies, and so the concern was expressed was that overlap and duplication among technology centres was a serious prospect and therefore was one of the "key issues or problems with current federal support." The issue for this portion of the study has been whether overlap and duplication, as anticipated, really exists to any significant extent, and if so where does it occur and is it indeed a problem.

Findings (Vol II s 3.1)

From a conceptual review of this issue, it has become clear that once the true level of federal investment in technology centres is recognized (i.e., 124 centres spending over 20% of their time/effort on direct service to industry, with federal support totalling less than $150 million annually), the likelihood of overlap and/or duplication is significantly reduced, compared to what was originally anticipated. Furthermore, given the small national investment in technological diffusion activities ($280 million annually for institutions spending over 20% time/effort on direct services to industry), and the immense range of areas in which centres can specialize, there is a high probability of gaps existing rather than overlaps. There is also a probability of significant fragmentation of resources.

From a systematic review of technology centre activities, covering technology field, industry sector, and services provided, it is clear that the the actual presence of overlap and duplication, even in the most frequently-serviced fields (e.g., microelectronics, biotechnology, and CAD/CAM), is negligible and immaterial.

Moreover fully 52% of centre respondents interviewed during the study reported no effect from the provision of a comparable service by another organization. In fact 30% of respondents perceived an actual increase in business, while only 10% reported a business decrease. Of the 10% reporting a decrease, over two-thirds also contended that at least one aspect of their resources, usually their personnel, was utilized to the full and in some cases the staff was working a considerable amount of overtime. The complaint about a decrease in business at those centres thus appears spurious. For the remaining one-third, the primary cause of these centres' decrease in business in all but one case could be linked at least equally strongly to other factors such as the recent cutting back by the federal government of its funding for certain technology areas (such as renewable energy), or the elimination by the centre's sponsoring organization of all core funding.

Conclusion

There is not a serious problem in terms of overlap and duplication of direct services to industry among Canadian technology centres.

3.2. PROLIFERATION

Issue/Description

Recent reports have identified excessive proliferation as a problem among Canadian technology centres. Proliferation is reputed to have provoked a fragmentation of effort by centres in general.

Findings (Vol II s 3.2)

Based on an in-depth review of the profile data collected by this study, it appears likely that a significant proportion of efforts in Canadian technology centers may be fragmented or under-funded in the sense that many centers operate with efforts in certain technologies which are below a minimum critical size needed to maintain a viable effort. For example, while there are over 100 centers providing services to industry in 12 technology fields in Canada, over 50% of their efforts in these fields amount to less than $100,000 per year, which is equivalent to roughly one scientific or technical staff person year devoted to providing that service. What is significant here is that more than half of the centres providing less than the threshold level of service receive some federal funding. It would appear that federal funding has not significantly contributed to preventing fragmentation, and may in fact have encouraged it.

The vast majority of centre officials interviewed stated that their centres were fully or over utilized, thereby showing at least circumstantial evidence of usefulness to their client community. In addition, both the interviews and the objective data analysis have revealed significant gaps in technology services provided, indicating the existence of ample room for more (albeit differently directed) investment in technology centres.

Conclusion

There is no evidence of undue proliferation of technology centres. However, there appears to be significant fragmentation or at least under-funding of service efforts among many Canadian technology centres. Federal funding has not prevented, and may have contributed to, this fragmentation.

3.3 COORDINATION & NETWORKING

Issue/Description

Among the factors believed to be contributing to overlap, duplication and fragmented effort by technology centres, was a lack of coordination among centres as well as between centres and the federal government. The issue for this portion of the study has been whether a lack of adequate coordination exists.

Findings

An analysis of interview findings showed that a very wide range of coordinating mechanisms exists and that many of them are being employed among technology centres as well as between centres and their clients, but that the depth of their application in many cases was limited.

Networking was identified as an exceptionally useful and effective coordinating mechanism and several outstanding examples emerged. Among these was the intensive networking among microelectronics centres, and the formal network between the IRAP program and provincial research organizations (PRO's). Apart from this latter case, networking between technology centres and the federal government was found to be generally poor.

Conclusions

Despite indications that networking and other mechanisms for coordination are useful for the better management of technology centres, it is reasonably clear that insufficient use is made of these mechanisms, particularly in light of the fact that centres in general display an apparently high degree of fragmentation.

3.4 SKILLED HUMAN RESOURCES

Issue/Description

Concern has been expressed that government-sponsored technology centers have acted as a drain on skilled human resources in the private sector.

Findings (Vol II s 3.4)

While a number of centres reported that they had experienced difficulty with recruiting and maintaining skilled staff, their main problem concerned the quality of available people, not the quantity. Competition with industry was not viewed as a significant problem.

Many centres viewed the training of university graduates as an integral part of their operations so that the only mention of technology centre human resource problems vis-à-vis industry was that caused by a high turnover rate whereby trained staff left the centres to join private firms.

Conclusion

Rather than being a drain on skilled human resources, technology centres appear to function as a source of practically-trained scientific and technical staff for industry. In terms of addressing an acknowledged shortage of high quality trained scientific/technical staff, technology centres may in fact be part of the solution rather than part of the problem. Due to the fact that no effectiveness review of the impact of technology centres on the availability of skilled human resources to the private sector has been conducted, further investigation into this issue is required before any firm pronouncements can be made.

3.5 FINANCING/SELF-SUFFICIENCY

Issue/Description

MOSST has been directed by Cabinet to employ a strategy which would emphasize the early attainment of financial self-sufficiency for technology centers.

Findings (Vol II s 3.5)

Of those centre officials surveyed, none was in favour of self-sufficiency. Analysis of the data revealed that while most centre representatives believe that a significant portion of their income should be derived from industry contract work, even the centres closest to achieving self-sufficiency were unsupportive of self-sufficiency as a goal for other centres as well as for themselves.

A review of the available data on sources of income for technology centres revealed that fewer than 15% of all centres interviewed earn over half of their income from industry revenues. (The percentage is higher for the HDSI centres, but nevertheless relatively low at only about 30%). In addition, the data show that in cases where a centre maintains a high proportion of industry income, the more proactive aspects of technology transfer and diffusion (both direct and indirect, e.g., training) decrease in intensity, while the more reactive aspects (e.g. supplying test facilities or testing services) increase in intensity. The increase in testing-related activities reflects the fact that the private sector is already willing to pay for this type of activity.

Furthermore, over 50% of the respondents who believed technology centres should fill a number of existing technological gaps explained this view on the basis that individual firms would not be able or willing to pay for, or carry out, the work required to fill the gap. This reflects the reason why the federal government in the past became involved in the area of technology centres, namely the apparent inability or unwillingness of industry to pursue the requisite technological development and diffusion activities.

Therefore, if a federal initiative is necessary to stimulate technology diffusion due to a perceived failure of the private market to invest adequately in these activities, then requiring the agents of diffusion (technology centres) to become totally dependent on private sources of income would cause them to concentrate on those services for which the private sector is already willing to pay. This would have the effect of reducing the services which are at once the raison d'être of these technology organizations and the policy objective of the federal government vis-à-vis encouraging technology diffusion.

Conclusion

While some of the services provided by technology centres may be legitimately self-financing, the goal of total centre self-sufficiency runs counter to the conceptual purpose of technology centres as agents of diffusion. In addition, such a policy would be practically difficult to implement given the heavy current reliance of most centres on public funding.

INTRODUCTION

1.1 BACKGROUND

1.2 STUDY APPROACH

1.3 ANALYSIS AND REPORTING

1.4 GUIDE TO REPORT

1. INTRODUCTION

1.1 Background

The government announced with the May 1985 Budget that it was concerned about the prospect that here had been excessive proliferation of technology centres in Canada; that there might be considerable duplication and overlap of services among them; and that it intended to review the level of federal support for these centres with a view to developing a plan for consolidating and rationalizing them. MOSST was tasked with leading an interdepartmental review project and reporting by August 19, 1985 with a strategy for rationalizing and redeploying federal resources, and a plan for fostering a more integrated national system. In particular, emphasis was to be placed on encouraging higher levels of self-sufficiency on the part of the centres being reviewed.

1.1.1 MOSST Study Administration

Organizationally, the review project was directed by a Steering Committee at the assistant deputy minister level with representation from MOSST (Chair), DRIE, NRC, NSERC and Statistics Canada. The Committee approved the workplan, provided resources and reviewed progress and final reports. An Advisory Group was also formed to ensure full interdepartmental liaison. This Group included officials from MOSST, NRC, DRIE, NSERC, Statistics Canada, the Science Council, DOC, EMR, Agriculture, MOT, DND, DFO, Secretary of State, TBS and PCO.

As part of the workplan, two teams were established to deal with the two tasks identified in the context of the government's review plan. These teams were:

° Team A, which was led by MOSST and involved participants from MOSST, DRIE, NRC, NSERC and BMC/SSC. This team determined issues, conducted consultations, and developed options and a plan for a national system of technology centres.

° Team B, which was led by DRIE and involved DRIE, MOSST, NRC, NSERC and private consultants. This report will only deal with the activity and findings of the team B.

1.1.3 Study Mandate

The mandate of the Technology Centre Resource Review Team (Team B) was to provide factual information in support of the study's overall objective to produce (a) a plan for a national system of technology centres and (b) a strategy to redeploy existing resources that would rationalize and consolidate existing centres.

1.2 Approach

The study approach was driven by the following questions:

i) What is the level and nature of the federal investment in technology centres; and

ii) With regard to technology centres is/are there:

   a) undue overlap or duplication
   b) excessive proliferation or fragmentation
   c) lack of coordination

d) strain on the availability of human resources; and

e) obstacles to self-sufficiency

1.2.1 Definition of a Technology Centre

The first step in understanding the questions raised regarding technology centres was to define the entity to be studied.

At a meeting of the Technology Centres Advisory Group, comprised of representatives from MOSST, NRC, NSERC, Statistics Canada and DRIE, the following was agreed to as a definition of technology centres for the purposes of the MOSST study:

> "Organizations sustained (through grants, contribution or contracts) or operated by the federal government and which were designed or now function predominantly in support of industry needs for new technology or specific technical skills."

This definition excluded most departmental laboratories which operate primarily as performers of mission-oriented R&D, (e.g., DND laboratories), but it included those with dirct industry support objectives. Where it was unclear whether an internal (federally managed) institutions activity should be included or not, an opinion was solicited from the responsible department. External organizations were identified by examining lists and data from many sources and by determining through extensive follow-up if they met the definition. Over 600 organizations were studied in this way, and in the end almost 300 were identified. This group formed the study's "operational universe".

The agreed definition was reduced to a practical set of selection criteria in order to obtain, from the universe of organizations that possibly were involved in technology diffusion and transfer, an operational universe of 'likely' centres. It was necessary to include non-federally sponsored centres in this exercise in order to permit studying of the overlap/duplication question. Also, it was realized that the directive to MOSST focussed especially on centres such as those established by DRIE, and did not include all federally supported organizations involved in technology transfer. (sec. 2.1.1 and 2.1.2)

The selection criteria which made up the definition of the operational universe were defined as follows:

Centres, either federally-funded or funded in another fashion, whose activities involve providing assistance to industry in adopting new technology, and which perform some or all the functions noted below:

a) Research, development, and adaptation, and the subsequent transfer to industry, of technologies expected to lead to products or processes which are new to the client;

b) Acquisition, storage, and dissemination of scientific and technical information;

c) Demonstration and diffusion of technologies, and demonstration of technology-based facilities, systems, equipment, software, and concepts;

d) Provision of research and testing facilities for use by the centre's clients;

e) Evaluation and testing of a client's prototypes, models, equipment, concepts, inventions, patents, or samples; and

f) Training and education of a client's staff in the application and use of new or existing technologies including training in management, marketing, and finance.

It should be noted that this operational definition of "centres" includes whole organizations, or identifiable units within an organization, that have a reasonably homogeneous scope of operations. For example, NRC was not taken as a whole but rather was subdivided into various units, only some of which were deemed to be 'likely' tech centres by the predetermined definition. In all cases where representatives of an organization recommended aggregating or dis-aggregating their respective organizations for the study, such advice was taken into account. For example, representatives of one provincial research organization(PRO) recommended subdividing the organization into its various component divisions because of the differing nature of their work and their relative autonomy. The representative of another PRO recommended treating his organization as a single unit because of the generally unified managerial and accounting structure, and its practice of soliciting clients' business from a central source.

In addition to the qualifying factors, the following exclusionary factors were applied:

a) organizations not included in the definition of "centres" were those whose predominant effort relates to either one or both of the following functions:

i) Post-secondary education aimed at the granting of degrees or diplomas[1];

ii) Technology-related activities aimed at internal/proprietary use by the organization itself;

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1. Although this exclusion was applied to university faculties of engineering, science, etc., it was not applied to centres that are affiliated with universities but serve a separate function like providing technical assitance to industry.

FIGURE 1.2 A
VETTING AND INTERVIEW PROCESS

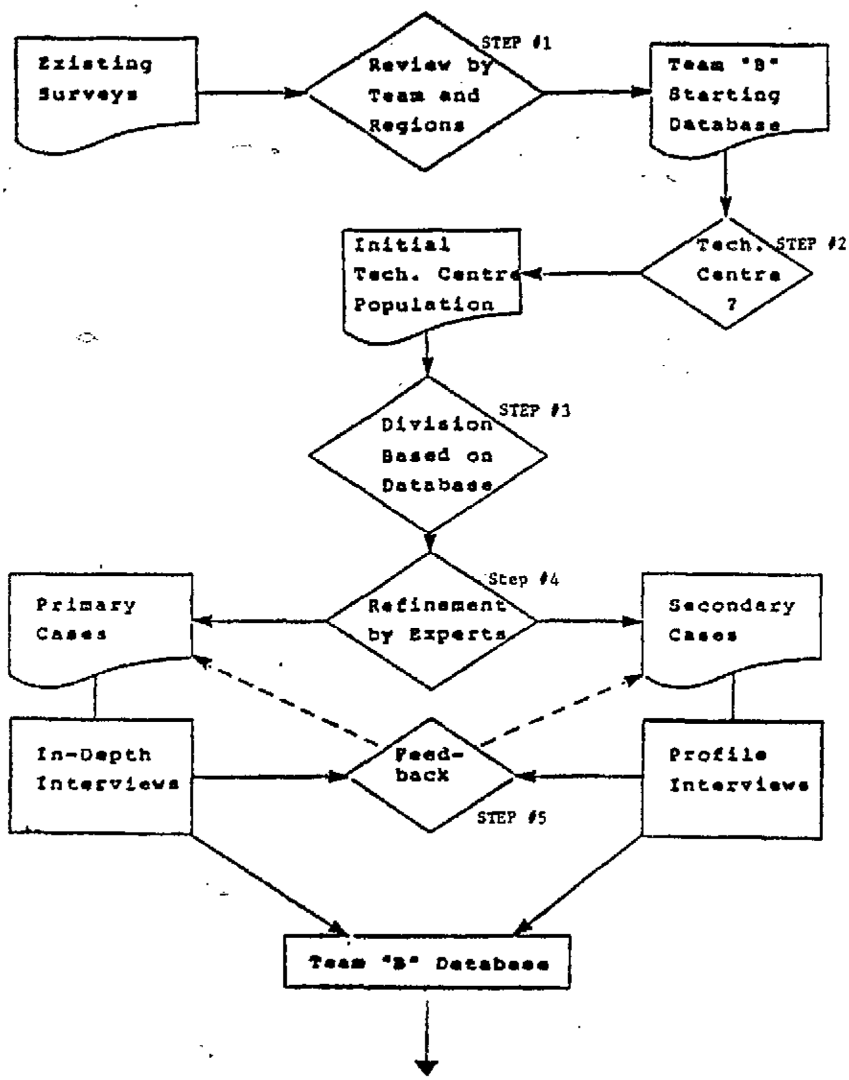
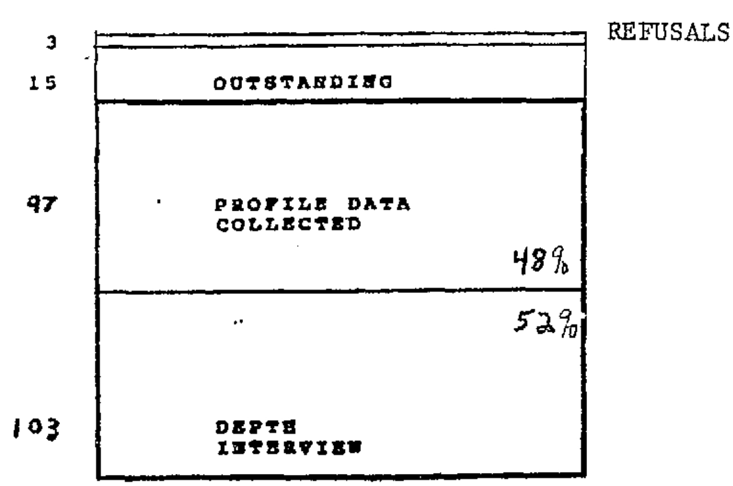


FIGURE 1.2 B
REFINED POPULATION OF POTENTIAL TECH CENTRES



b) certain federal government departments were excluded on the basis of agreements negotiated with MOSST, based on the fact that in-depth internal reviews were in progress; and

c) organizations receiving federal funding predominantly in the form of contracts, where the primary intent of the funding was acquisition by the government of the resulting goods and/or technological information.

1.2.3 Vetting and Interview Process

In order to obtain as complete a list as possible of organizations that might meet the study's definition of a technology centre, the list of over 300 centres referred to previously was merged with an existing Statistics Canada list, as well as with lists obtained from other government departments.

As shown in Figure 1.2 A, the resulting list of over 2,000 centres was further reviewed by Team B members and DRIE regional contacts (step 1) in order to ensure that all legitimate centres would be included in the data collection exercise. This formed the starting data base to which the operational definition (described in s1.2.2) was applied by experts, regional representatives, and federal departments (step 2) resulting in the starting data base (600 organizations) which were further refined into prospective technology centre population of close to 300 centres (Fig. 1.2.B).

The make up of the resulting data base of prospective technology centres is described in more detail in volume 3.

FIGURE 1.2 C
WHAT INFORMATION ARE WE COLLECTING

In-Depth Interviews
(pre-send and interview guide)

- organizational characteristics
- human and financial resources (including sources of revenue)
- market information on:
    - services
    - sectors
    - client size
- qualitative information on:
    - services
    - utilization overlaps
    - human resources
    - role of funding agencies

Profile Interviews
(short telephone questionnaire)

- services, markets
- human resources

A division was made at this point (step 3) to separate the organizations judged most likely to meet the definition of a technology centre, as well as those most likely to overlap with other centres, from the organizations judged less likely to meet the definition. This separation was made based on the criteria of size ($250 K budget, 5 employees) and on industry sectors served, and services provided. Larger and more diversified centers (about 120) were initially selected for in-depth interviews while another 150, mostly the smaller centres, were initially selected for profile interviews.

Once the initial separation of centres into in-depth interview candidates and profile candidates had been made, the selections were reviewed by team B and other experts (step 4) with a view to ensuring that true technology centres, as well as those already targetted as potential areas of overlap, would be included in the in-depth interviews. (The survey instruments are displayed in volume 3).

During the interviewing process, direct attempts were made to solicit comments and suggestions as to additional or different technology centres to be included in the study (step 5). A number of additions, deletions, revisions, subdivisions, and amalgamations, were made as a result of this process, resulting in the current Team B database of 200 centres. Of these 200 centres, 103 were interviewed in depth and 97 were surveyed for profile data only. In total, 175 provided sufficient data for analysis.

1.3 Analysis and Reporting

As shown in Figure 1.2 C, the analysis for the study was divided into two parts. First, profile data was processed and interpreted to answer questions relating to the nature of technology centres in Canada and the federal investment in them. Second, information pertinent to the major study questions regarding overlap, duplication, proliferation, coordination, human resources, and funding was produced and analyzed by question.

The study results were then reviewed by all members of the study team, and this draft final report was produced.

1.4 Guide to Report

This report consists of 4 major sections.

- Section 1 is an introduction to the report and describes the background mandate, technology centre definition used, and the study approach used by the Review Team (Team B);

- Section 2 provides profile information on Canadian technology centres and the federal investment in them;

- Section 3 reports on the background, findings, and analysis of the major study questions related to overlap and duplication, proliferation, coordination, skilled human resources, and funding/self-sufficiency.

- Section 4 consists of a review of selected projects assisted by technology centres.

PROFILE

2.1 CATEGORIES

2.2 RESOURCES

2.3 SERVICES AND CLIENTS

2.4 ROLES

2.0 PROFILE OF TECHNOLOGY CENTRES

2.1 Categorization of Technology Centres

In this section, technology centres are described by means of several different categorization methods. These categories help to understand the nature of technology centres, and permit the distinguishing of technology centres from other organizations which appear to serve a related function. The categories that have proven to be most useful are:

- Sponsor categories which indicate the centres' primary operators or funding sources, including:

  - Federal (F): These centres are funded and operated almost exclusively by the federal government. 42 have been examined; and another 66 operated by Agriculture Canada have been added (profile data only) to the database (see 2.1.1 and 2.1.2)).

  - DRIE Centres (D): These centres received start-up funding from the Department of Regional Industrial Expansion but are not operated by the federal government. 14 have been examined.

  - Industry (I): These centres are funded primarily by industry and provide services to a specific industry sector. 13 have been examined.

  - Provincial Research Organizations (PRO): These centres were created and are operated by eight of the provinces. 21 units or divisions of PROs have been examined. Also included are BILD Technology Centres in Ontario, of which 5 have been examined.

- Other (U): This group includes centres based at universities, and all other centres not in the above listed groups 80 centres were examined.

o <u>Direct Service to Industry categories</u>:

centres which devote a relatively <u>high</u> proportion of their resources to direct technology diffusion and transfer service to industry (HDSI), and others which devote a <u>low</u> proportion (LDSI),

o <u>Size categories</u>:

size of centre as determined by the number of full-time scientific and technical staff, or equivalent part-time staff, or by total budget, and

o <u>Regional categories</u>:

geographic region of Canada as determined by location of the centre, using an aggregate four region breakdown (Atlantic, Quebec, Ontario, and Western Canada).

Technology centres are described below using these categorizations.

2.1.1 The Special Case of Federal Laboratories (see Appendix C)

The federal government spends about $1.2 billion annually to operate some 1,000 laboratories and centres that employ 8,000 scientists and engineers. Each of these laboratories is closely integrated with the mission of its respective department or agency. These missions are defined by individual statute, and the laboratories are the responsibility of their respective Cabinet Ministers or agency heads. In addition, the management of these laboratories is governed by umbrella legislation such as the Financial Administration Act and the Public Service Employment Act, as well as by the regulatory control of central agencies or bodies including the Treasury Board, the Public Service Commission and the Office of the Auditor General.

Special factors determine the management environment of federal laboratories. The research laboratories are operated and managed to meet such objectives as the following:

1. To provide technical support for overall departmental objectives. For example, research activities in Health and Welfare are dedicated primarily to the enforcement of health regulations and to safeguarding the health of individual Canadians. Considerable research in Environment Canada is related to setting and enforcing pollution standards. Where departments do not have their own laboratories or suitable expertise, they may use other laboratories such as those of NRC.

2. To maintain Canadian standards of physical measurement such as length, mass, time, radiation intensity, and electrical current. Maintaining the necessary precision and accuracy in measurement technologies, which grow continually more advanced, requires ongoing research.

3. To provide research and testing facilities whose scale is such that no single firm or other type of user, could sustain them financially nor occupy them fully. Because the clients, research and testing activities continually grow more demanding in terms of accuracy, precision, size, capacity, correction factors, data gathering capability, and the stability of conditions being controlled, ongoing research is needed on methods and systems for incorporating into the facility and for operating it effectively.

4. To conduct medium- to long-term research and development whose results are expected to be of importance to Canadian industry, but whose risk is such that no single company could sustain the necessary involvement over the required time period.

The nature of these activities makes it difficult for government laboratories to identify clearly the overall level of direct service to industry. This is illustrated by descriptions of three federal laboratory organizations as follows:

i) Canadian Centre for Mineral and Energy Technology (CANMET)

CANMET is the major research arm of Energy, Mines and Resources Canada, and conducts research, development, testing, and related activities in mining technology; mineral extraction; metallurgy; the utilization of metals and alloys; energy conservation; heavy oils and oil sands; coal conservation and utilization, including combustion; uranium recovery; energy transportation; explosives; health and safety in mining; and environmental impacts of effluents from mining and mineral processing operations.

CANMET operates laboratories in the National Capital Region, and in Edmonton, Elliott Lake, Ontario, and Sydney, Nova Scotia. Among the main industry sectors served by these laboratories are the hard rock and coal mining and processing industries, the oil sands mining and extraction industries, and the petroleum industry.

CANMET originated in 1907 as the Mines Branch of EMR's precursor department, Mines and Technical Surveys, but was renamed and reorganized in 1974. Since 1968 an industrial advisory body, the National Advisory Committee on Mining and Metallurgical Research, has provided a link to CANMET's user committee as well as advice on its activities.

CANMET's expenditures in 1984-85 totalled some $75 million, and its person-year utilization was nearly 800.

ii) Research Branch, Agriculture Canada

The research arm of Agriculture Canada serve Canada's agricultural industry, as well as providing technical support for the Department's responsibilities. Areas of research include land resources, plant and animal breeding, agricultural engineering, plant and animal diseases, biochemistry, statistics, biosystematics and food research. While the research emphasis is on service to the Department's enforcement and support responsibilities to the farming community and associated industries, a substantial part of the resources is devoted to medium- to long-term research for the benefit of Canadian agriculture generally.

Agriculture Canada operates laboratories and field stations in all provinces, in all major agricultural areas. In cooperation with provincial laboratories and stations, they serve individual farmers and work on the solution and prevention of national and regional agricultural problems.

The research activities of Agriculture Canada had their beginnings around the turn of the century. The Department has established a series of coordinating committees in several areas, which help the Research Branch set priorities and prevent overlap and duplication of effort with universities and other research organizations. Research expenditures amounted to about $220 million in 1984, and the scientific person-year utilization was just over 900.

iii) National Research Council of Canada (NRC)

NRC is the federal government's largest and most diversified scientific research organization, and undertakes eight principal types of activities in support of virtually all sectors of the Canadian economy, Canadian industry, universities, governments, and individual citizens. The activities include research and development; technology transfer; the provision of specialized technical advice; the management of scientific and technologically based industrial development programs; the acquisition, storage, and dissemination of scientific and technical information; the maintenance and application of Canada's national physical standards such as length, mass, time, radiation, and light intensity; the provision of specialized testing and analytical services; and the maintenance and operation of research and testing facilities such as wind tunnels, hydraulics (wave) tanks, and observatories.

NRC operates sixteen laboratory divisions that undertake work in selected areas of physics, chemistry, biology, biotechnology, electrical engineering, mechanical engineering, aeronautical engineering, astrophysics, space science, industrial materials, buildings engineering, marine dynamics, and microstructures related to electronic and other materials. The laboratory facilities are located in the National Capital Region as well as in Victoria, Vancouver, Penticton, Saskatoon, Churchill, Toronto, Algonquin Park, Montreal, Halifax, and St.John's. In addition, NRC operates Canada's national scientific and technical library, located in Ottawa, and an Industrial Development Office with headquarters in Ottawa and field offices that provide technical outreach to industry in all major cities across the country. It also funds and helps direct two major non-federally-owned facilities for optical astronomy and intermediate energy particle physics, as well as several large-scale extramural research programs in nuclear fusion and wind energy turbines.

With respect to the industrial community, NRC's principal clients include Canada's medium and high technology industry sectors, including manufacturers of communications equipment, microelectronics, computing and office equipment, aircraft and aircraft engines, aerospace equipment, pharmaceuticals, scientific instruments and professional equipment, chemical products, industrial machinery, and land transportation equipment. Medium and high technology companies in the resource and service industry sectors are also major clients. The Council also undertakes outreach services to lower-technology industry and especially to small companies through a network of field advisory services linked with provincial research organizations, with other research institutes, and with consulting engineering firms across Canada.

NRC was established in 1916. Since then its activities have been overseen by a governing Council, comprised of prominent representatives from Canada's industry, university, and government sectors. NRC also relies on advice about the content and application of its programs from 38 associate and advisory committees with members drawn from Canadian industry, universities, and governments; and it undergoes regular assessments of the scientific calibre of its work by peer review committees drawn from similar Canadian and foreign sources. All told, nearly 1,000 external experts are involved each year in providing technical and strategic inputs through these committees.

NRC's 1984-85 total expenditures were some $520 million and its person-year utilization was aout 3,560.

IRAP and PILP are federal programs managed by NRC that promote the development and application of new technology by industry. Although they engage in significant technology transfer activities of the kind associated with technology centres, neither of them maintains facilities or develops and maintains scientific expertise in the technology being transferred. Rather, they functions as stimulators and managers of technology development and transfer by providing funds to industry and arranging for the provision of technical expertise.

Under the technology transfer components of IRAP, field staff visit and assist companies to identify problems that could be addressed by the application of suitable technology. The field staff seek out the necessary technical expertise in laboratories anywhere in Canada, or abroad if necessary, and make arrangements to have the technology transferred to the company in question and, where appropriate, to have further research undertaken. Financial assistance is provided where necessary.

Under PILP, research results that originate anywhere in Federal government laboratories and that have good commercial potential are transferred to companies that show an interest in exploiting the technology. The "transfer" activity normally consists of an R&D project conducted by the company with direct hands-on assistance from the government scientist who developed the technology. Such projects usually are necessary to refine the technology into a commercially-useable form. PILP officers seek out interested companies, manage the projects, and arrange for funding contributions to help offset the company's financial risk.

The result of their methods of operation is that neither IRAP nor PILP fit into the definition of technology centres as employed in this study. As a result, their funds are not included with federal grants and contributions to technology centres. However, their funds and efforts are included in the discussion of efforts in technology fields under the heading "Federal Organizations", because these funds and efforts are of direct service to industry.

It should be noted that as a result of their methods of operation, both IRAP and PILP have developed extensive networks. IRAP's field staff is comprised of a mixture of Federal employees and employees of Provincial Research Organizations and many other research organizations in Canada. All PRO's are provided with IRAP contributions to pay for dedicating some of their personnel to act as IRAP field officers. A variety of other research organizations also receive IRAP funding for the same purpose, as do numerous member companies of the Association of Consulting Engineers of Canada. All personnel participating in this large formal network are trained by IRAP in Ottawa and are interconnected with each other by a variety of means. The PILP network consists of project managers from all major federal science departments, who participate in the program's management and administration, review each others' project proposals, and have access to a common fund for arranging financial contributions.

2.1.2 Definition of Direct Service to Industry (DSI)

The basic definition of a Technology Centre as used in this study is given in the preceding section (Introduction). This definition is based on the provision of technology support activities to industry involving efforts such as in technology adaptation, transfer, demonstration and diffusion, and other services of a hands-on nature. It excludes the provisi of research service of a proprietary nature or education for degree-granting purposes.

The part of the definition involving technology support to industry was established in the following way. As part of the data collection process, respondents were asked to estimate the allocation of their organization's time and effort spent providing services to industry, to governments, and to activities not assignable to either. In addition, respondents were asked to estimate the allocation of time and effort to "background research". If there were a question as to the interpretation of background research, it was specified as comprising activities that were not directly related to a client of the organization, even if they would eventually be useful to industry and might lead to contracts with clients. Development of expertise in a new area would be an example.

Time and effort spent on background research was not counted as technology support to industry even though it is recognized that it may be essential in the development of new and future technologies. The operational definition of direct service to industry (DSI) was taken as the respondent's estimate of time and effort allocated to industry unless this amount was greater than time and effort <u>not</u> spent on background research. In the latter case, DSI was defined as the total amount of time and effort <u>not</u> spent on background research (i.e. 100 minus the percentage of background research).

The DSI index is used only to separate centres into various groups that have largely different mandates as a purely descriptive variable, the DSI index implies absolutely nothing about the industrial relevance of a centre's work, nor its responsiveness to industrial needs, nor its effectiveness in fulfilling its mandate, nor he importance to Canada of the centre pursuing such a mandate.

The DSI index merely reflects the degree to which an organization is involved in outreach activities, for example, of the kind that tend to be needed in supporting Canada's large population of low technology companies. By contrast, centres involved in supporting Canada's high technology companies (who do not need a great deal of technical awareness-building and hand-holding, but who do benefit from short bursts of high-level coupling) tend to have a low DSI index because of the need for undertaking considerable background research. Two examples taken from the data base illustrate the meaning and limitations of the DSI index:

- A provincial CAD/CAM centre devotes nearly seven-eights of its time to training and educating its clients in the application and use of CAD/CAM systems and equipment. Its primary clients are manufacturers of machinery and equipment, auto parts, and miscellaneous electrical equipment, all of them medium to low technology sectors. Because of the high proportion of time spent in direct contact with clients which is in fulfilment of the centre's mandate, its DSI index is fairly high at 82%. It clearly is a technology centre.

- A federal materials and structures laboratory devotes three-quarters of its time to research and development, primarily in developing generic information about the performance properties of advanced metals, metal alloys, and composites under the design and service conditions prevalent in aircraft and space applications. Nearly 80 per cent of its industrial clients are manufacturers of aircraft and aircraft parts, an exceptionnaly high technology sector. Because most of the technology exchange with clients is in the form of brief, high-level information exchanges, only a small proportion of the centre's time is spent in direct contact with clients. Nevertheless the clients depend on the information received, and on the centre's fulfilling its mandate to conduct the necessary background research needed to generate this information. The centre's DSI index is (appropriately) low at 20%. It clearly is a research organization with associated technology activities.

Since the major objective of technology centres is the transfer of technology, a brief description of the methods of technology transfer used in practice would be useful. It should be noted that in the most effective methods, the technology is transferred from one person to another. Technology is seldom a black box or a wrapped-up piece of paper that arrives in the mail and works without transfer of expertise.

Also, no method of transfer is clearly separate from all others: A technology transfer may start with one method, but other methods may be required at one stage or another to make the transfer successful.

Methods of technology transfer include:

1. The selling, installation, and initial operation of a new piece of equipment or new process, to a customer not yet familiar with the equipment. The transfer of technology involves the vendor's salesmen and quite often its back-up technical experts. Vendors providing full service, i.e. that are competent and willing to transfer the know-how about the equipment; generally are successful. An example is the selling of computer equipment to small businesses, where hands-on know-how rather than a 500 page book is what the customer needs. For more complicated pieces of equipment and processes, many companies provide hands-on training courses for clients. Technology centres are involved with this method where commercial equipment, processes and training is not available, for example when the equipment or process, has been made or developed by the center for one or a few specific industries. Transfer involves communication at the level of the customer.

2. Development of a new or adapted piece of equipment, process, or technology to fit customer needs. This development involves the interaction of client's staff with technical personnel in a vendor organization that are capable of providing what the client wants by translating his demands into appropriate specifications requirements. Some level of initial technical expertise by the client is required to make this process work. Technology centres generally have expertise to understand client's requirements and to translate them into technical requirements, hence often fulfill the role of vendor organization in this process.

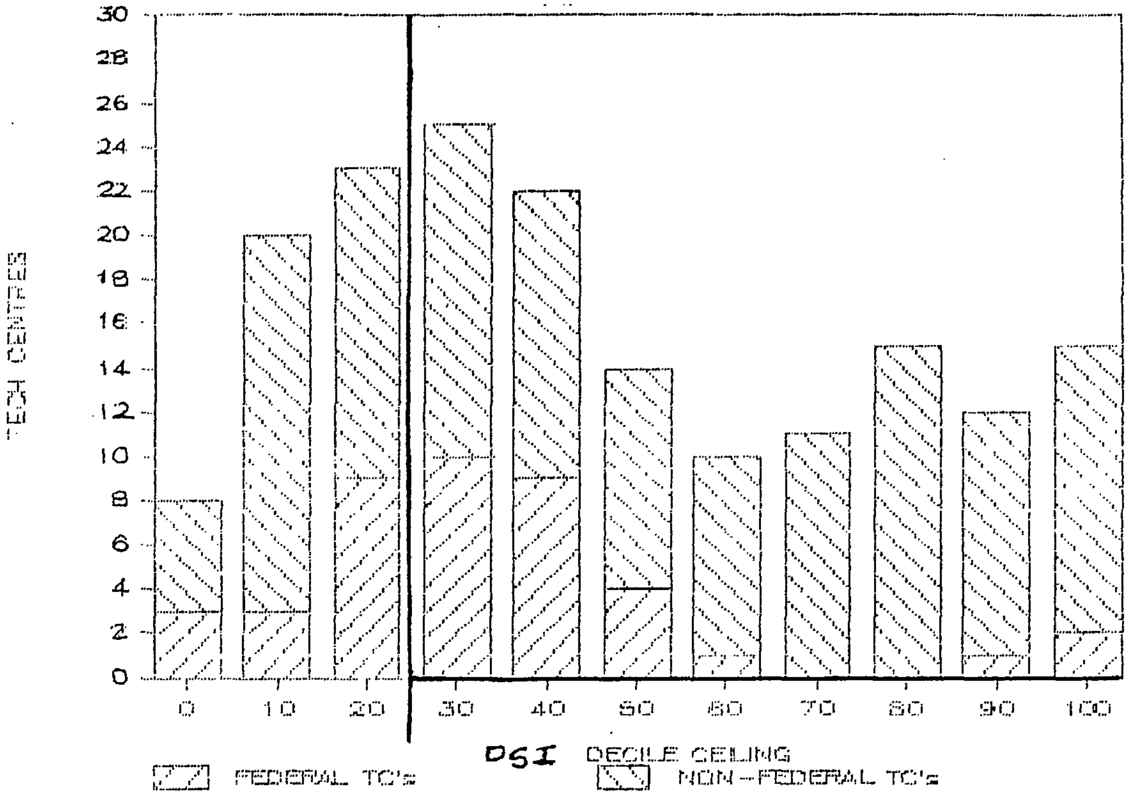
3. Extraction of technologies from the technical or scientific literature. This requires a high level of specialized technical competence by the technology recipient. It usually requires testing and adaptation before the technology is transfered successfully. Since this specialized technical competence is seldom found in small companies, technology centres can and do provide this service.

4. Translation of scientific findings into new technologies. This the method is possible only if the client's personnel are capable of understanding the scientific language and concept. This technology transfer method frequently occurs between highly qualified technical people in larger, technically sophisticated client companies, and the staff of laboratories (usually federal or university) who are engaged in medium- or long-term research that developed the scientific findings. Technology centres generally do not become involved in this method of transfer. The actual transfer normally occurs in a laboratory or at scientific meetings. Programs such as PILP and to some extent IRAP sometimes stimulate this kind of technology transfer to companies capable of using suitable ideas and processes developed in research laboratories.

This discussion indicates the importance of person-to-person contact in the process of technology transfer. For this transfer to work, the client has to develop a justifiable confidence in the person land institution wanting to transfer. The technical expertise of a tech centre and the confidence placed in it is only developed over a period of time by competent people. Part of the technology transfer process is training. Expertise has to flow from the one who knows to the person that does not yet know, but may have to put money and reputation on the line in using the new knowledge.

FIGURE 2.1 A
TOTAL NUMBER OF TECH CENTRES AND RESEARCH ORGANIZATIONS

(# TC'S 175)



2.1.3. Technology Centres by Level of Direct Service to Industry

The most useful categorization of technology centres was found to be that determined by the measure of direct service to industry. Using the definition as described in the preceding section, the level of direct service to industry (DSI) was calculated for each centre based on the responses to the interviewers' questions.

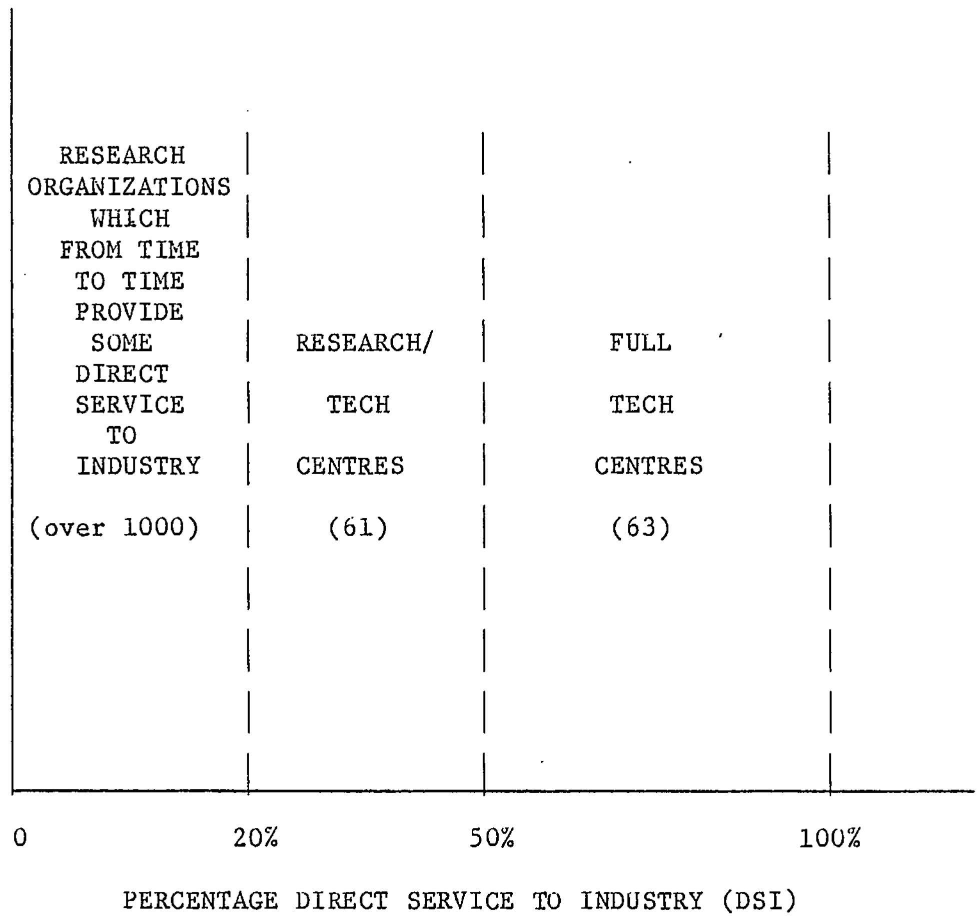
Figure 2.1 A (opposite) illustrates this classification of centres. The bar chart indicates the number of centres within each band of the DSI variable at ten percentage point intervals. Based on the responses available for 175 centres, this graph indicates that 63 centres (that is, the sum of the five rightmost bars shown) provided more than 50% direct services to industry and approximately 110 centres provided less than or equal to 50% DSI. The graph also shows that the proportion of these centres which are in the federally operated group (as defined above) is much greater in the lower DSI category than in the higher DSI category, because of the way in which direct service to industry was defined.

The categorization of centres by the DSI index is most important. As well, the demarcation of centres at the 50% point of DSI will be used throughout this report. Those 63 centres with greater than 50% DSI are referred to as the High DSI category, or simply, HDSI. The centres with Low DSI, or the LDSI category, are represented by the 110 or so other centres examined in this study. (It should be evident from what has been mentioned however, that a large number of centres that might fall into the LDSI category have not been examined in this study). Centres (or more appropriately, organizational units) with very low DSI are not considered to be technology centres for the purpose of this review.

By the nature of the vetting process used for determining which organizations were to be examined in this study, many organizations with a DSI

Figure 2.1 B

CATEGORIZATION OF ORGANIZATIONS BY PERCENTAGE DIRECT SERVICE TO INDUSTRY



value of 20% or less have not been included. Conversely, many organizations with a DSI value of 20% or less have been included in the survey. Organizations with DSI definitely equal to zero have been omitted from the discussion in this report. Some organizations with missing data such that DSI could not be calculated have not been omitted but rather appear on the graph at zero DSI. The salient point is that if all organizations in Canada were examined, and a DSI value were estimated, the distribution shown in Figure 2.1 A would show considerably more centres at 10% DSI and probably also at 20% DSI.

It is our contention that only centres with higher DSI indices are of real interest in this study, namely those with DSI greater than 20%, and especially those with DSI greater than 50%. The reason that many with a lower DSI value have been included is strictly for comparison. The categorization of centres by DSI index is illustrated in Figure 2.1 B. The reader is reminded that the DSI index is a convenient way of categorizing, but does not constitute a value judgment and cannot be taken to indicate effectiveness.

It is helpful to see the distribution of centres by group in the HDSI and LDSI categories. As shown in the table, the federal group is primarily in the Low DSI category, making-up about one-third of all centres with a DSI less than 20%. The DRIE centres are concentrated in the High DSI category, and those few in the LDSI category have, with one exception, a DSI of greater than 20%. The industry group is almost completely in the HDSI category. Both the PROs and the other (primarily university based) groups are proportionally distributed among the DSI categories.

FIGURE 2.1 C
TOTAL PERSON YEARS IN TECH CENTRES AND RESEARCH ORGANIZATIONS
(TOTAL #175)

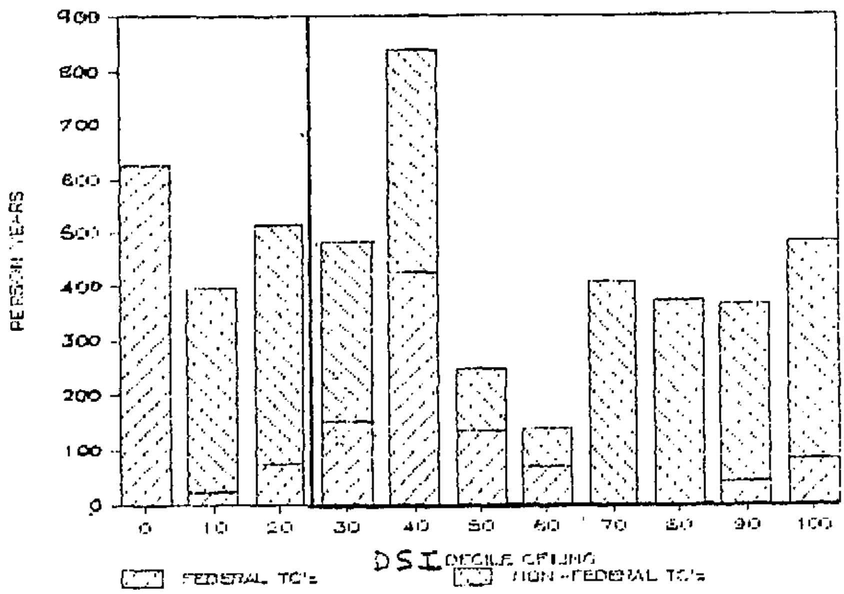
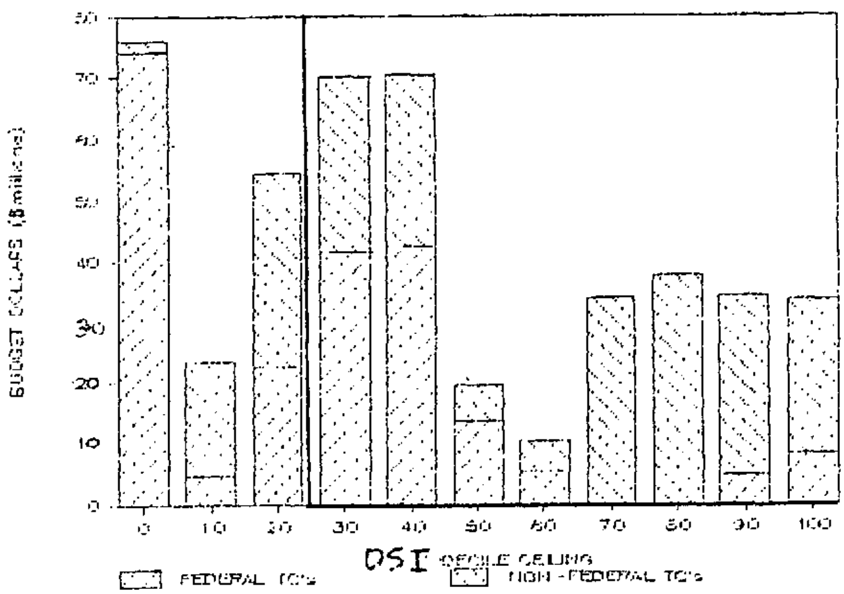


FIGURE 2.1 D
TOTAL BUDGET FOR TECH CENTRES AND RESEARCH ORGANIZATIONS
(TOTAL #175)



TECHNOLOGY CENTRES BY GROUP AND CATEGORY

GROUP	# CENTRES IN HDSI CAT. (DSI 50%)	# CENTRES IN LDSI CAT. (DSI 20%)	# RESEARCH ORGANIZATIONS (20% DSI 50%)
Federal	4	23	15
DRIE	9	4	1
Industry	12	1	0
Prov. Res. Orgn.	13	8	5
Other	25	25	30
TOTAL	63	61	51

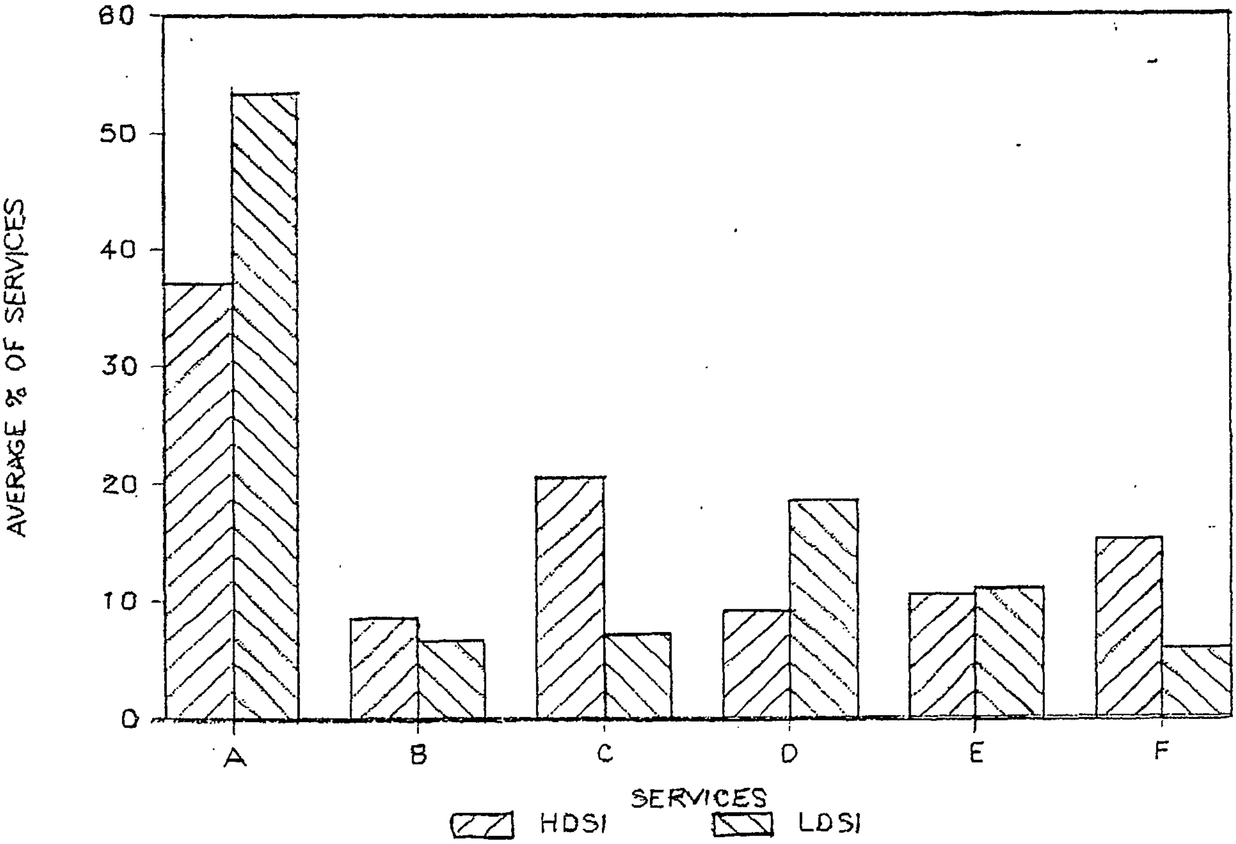
Figures 2.1 C and 2.1 D show more distinctly why the point of demarcation of 50% of DSI is appropriate for separating HDSI centres from LDSI centres. The size of the centres as measured either by total budget dollars, or by total scientific and technical staff, indicates that there is a natural break around the 50-60% DSI point. As already stated, for purposes of this report the HDSI category has been taken as those centres with DSI greater than 50%.

2.1.4 Types of Services Provided by Technology Centres

A major difference between HDSI and LDSI centres emerges from the analysis of services provided to their clients. Services provided by technology centres have been defined as follows:

A. R&D and related technology transfer - Research, development and or adoption and subsequent transfer to industry of technologies expected to lead to new poducts or processes.

FIGURE 2.1 E
DISTRIBUTION OF SERVICES PROVIDED
BY CATEGORY



Note: KEY TO SERVICES

A= R & D and/or adoption and subsequent transfer to industry of technologies expected to lead to new products or processes.

B= Acquisition, storage and dissemination of scientific information.

C= Demonstration, and/or diffusion of technologies and/or facilities, systems equipment software and concepts.

D= Provision of research and testing facilities for use by centre's clients.

E= Testing of client's prototypes, models, equipment or samples.

F= Training and education of client's staff in application and use of new technology.

B	Information dissemination	- Acquisition, storage and dissemination of scientific information
C	Demonstration and/or diffusion	- Demonstration, and/or diffusion of technologies and/or facilities, systems, equipment, software and concepts
D	Providing test facilities	- Provision of research and testing facilities for use by centre's clients
E	Testing prototypes	- Testing of client's prototypes, models, equipment or samples
F	Training & education	- Training and education of client's staff in application and use of new technology.

As shown in Figure 2.1 E, HDSI category technology centres provide relatively more:

- demonstration and/or diffusion, and

- training and education

services than the LDSI category centres. Conversely, the LDSI category centres provide relatively more:

FIGURE 2.1 F
SIZE OF TECHNOLOGY CENTRES
BY NUMBER OF SCIENTIFIC PEOPLE BY CATEGORY

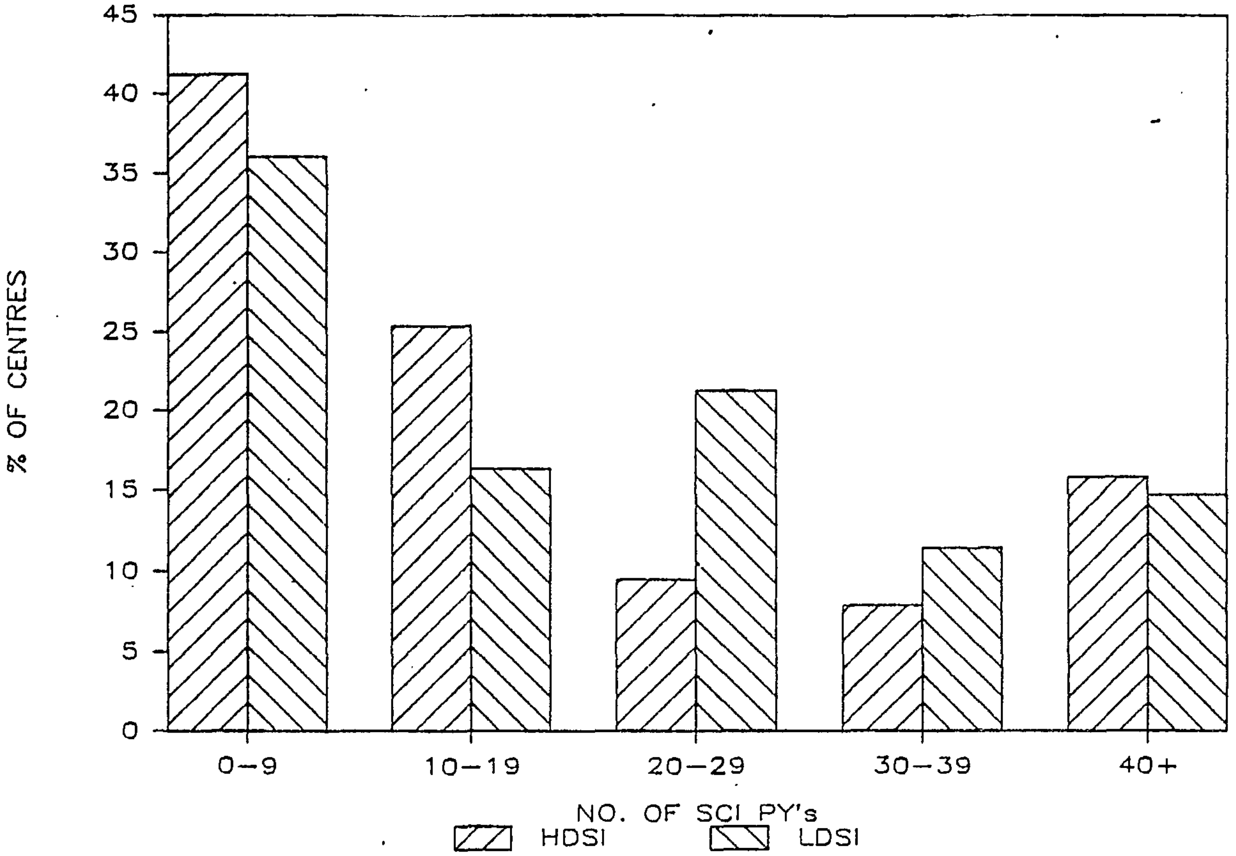
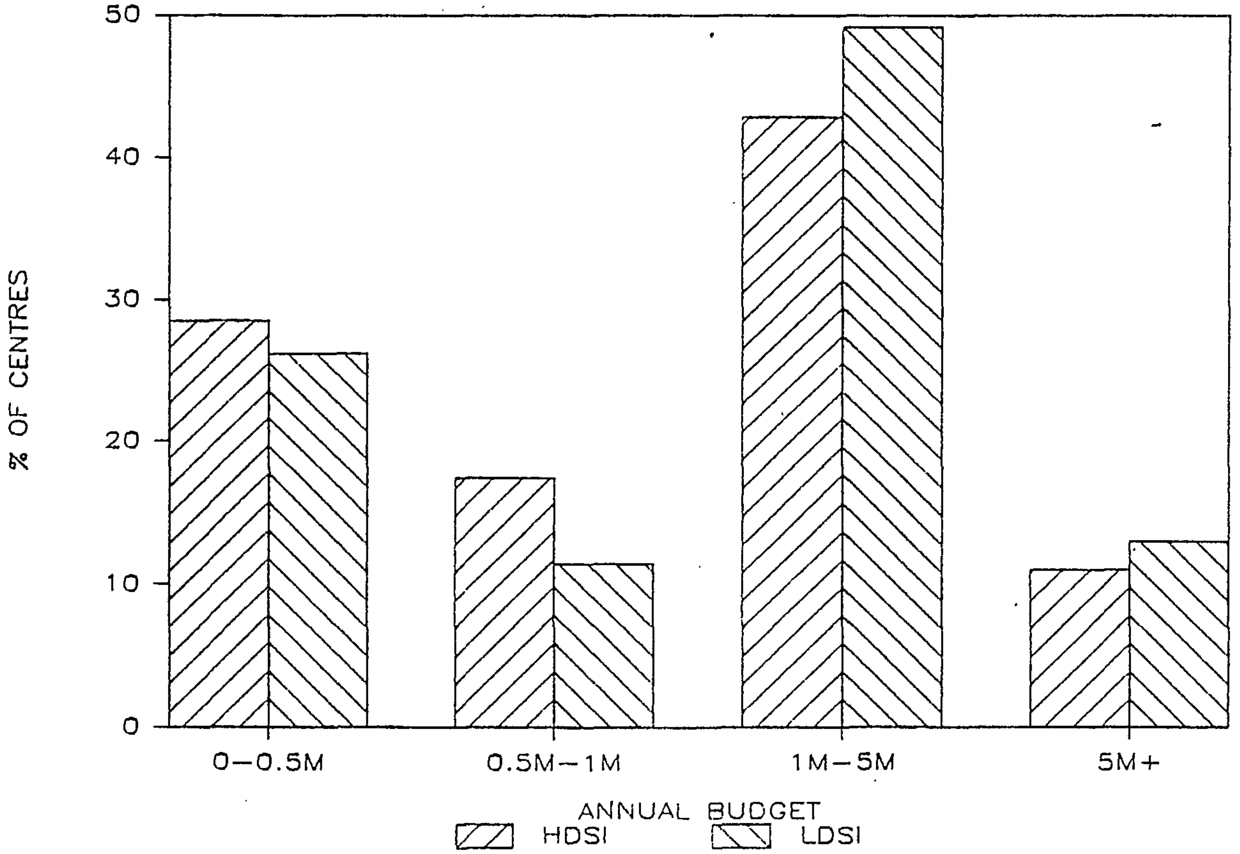


FIGURE 2.1 G
SIZE OF TECHNOLOGY CENTRES
BY BUDGET DOLLARS (# OF TC'S 124)



- R&D and related technology transfer, and
- testing

services than the HDSI category centres.

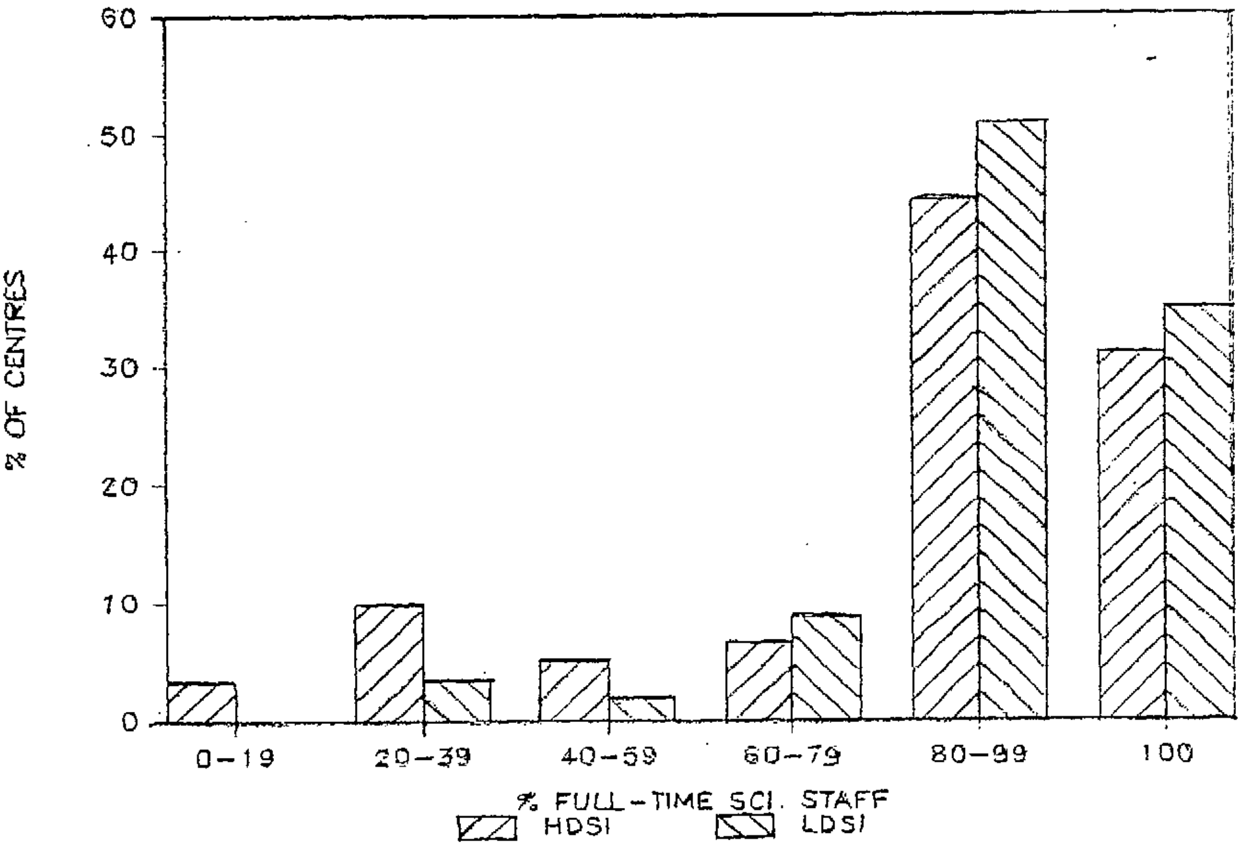
2.1.4. Distribution of Technology Centres by Size

Technology centres are small organizations. Figure 2.1 F shows the distribution of technology centres by the number of equivalent person-years of scientific and technical staff. Almost 40% of the centres have a staff numbering fewer than 10, while 60% have a staff of fewer than 20. Similarly, as illustrated in Figure 2.1 G, the majority (almost 90%) of centres have an annual budget of less than $5 million. In fact over 25% operate on a budget of less than $0.5 million.

2.1.5. Full-Time vs Part-Time Scientific and Technical Staff

Technology centres differ with respect to whether their scientific and technical staff are primarily full time or part time. As part of the data collection task of this study, levels of full-time and part-time staff were gathered as well as the amount of time actually worked by the part-time staff. Time spent by part-time staff was converted to full-time equivalent person-years. Figure 2.1 H illustrates the distribution of the ratio of full-time scientific and technical staff to the equivalent total scientific and technical staff. The ratio of full-time staff to total staff resources is remarkably high: some 80% of centres have more than 80% of their scientific and technical resources as full-time resources. The federally operated group of centres shows relatively more full-time resources while the other groups show relatively more part-time resources.

FIGURE 2.1 H
DISTRIBUTION OF TECH CENTRES
BY CATEGORY AND % FULL TIME SCIENTIFIC STAFF



2.2 RESOURCES

The financial and human resources allocated to technology centres in total and by the federal government is an important item in this study. Data were collected on staffing levels (both full-time and part-time) for all centres contacted in this study. Data on financial resources were collected on those centres that were interviewed in-depth (approximately 100 centres). Financial data were also available for many centres in our target population from the previous Statistics Canada surveys on institutions performing research and development in Canada. Based on these two sources of financial data, and making estimates based on detailed data concerning staff levels, a detailed picture of resources employed by technology centres in Canada was obtained.

2.2.1. Annual Budget per Person-Year

For those few centres (approximately 10%) for which financial data were not available from either our in-depth interview or from the Statistics Canada database, our estimates are based on the data collected on scientific and technical human resources. For estimation purposes, an equivalent annual budget per full-time scientific and technical person was determined. Figures 2.2 A and 2.2 B show in scatter plot graphical form the relationship between total centre annual budget and equivalent full-time scientific and technical person-years. The two graphs are shown so that the full range of data can be distinctly illustrated -- Figure 2.2. B shows in larger scale the points of Figure 2.2 A that are clustered near the origin. The points on the axes of the graph illustrate those centres with missing data values.

As illustrated in these two figures, a value of $95,000 annual budget per person-year adequately represents the trend shown in the data. It is this value that has been used to estimate financial budgets for those centres with missing data values.

FIGURE 2.2 A
BUDGET VS PY
OPERATIVE AND CAPITAL

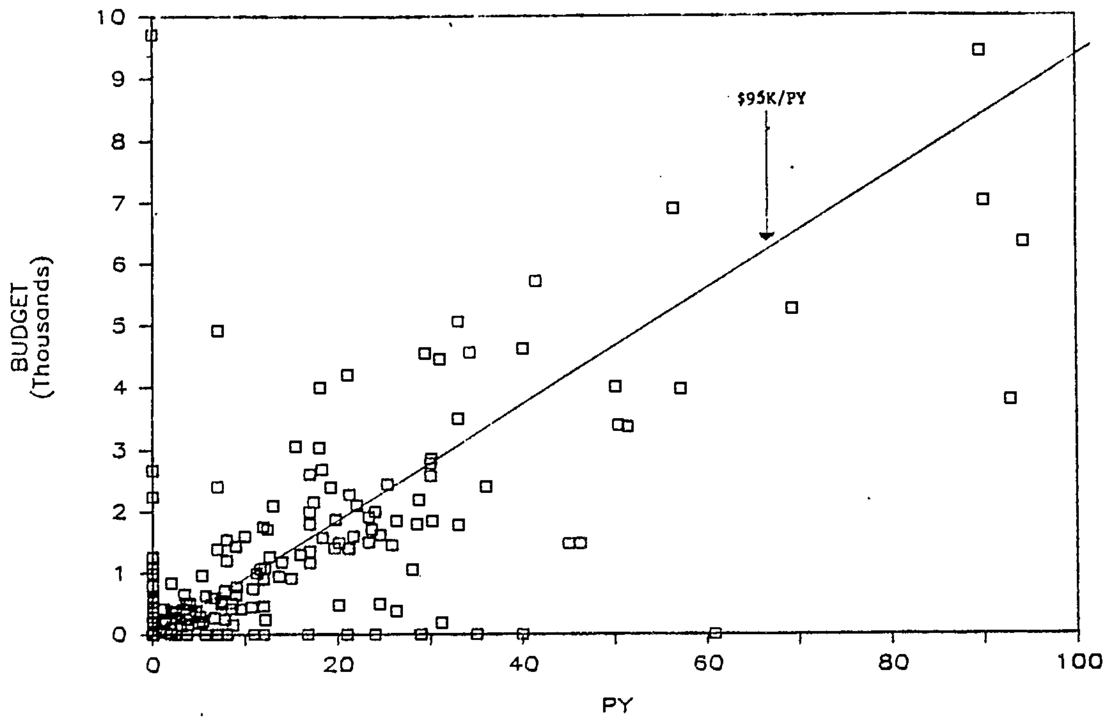
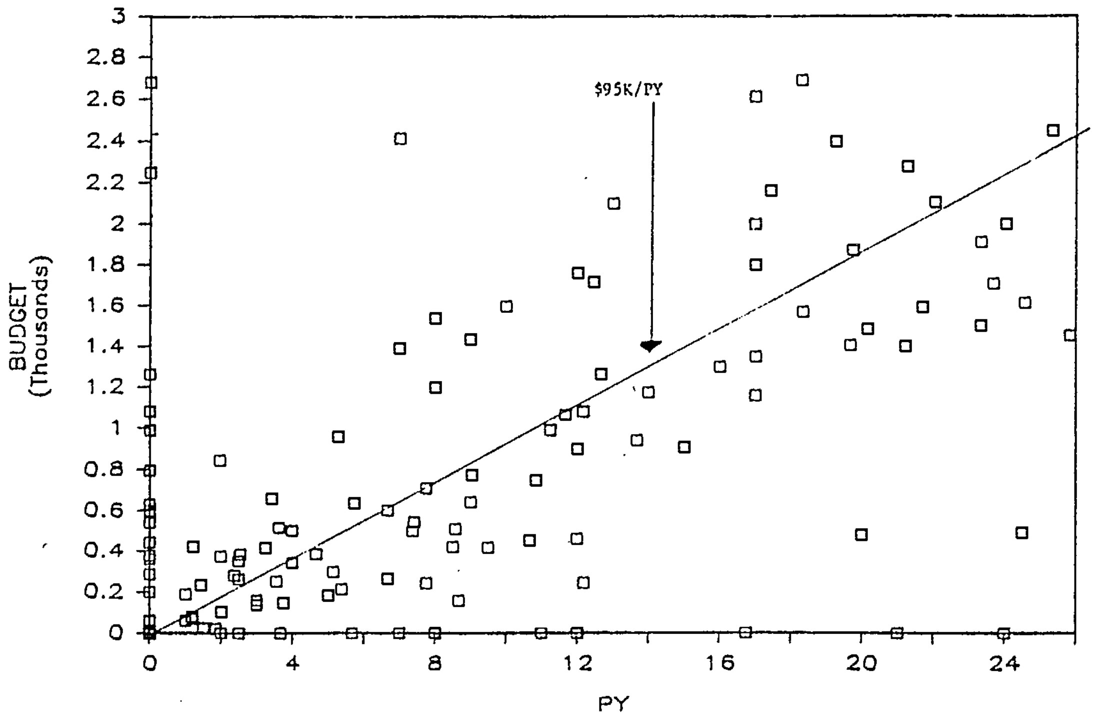


FIGURE 2.2. B
BUDGET VS PY
OPERATIVE AND CAPITAL



2.2.2. Federal Funding for Technology Centres

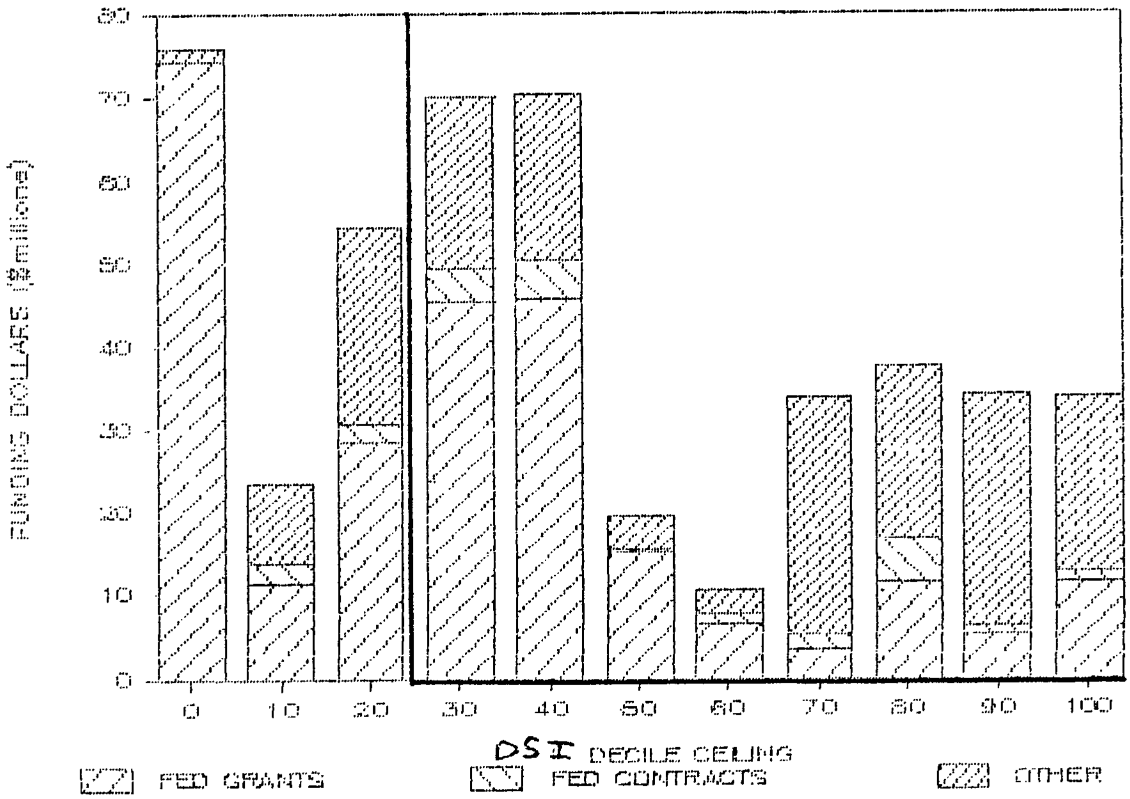
Another important aspect of technology centre resources is their source of funding. Data on the sources of funding were collected as part of our in-depth interview process. In addition, similar data were available from the earlier Statistics Canada surveys. In those cases where data were missing from both sources (approximately 10% of cases), budget levels were allocated to funding sources using average ratios within each group (i.e. Federal, DRIE, Industry, PRO, Other) of technology centres. These average ratios and the number of centres involved are shown in the table below. For all centres in the federally operated group, it was assumed that all funding was from the federal government, and that there was no federal contracting funds involved in the federal group. In addition to the 157 centres identified in the table below, there were some 18 centres without either financial data or human resource data so that no estimate could be made of either total budget or sources.

AVERAGE RATIOS FOR FUNDING SOURCES

GROUP	FED. CONTRACT $ TO TOTAL $	FED. OTHER $ TO TOTAL $	# TCs WITH DATA	# TCs WITHOUT
Federal	0.0	1.0	42	0
DRIE	0.195	0.293	12	2
Industry	0.134	0.176	13	0
PROs	0.188	0.059	24	2
Other	0.122	0.312	66	14
Total			157	18

Federal funding for technology centres is presented in the tables below. For approximately 10% of the centres, estimates have been made for total budget based on scientific and technical resource levels, or for federal funding based on ratios within each group.

FIGURE 2.2. C
SOURCES OF FUNDING TO TECH CENTRES AND RESEARCH ORGANIZATIONS
(TOTAL #175)



PROFILE FINANCIAL DATA ON TECH CENTRES AND RESEARCH ORGANIZATIONS STUDIED

i) ORGANIZATIONS COMPUTED AS BEING EITHER TECH CENTRES OR RESEARCH/TECH CENTRES BY VIRTUE OF CALCULATED DSI INDEX > 20%

Group	No. of Centres	SOURCES OF FUNDING ($000) Federal Contracts	Federal Other	Other Contracts	Other Funding	Total
Federal	27	0	113,239	1,940	204	115,383
DRIE	13	2,780	3,047	5,921	4,126	15,874
Industry	13	3,145	4,116	4,170	21,853	33,284
Provincial	21	6,612	1,714	28,334	44,401	81,061
Other	50	2,886	11,175	8,930	11,742	34,733
TOTAL	124	15,423	133,291	49,294	82,327	280,335

ii) RESEARCH ORGANIZATIONS ORIGINALLY EXAMINED AS POSSIBLE TECH CENTRES BUT SUBSEQUENTLY FOUND TO PROVIDE LESS THAN 20% OF THEIR TIME AND EFFORT IN DIRECT SERVICE TO INDUSTRY

Group	No. of Research Organ-izations	SOURCES OF FUNDING ($000) Federal Contracts	Federal Other	Other Contracts	Other Funding	Total
Federal	82	-	324,978	209	-	325,187
DRIE	1	274	200	91	-	563
Industry	-	-	-	-	-	-
Provincial	5	552	275	8,312	9,045	18,183
Other	30	2,478	9,854	2,198	10,700	25,230
TOTAL (OF THE ORGANIZATIONS STUDIED)*	118	3,302	335,307	10,810	19,745	369,163

* NOTE: The research organizations in this second set (DSI < 20%) represent only a small sample of the organizations in the Canadian population which would fall into this category. Those organizations not represented include much of NRC, several sections of PROs, many Federal government labs, and others. (see s 2.2)

The data on federal funding of centres is illustrated in Figure 2.2 C (excluding again AgCan centres). In this figure, federal funding and overall annual budgets are shown as a function of the DSI variable which measures the percentage of centre resources devoted to direct service to industry. Federal funding of technology centres is relatively concentrated in the Low DSI category of centres (primarily because most federal centres are in this category as shown above). In the High DSI category, the aggregate of centre budgets is approximately $150 million, of which $26 million is federal funding plus another $11 million of federal contracts.

FIGURE 2.2. D
TECH CENTRE BUDGET BY DSI

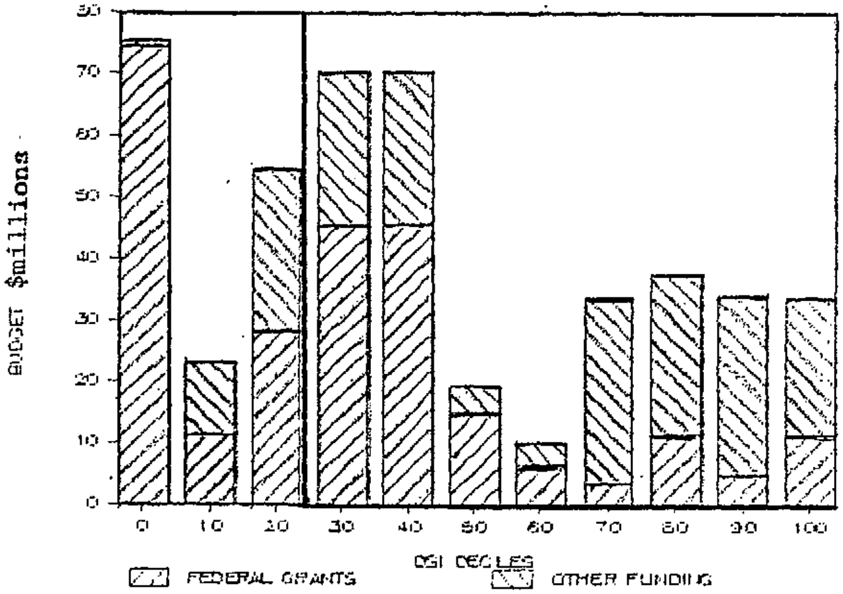
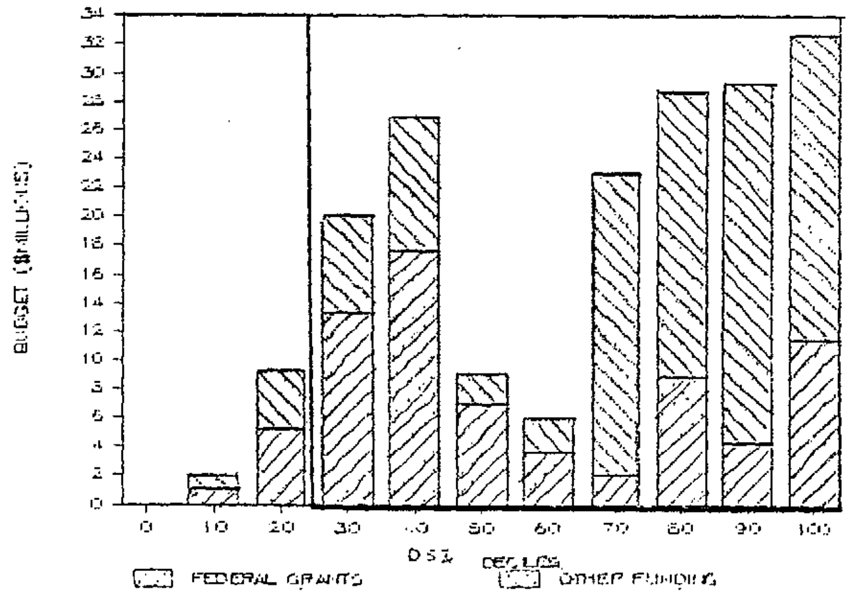


FIGURE 2.2. E
TOTAL FEDERAL RESOURCE LEVELS MULTIPLIED BY DSI



2.2.3. Resources Devoted to DSI by Technology Centres

An important aspect of resource levels for technology centres is the amount allocated for direct service to industry (DSI). Figure 2.2 D shows total resource levels by DSI and the federal (non-contracting) components.

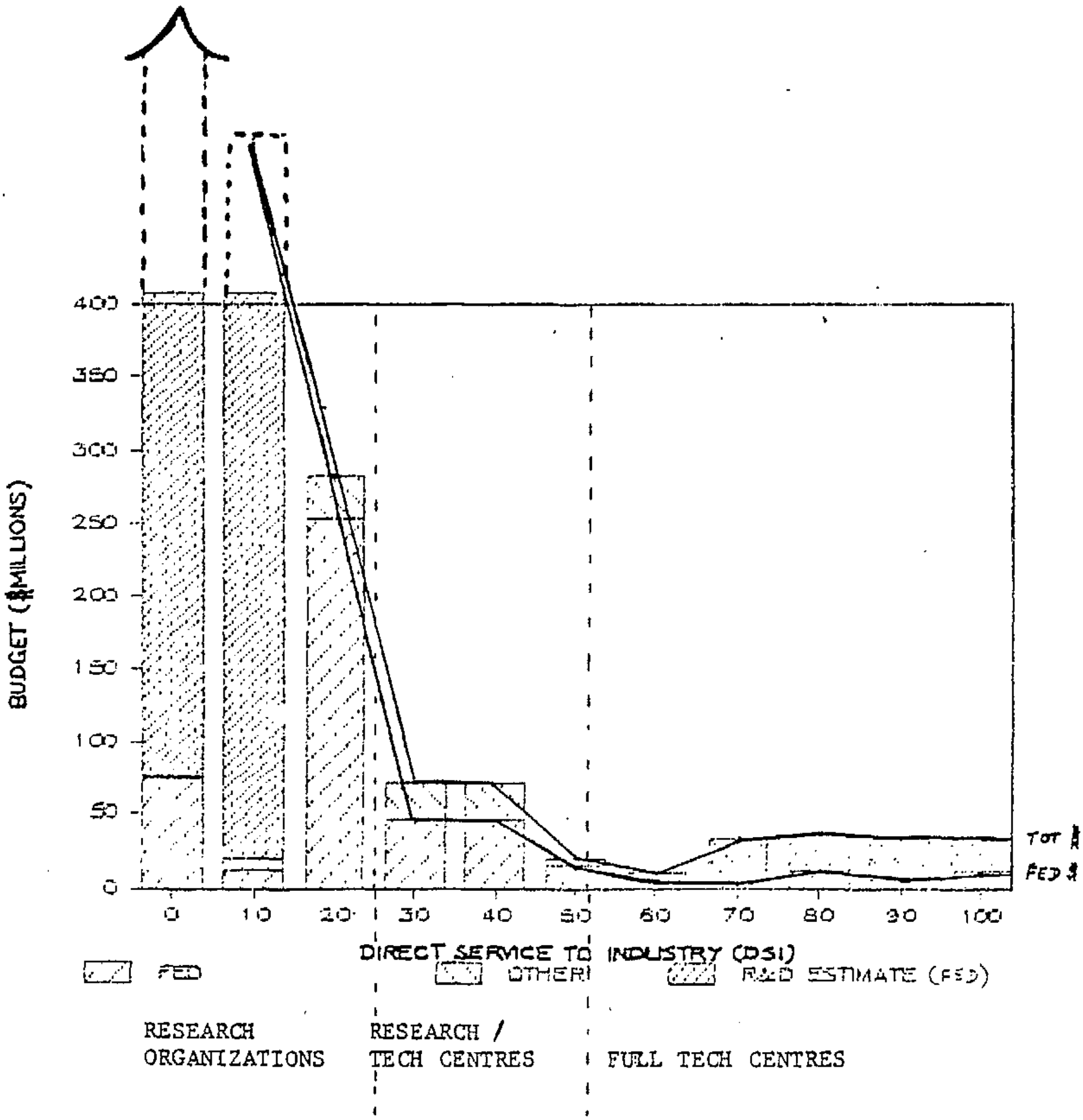
Figure 2.2 E shows the same resource data but each centre's resource levels have been multiplied by the DSI variable. This graph shows the amount of resources allocated to direct service to industry. The demarcation between the HDSI category and the LDSI category is much more pronounced in this graph. The total amount of resources allocated to DSI depicted in Figure 2.2 E is less than $200 million of which less than $50 million is from federal sources. (It should be kept in mind that data at a DSI index of 20% and below are quite incomplete)

The relationship between resource levels and DSI is further illustrated in Figure 2.2 F. In Figure 2.2 F, the resources available for all centres in the data base is shown by DSI percentages.

Again at the lower values of DSI (less than 30%), this study has not identified all organizations that might provide some direct service to industry. These curves in Figure 2.2 F have been extrapolated back toward zero percent DSI based on an estimate of the total federal funding allocated to technical R&D. These data are shown in Figure 2.2 F in non-cumulative form. The estimates for R&D at DSI of zero and 10% are intended only for illustrative purposes.

What is clearly depicted in the figure is the small amount of funding allocated for HDSI centres out of the total R&D funding in Canada.

FIGURE 2.2. F
TOTAL AND FEDERAL CANADIAN EXPENDITURES
ACROSS DIRECT SERVICE TO INDUSTRY CENTRE CATEGORIES
(1984)



2.3 CLIENT CHARACTERISTICS

2.3.1 Client Size

Data on the size of the client organization served by technology centres were collected in the in-depth interview process. Data are available for approximately 80 centres.

A simple summation of the number of client organizations (firms) based on size of firm served by centres results in the following table.

Number of Client Organizations Served

	Client Organization Size (Employees)				
	1-50	51-100	101-500	500+	Total
HDSI category TCs, #	2202	1502	979	374	5057
HDSI, percentage	44	30	19	7	100
LDSI category TCs, #	1660	516	334	308	2818
LDSI, percentage	59	18	12	11	100
Total, number	3862	2018	1313	682	7875
Total, percentage	49%	25%	17%	9%	100%

Both categories serve mostly small firms, but LDSI TC's relatively more so than HDSI TCs. The latter tend to service relatively more medium sized firms than the former (LDSI), which are more involved with very large firms. This suggests technology transfer from laboratories to sophisticated industry, without the need for hands-on TC assistance.

In relative terms, it can be seen that the HDSI category TCs tend to serve more middle sized firms (51-500 employees) and the LDSI category TCs tend to serve the small (1-150) and very large (500+) firms.

If, however, the percentage distribution of client size is first calculated for each centre and these percentages are then averaged, another pattern is evident. In this case, the average for all centres is 37% for small sized firms, 17% each for medium and large firms, and fully 29% for very large firms (500 + employees). The implication from this distribution, compared with that in the table shown above, is that many centres serve a few client firms, most of which are very large.

It must be noted, as well, when assessing the percentages on client size, that the distribution of manufacturing establishment size in Canada in total is approximately 82% small (1-50 employees), 8% medium (51-100), 8% large (100-500) and only one percent very large (500 + employees). Thus, relatively speaking, technology centres tend to serve medium, large and very large firms rather than small firms.

2.3.2 Barriers to Technical Change

A recurrent theme which emerged from every interview was the overwhelming need for Canadian business to keep abreast of technology advancement in the world community. Relative to this need it appears that most businesses display considerable reluctance to adapting technological change to their products or manufacturing processes. The underlying reasons for this resistance to change are:

1. lack of awareness

2. technical capability of the client base

3. lack of available funds.

The description which follows amplifies the above considerations and provides some insights for formulating a strategic response.

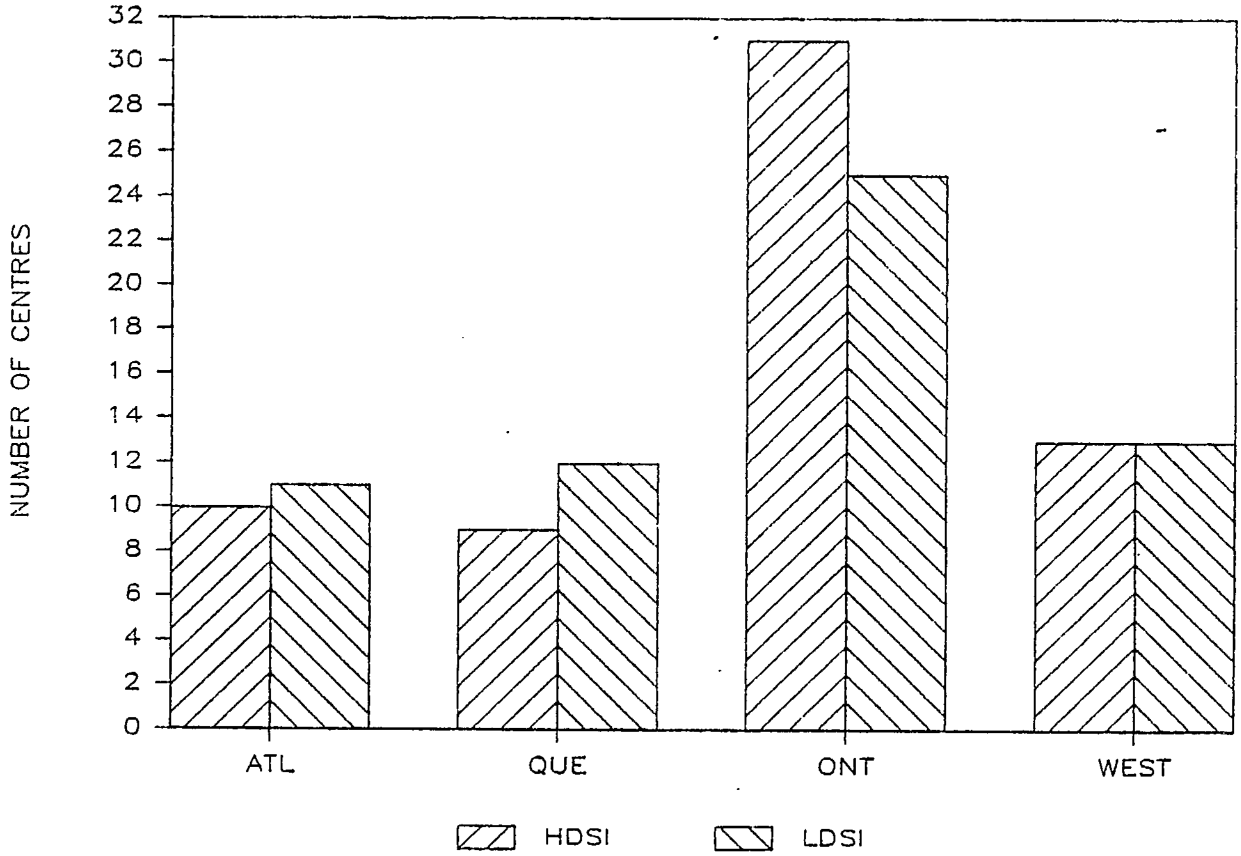
Lack of awareness includes three broad areas. Firstly, it appears many businesses are not cognizant of new technology developments and how they can be applied to their organization. Secondly, there are many businesses which are not familiar with services available from technology centres and how readily these services could be applied to improving products and operational processes. And finally, most businesses are not aware of the financial assistance available from governments.

Some interviewees observed that the businesses which would benefit most through technology enhancement are the same which are also most vulnerable to failure arising from technological obsolescence.

The technical capability of the technology centre's small client is the second barrier to the introduction of technological change. Of primary importance, 75% of their client market is comprised of companies which employ a staff of 100 or less. These small to medium sized companies typically employ only one technical professional, if any. As a consequence the availability of advice and counsel on technical subject matter tends to be very limited.

The third barrier to change is that most technology centre clients have access only to limited funds which can be dedicated to technology development. Given the combined cost of conducting the research and development, then purchasing equipment and converting manufacturing processes, and finally, training staff in the new technology, many potential clients are reluctant to begin the process. One respondent observed that many of his industrial clients are reluctant to sign agreements for more than $15,000. If this is the general practice of small business, it explains why the process of technological advancement is slower than desired.

FIGURE 2.4 A
NUMBER OF TECH CENTRES
BY REGION + CATEGORY



2.4 REGIONAL CHARACTERISTICS

2.4.1 Number and Resource Distribution by Region

Figure 2.4 A shows the number of centres by region and category. Of the total HDSI category, 50% are located in Ontario with the balance distributed evenly among the three other regions. The distribution of the LDSI category follows the same general profile with Ontario having slightly less than 50% of the centres. It may also be noted that Quebec has the least number of technology centres of any region. This is particularly significant with respect to the HDSI category because it is these technology centres which play a leadership role in the change process.

Funding for centres from government, industry & other sources is shown in Figures 2.4 B and 2.4 C for the HDSI and LDSI categories but excluding all federal centres. The significant differences in source and amount of funding on a regional basis are as follows:

Atlantic — Total funding for HDSI centres is more than double that for LDSI centres. Industry and the provinces are providing more support proportionately for HDSI centres than for LDSI centres.

Quebec — Total funding for HDSI centres is almost ten times that for LDSI centres. This significantly larger amount is due to high average contributions by industry and the province respectively to two technology centres.

Ontario — The total funding for HDSI centres is three times that for LDSI centres. The percentage funding from industry and the province is higher for the HDSI centres than for the LDSI centres.

West — Total funding for the HDSI centres in the West is substantially lower than for LDSI centres. While federal and industry funding are relatively high, the substantial provincial income for the LDSI technology centres creates a significantly different profile of LDSI centres in Western Canada.

FIGURE 2.4 B
FUNDING LEVELS BY LDSI FOR RESEARCH/TC

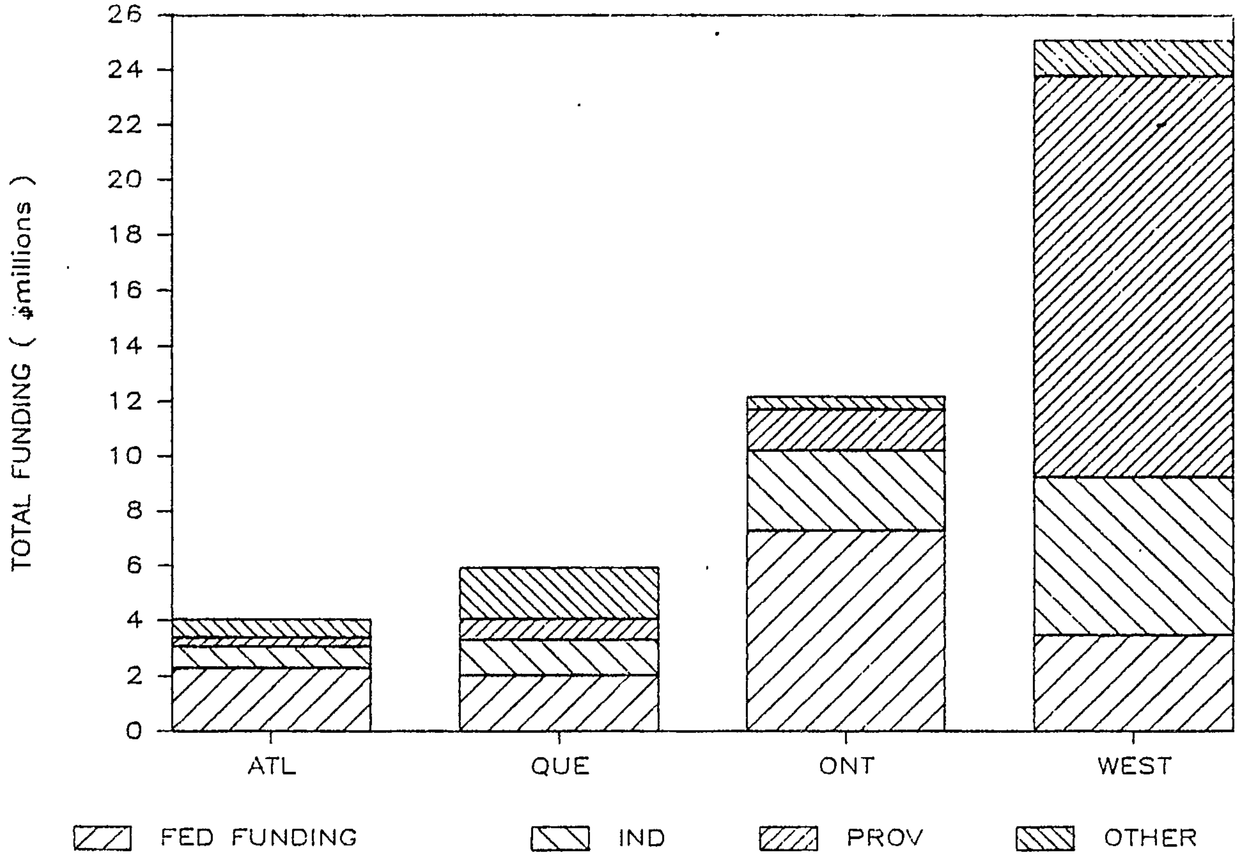
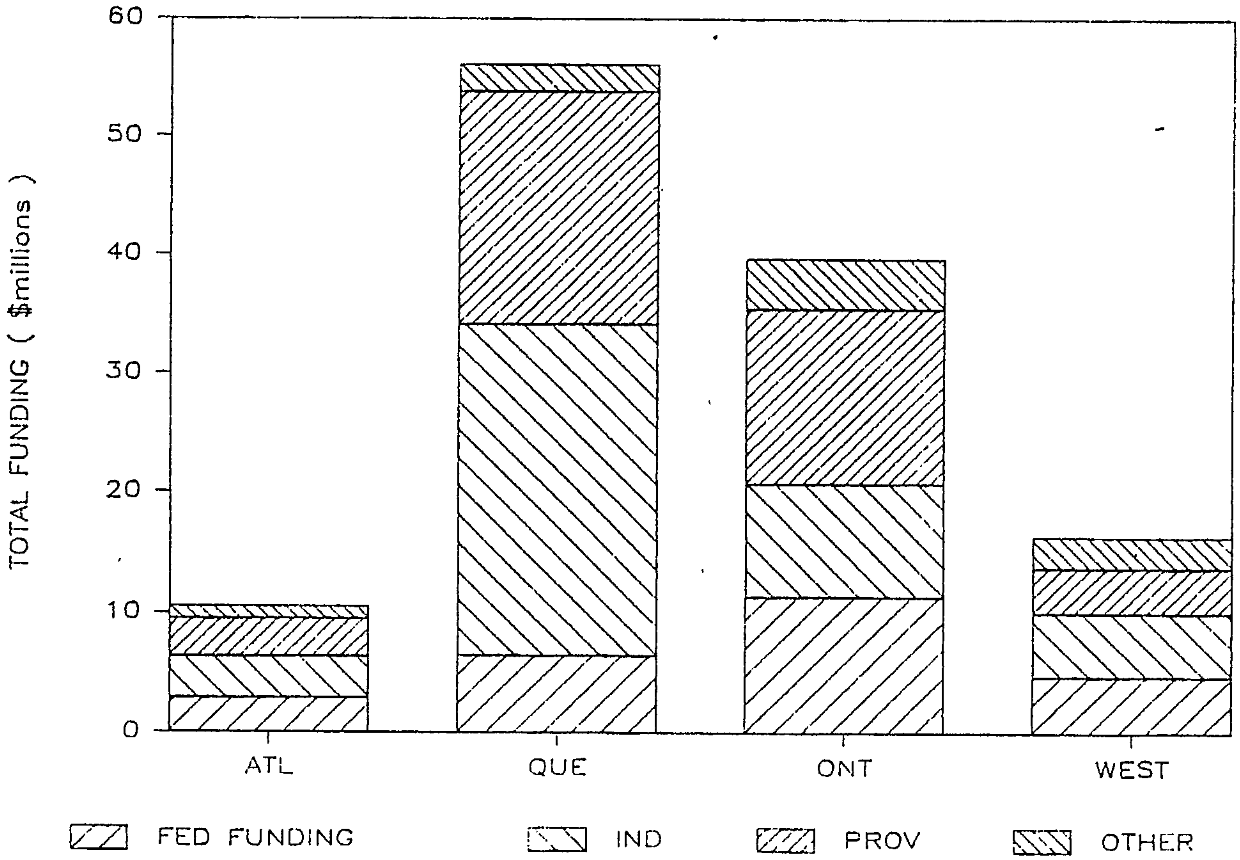


FIGURE 2.4 C
FUNDING TO TC'S FROM GOVT,IND & OTHER
BY REGION (CATEGORY HLDSI) (NO FED TC'S)



2.4.2 Economic Differences by Region

2.4.2.1 Atlantic Region

The small industrial base in the Atlantic provinces presents limited marketing opportunities for technology centres. The regional economy is heavily dependent upon primary industry which is not amenable to technological change. Also, many of the manufacturing firms represented in the region are divisions of larger companies based in central Canada. Most of these companies carry out their own R&D independently. The remaining companies which comprise the technology centre market are generally not highly sophisticated in their manufacturing technology. As a consequence, the level of technology recommended is influenced to a greater degree by what currently exists than by the unrealized potential for change. Hence the process of change tends to be more evolutionary and appears to lag behind development in other regions.

The small, sparse population of the region offers a limited scope to both total market size as well as growth potential. When taken with depressed incomes from high unemployment, there does not appear to be much inducement for manufacturers to introduce new technology unless the pay back period is relatively short.

2.4.2.2 Quebec Region

The Quebec economy presents a problem of balance in the distribution of industry. There is heavy concentration in primary industry essentially in the mining and forest products areas. Most of these large companies provide their own R&D. Many Quebec based companies are engaged in low technology, labour-intensive industry such as furniture, footwear, textiles and clothing. The opportunities for technology centre contributions to these firms is limited. While there are a growing number of small to medium-sized companies producing for diversified markets, the depressed economy and high unemployment tend to keep R&D expenditures at a relatively low level.

Although technology centres in Quebec report high levels of utilization, they also observe that opportunities for more companies to benefit from their services are not being exploited to their potential.

2.4.2.3 Ontario Region

In Ontario, which has more than fifty percent of Canada's manufacturing capacity, technology centres are operating near full capacity. Only those which are in a start-up mode or in leading-edge technology areas such as CAD/CAM, micro-electronics and computer-integrated manufacturing reported excess capacity. Most respondents indicate that if industry spending on R&D increased they could expand their services substantially by hiring more scientific and technical personnel.

2.4.2.4 Western Region

Technology centres in western Canada identified a number of economic barriers to growth. The manufacturing economy is dominated by a few forestry plants and a number of large extractive industries. The potential market for technology centre services is comprised of many small companies which require the infusion of external funding to accelerate change. The economy which is characterized by high unemployment is not generating sufficient surplus to support the costs of technology enhancement.

MAJOR STUDY QUESTIONS

3.1 OVERLAP & DUPLICATION

3.2 PROLIFERATION

3.3 COORDINATION AND NETWORKING

3.4 SKILLED RESOURCES

3.5 FUNDING

3.1 DUPLICATION/OVERLAP

3.1.1 Issue

Cabinet has expressed concern that over 300 technology centres have been established by the separate activities of 11 government departments and agencies. For this reason, overlap and duplication among technology centres was identified as a serious prospect and therefore was one of the "key issues or problems with current Federal support." The issue for this study has been whether overlap and duplication really exists to any significant extent, and, if so, where it does occur and and whether or not it is indeed a problem.

3.1.2 Background

The anticipation of significant overlap and/or duplication in technology centres' activities stems from a perception that there has been proliferation in the number of centres and from the number of different federal departments believed to be funding these centres. In addition, some specific concerns were raised during preliminary expert interviews in this study that duplication appeared to be present among centres in the microelectronics, biotechnology, and CAD/CAM technological areas. As far as this study has been able to ascertain, no systematic review of technology centres' services had been conducted previously in order to establish that overlap and duplication did exist.

For purposes of this study, overlap and duplication have been taken to mean the existence of cases where two or more centres provide the same kind of service, to the same client community, in the same technology field. "Client community" takes into consideration the industry sector, the location (region), and the size category of various clients, wherever these factors form a valid basis for differentiation among the clients. "Kind of service" encompasses the provision of R&D services; the acquisition, storage and dissemination of scientific information; the demonstration and diffusion of technology; the provision of research facilities; the provision of testing services; the training of clients' staff; the design of products; problem solving and analysis; and brokerage and client referrals. "Technology field" refers to the area of technical subject matter in which the centre offers its expertise.

3.1.3 Statement of General Findings

From a rationale review of the concept, an objective systematic review, and an analysis of the interview responses, there does not appear to be an overlap/duplication problem among Canadian technology centres.

3.1.4 Interpretation and Analysis

3.1.4.1 Issue Analysis

The assessment that overlap/duplication must be taking place among technology centres is based on the premise that more than 300 centres were involved in providing a significant level of direct service to industry. However, as discussed in the profile information in section 2, while it is true that there are many research institutions in Canada, there is only a small number which can be considered 'technology centres' (i.e., organizations whose primary function is to provide technological diffusion through services to industry). The potential for overlap/duplication therefore is significantly reduced from that which had been originally anticipated.

Moreover, the conduct of this study has revealed that the complexity of modern technology provides almost unlimited scope for specialization. Canada's few score technology centres have available a range of some 14,000 different specialties in which to provide service, so that the potential for centres to avoid overlapping each other is truly immense. With such manoeuvering space available, the hypothesis seems tenuous that tech centres would cluster together and compete directly with each other. Of course the

Canadian infrastructure neither needs nor can sustain 14,000 tech centres but the "head room" for current centres appears great.

To illustrate the degree of specialization upon which industrial technolo gy depends, examples of several centres are given:

- One centre specializes in providing computing and communications technology support to the communications and electronic equipment sector and the office equipment and computer sector, in the field of digital video signal processing for television broadcasting applications.

- Another centre specializes in providing microelectronics and transportation related technological support to the aircraft sector and the machinery and equipment sector, in the field of systems and methods for diagnostic testing of plasmas in gas turbine engines used in aircraft and industrial pumping applications.

- Another centre provides specialized software technology support to the paper and allied products industry in the field of image processing for automated measuring of such quantities as fibre lengths in paper slurries.

For purposes of this study we have represented the specialization possibilities as cells in a three-dimensional cube. A centre's technological field is one dimension of specialization and so it becomes one axis of the cube. The type of service provided is another dimension, and it becomes the cube's second axis. Similarly, the industrial sector of the centre's target clients is the third dimension and it becomes the cube's final axis. Therefore by providing a given type of service to a given client sector in a given technology field, a tech centre conceptually occupies one cell in the cube.

At the level of detail initially identified for the study, there were eleven broad technology fields, thirty industry sectors and sub-sectors, and six types of service, for a total of 1980 cells of which just over half, 1026, represented logical combinations (i.e., excluding such unworkable combinations as the providing of biotechnology services to the aircraft industry).

Breaking down the cube into more specific technology fields and industry sub-sectors would increase the number of cells to some 14,000. Adding a regional factor would increase it further, and adding a company size factor would increase it further still.

Given that the overall investment in technology centres is low vis-à-vis total research spending, both within the Federal government and in the nation as a whole, and that Canada significantly under-invests in research and technology compared to its major (OECD) competitors, it would be more logical to hypothesize that, rather than choosing to duplicate each other, directors and management of centres would spread their scarce resources in such a way as to cover unique areas in the multidimensional matrix (cube) of direct technological services to industry. If this hypothesis were true, one would expect to find gaps in coverage of technological industry service areas, and/or a fragmentation of tech centre activities. This is indeed the case, as will be discussed subsequently.

3.1.4.2 Data Analysis

The study examined those cells in the matrix (cube) where technology centres currently provide direct services to industry in the amount of at least $100K of effort. This threshold was chosen because it corresponds to roughly one person-year of activity, when overhead is taken into account, and thus represents a barely-significant level of effort.

For initial purposes the cube was compressed into a flat checkerboard by taking only the eleven technology fields and thirty industry sectors into

FIGURE 3.1 A
NUMBER OF CENTRES PROVIDING DIRECT HANDS-ON ASSISTANCE AT OVER $100K LEVEL OF EFFORT

BROAD TECHNOLOGY FIELDS / INDUSTRY SECTORS	Agriculture	Forestry	Fishing and Trapping	Mines & Oil Wells	Food, Beverage, Tobacco	Rubber and Plastics	Leather	Textiles, Knitting, Clothing	Wood Products, Furniture	Paper & Allied Products	Printing, Publishing	Primary Metal Products	Metal Fabricating	Machinery & Equipment	Aircraft & Aircraft Parts
- Biotechnology	1				2					1					
- Micro-electronics									1	1			1	2	1
- Software Computing Technology Informatics				1		2								1	1
- CAD/CAM Robotics Flexible Manufacturing						1			1				9	5	1
- Instrumentation Sensing Devices				1		1							1	1	1
- Lasers Photonics Fibre Optics						1							1		1
- Metallurgy Metalworking Welding				2						1	1	2	6	5	1
- Industrial Materials						2							5	5	1
- Chemical processes	1	1		1	2	2				2					
- Transportation Communication				4										1	2
- Artificial Intelligence														1	

BROAD TECHNOLOGY FIELDS / INDUSTRY SECTORS	Other Transportation Equip	Communications, Electronics	Office Equip., Computers	Other Electrical Products	Non-Metallic Mineral Products	Pharmaceuticals, Medicines	Other Chemical Products	Petroleum, Coal Products	Scientific, Professional Equip.	Other Manufacturing	Construction	Transportation Services	Communications Services	Utilities	Other Services
- Biotechnology						2			2						
- Micro-electronics	1	4	1						1					2	
- Software Computing Technology Informatics		2	2							1	2		1	1	1
- CAD/CAM Robotics Flexible Manufacturing	3	3	1	1						1				2	
- Instrumentation Sensing Devices		1				1	1		1			1		1	
- Lasers Photonics Fibre Optics															
- Metallurgy Metalworking Welding														2	
- Industrial Materials	1	1			1						1			1	
- Chemical processes					1	1	3	4							
- Transportation Communication	2	2	1				1					2	1		1
- Artificial Intelligence												1			

Note: Rows and columns cannot be totalled meaningfully, as centres often provide services in more than one technology area, or to more than industry sector, and so are repeated in the table account (leaving aside the third dimension, type of service). This gave 330 possible combinations (squares) of which 171 were technically logical. Of the 171 combinations, only 92 were found to be served above the threshold level by even one tech centre. Involvement by more than one tech centre was found in only 35 of the 92 cases. The matrix is illustrated on the opposite page. (Fig. 3.1 A)

Each of these 35 cases represented a potential for overlap/duplication, and so each was examined to see whether other factors were involved such as specialization not evident at the matrix's broad level, or other bases of differentiation including type of service, geographical region, or size of client firm.

Attached as Appendix B is a description of the examination of all 35 cases. In only one of the cases was the ostensible overlap not eliminated by these other factors. In this case, one centre reported having lost business to another which opened less than 100 km away and provided a similar service (training) in the same technology field (CAD/CAM) to the same industry sector (metal fabricating). However, the underutilization reported by the former centre was due in part to its recent move to considerably larger facilities, designed to accommodate future growth, in a new location farther away from main transportation links. The current underutilization may prove temporary. This is the only case of direct overlap between centres found in the study. It should be noted that the newer centre was established entirely as a provincial initiative and without federal sponsorship.

Further evidence of the overall lack of overlap and duplication can be found in the centres' level of utilization on a broader basis. If centres were duplicating each other's activities one would expect to find under-utilization of their human or physical resources, because to the extent any two centres compete for finite amounts of the same work then at least one of them would be expected to show idle capacity.

However virtually no evidence of underutilization was reported by centres that could be attributed to competition from other centres. Of the over 100 centres surveyed in detail in the study, only nine reported cases of underutilization:

- three of these cases of underutilization were caused entirely by business declines in the industry which the centres were serving, or by cutbacks in the level of federal support for the technology they were addressing (e.g. renewable energies), and not by the presence of other centres.

- one of the underutilization cases was attributed by the respondent to a lack of motivation at his centre, owing to excess job security of the staff. Other centres were not stated to be a cause of underutilization.

- three centres with underutilization attributed it to a lack of client demand for their services, but all three are located in Atlantic Canada where the size of the industrial base may be the governing factor, and moreover the respondents specifically did not attribute their underutilization to the presence of other centres. In fact, two of them observed that the presence of other centres had <u>increased</u> their levels of business.

- one case involved a centre which recently had lost its traditional core funding from its sponsoring organization and as a result there was indication of a decline in the skills and expertise of its staff. Technology was beginning to overtake the centre and so were its clients: some of the clients had, in fact, developed more expertise than the centre and were now direct competitors for the available business. <u>Industry</u>, not other technology centres, was taking away the centre's business, and, lacking core funding, the centre was hampered from moving into new areas that industry could not adequately serve by itself.

- In only one case, the ninth, did underutilization appear significantly related to the presence of another centre. This is the case described in a previous paragraph.

In summary, the objective evidence pointed to a virtual absence of overlap or duplication at a level of significance in any given specialization.

3.1.4.3

About 60% of those tech centre representatives interviewed were able to identify centres providing services that were in some respect similar to those their technology centre provided. However, only 7% of those interviewed stated that they experienced decreases in business as a result of the existence of centres offering comparable services. Further investigation of this small group showed that the cause of these negative responses could be largely attributed to factors such as former corporate clients becoming competitors, a loss of provincial funding so that the center couldn't keep abreast of new technology, and a restrictive DSS contract bidding policy which excluded the center from obtaining certain federal contract revenues.

3.1.5 Conclusion

There is no serious problem with regard to overlap and/or duplication in Canadian technology centres' activities.

3.2 PROLIFERATION

3.2.1 Issue

Cabinet has expressed concern that, based on the assumption that there were over 300 technology centres, the proliferation of technology centres has led to a fragmentation of services. The issue for this section is whether or not there is a proliferation of technology centres.

3.2.2 Background

Several reports and papers have raised the question whether or not there has been an undue proliferation of technology centers. Considering the limited resources available both in funds and manpower, it would not be acceptable to waste resources by permitting unnecessary duplication and proliferation.

There is by no means unanimity on the question on wasting resources in Canada by having too many technology centres. It has been shown time and again that Canada's R&D expenditures, particularly by the private sector, are well below the level considered desirable from the point of view of creating jobs and expanding international trade in the manufacturing sector. Also, the slow adoption by Canadian industry of technologies has been lamented on several occasions. This puts Canada in a very weak competitive position with respect to the U.S.A. and Japan, our main trading partners. The desirability of keeping Canadian industry, and particularly the smaller industries, with their job creating potential, in a good competitive position, might require extra-ordinary measures in exposing these industries to new and improved technologies, according to some points of view.

In light of this it is necessary to establish exactly what the problem of proliferation is understood to mean. Were too many centres created relative to the amount of work to be done? Were centres created for non-important fields? Or were centres created too small to make a significant impact on the work that was to be done?

The question of whether or not too many centres exist can only be answered by analysing the method of operation of the centres thoroughly. For each category, HDSI or LDSI, the operation should be considered in terms of the technology fields the centres operate in, the size of their efforts in these fields, the industry sectors, size and type of industries they serve, the types of service they provide, and the extent to which they need to operate on a local, regional, or national scale. It should be remembered that these centers were largely set up to develop industries' awareness of new technologies, and to assist industries in adapting new technologies, processes and products that were not available to them through commercial channels. Many of the centres were specifically mandated to serve small and medium sized industries, which generally have difficulties in adopting and adapting new technologies into their specialized, small-cash-flow operations, through commercial channels. The information presently available in the data base allows only a limited examination based mostly on technology fields and size and operation. The discussions on profiles, overlap and duplication have some more information on industry sector and type of service for part of the centers.

As a point of explanation the term "effort" is defined in this section in the same fashion as it was used in Section 3.1. It is the amount of resources, expressed in dollars, a centre devotes to a certain technology field in direct service to industry.

3.2.3 Statement of General Findings

No proliferation was found relative to the amount of work that needs to be done. However there are substantial indications of fragmentation of efforts in several centres and technologies.

FIGURE 3.2 A
SIZE OF EFFORTS IN HDS1 CENTRES

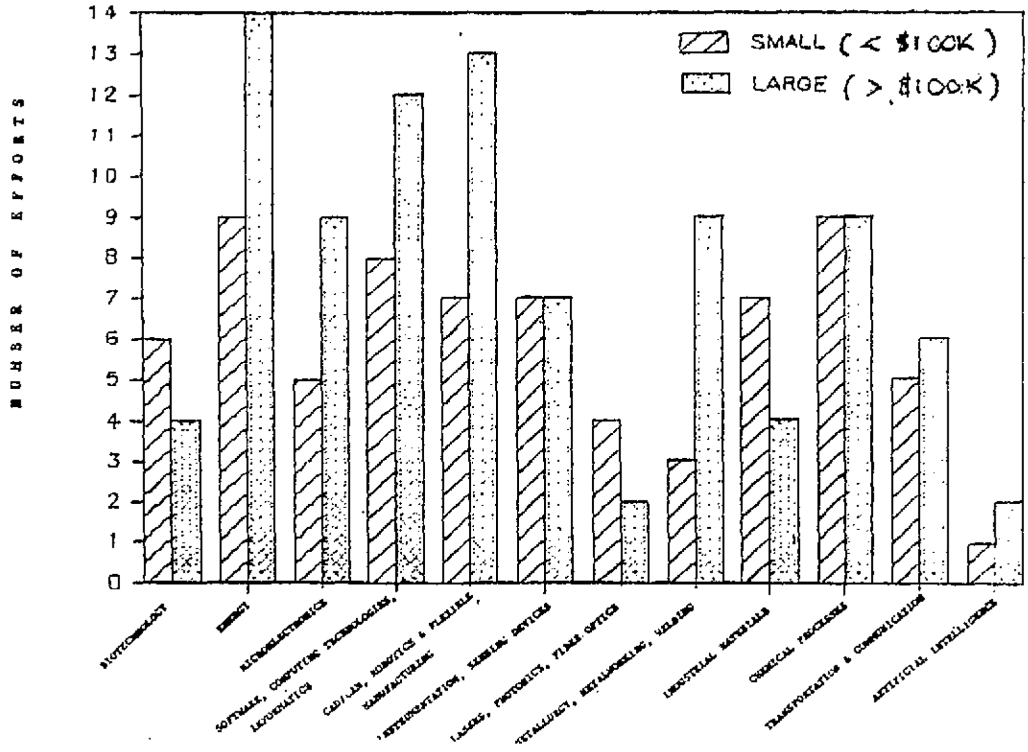


FIGURE 3.2 B
DISTRIBUTION OF SIZE OF EFFORTS IN LDS1 CENTRES
BETWEEN TECHNOLOGY FIELDS (FEDERAL LABS & ORGANIZATIONS ARE EXCLUDED)

Technological Field	SMALL (less than $100K)	LARGE (more than $100K)	TOTAL
Biotechnology	14	4	18
Energy	20	11	31
Microelectronics	9	3	12
Software, computing technologies, informatics	16	4	20
CAD/CAM, robotics & flexible manufacturing	5	4	9
Instrumentation, sensing devices	17	1	18
Lasers, photonics, fibre optics	5	1	6
Metallurgy, metalworking, welding	11	1	12
Industrial materials	14	3	17
Chemical processes	12	8	20
Transportation & communication	10	6	16
Artificial intelligence	2	2	4
TOTAL number of efforts	135	48	183

3.2.4 Interpretation and Analysis

The number of HDSI and LDSI technology centers operating in different technology fields, segregated as to the size of their effort, attributable to these fields, are presented in Figure 3.2 A. and Figure 3.2 B.

It should be noted that the differences in the number of centres active in the various technology fields reflect the peculiar nature of the fields and of the industries occupying these fields:

1. Energy is of concern to all industries and governments. Many centres have developed some expertise in this field mostly as a result of government funds made available in the last decade. Many of the efforts are small. Efforts will presumably decrease in number with the present energy "glut" and reduction in funding for some energy topics. Some very large efforts are in support of energy producing or energy delivering sectors of the industry. Services in the field of energy are generally required locally rather than nationally or regionally.

2. Biotechnology is an emerging technological field in which several small industries are trying to establish themselves. World wide, technology development is proceeding ahead of the industrial base's development. This stage of the development suggests that the number of small efforts in biotechnology may be rather large. Also the nature of the field and the industry sector suggests that technology centres probably should mostly be national or regional in scope, rather than local.

FIGURE 3.2. C
LARGE EFFORTS IN TECHNOLOGY CENTRES

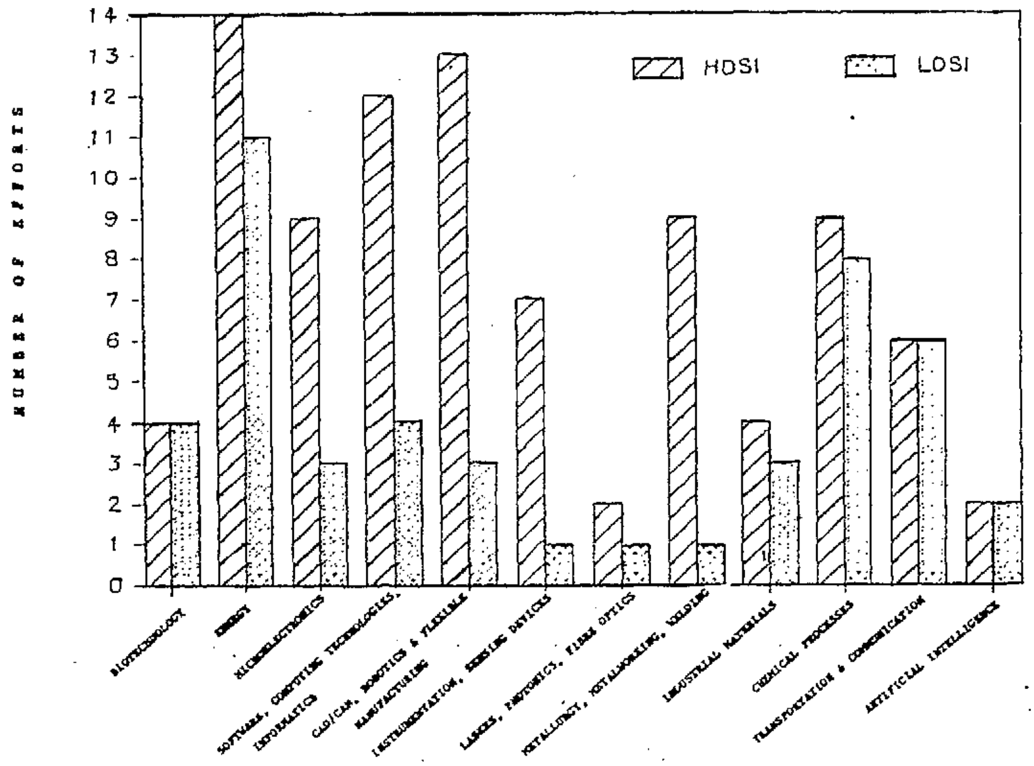


FIGURE 3.2 D
NUMBER OF CENTRES PROVIDING LARGE (OVER $100K) EFFORTS IN TECHNOLOGY FIELDS (FEDERALLY FUNDED AND MANDATED LABORATORIES AND ORGANIZATIONS ARE EXCLUDED)

Technological Field	HDSI CENTRES	LDSI CENTRES	TOTAL
Biotechnology	4	4	8
Energy	14	11	25
Microelectronics	9	3	12
Software, computing technologies, informatics	12	4	16
CAD/CAM, robotics & flexible manufacturing	13	3	16
Instrumentation, sensing devices	7	1	8
Lasers, photonics, fibre optics	2	1	3
Metallurgy, metalworking, welding	9	1	10
Industrial materials	4	3	7
Chemical processes	9	8	17
Transportation & communication	6	6	12
Artificial intelligence	2	2	4
TOTAL number of efforts	90	48	138
Number of centres involved	33	23	56

3. Instrumentation, sensing devices, metallurgy, metal working, welding, industrial materials, chemical processes and transportation and communications are well-established technology fields with a well-established industrial base. This base is made up of small, medium and large industries. The larger industries are generally served by technology centres because these industries can pay for their services and contribute in a major way to the centres' financial stability. Smaller industries are served because of centres' mandates to help these industries and this means the area a centre can cover is limited. The proportion of small efforts (almost 50%) appear to be rather high, however.

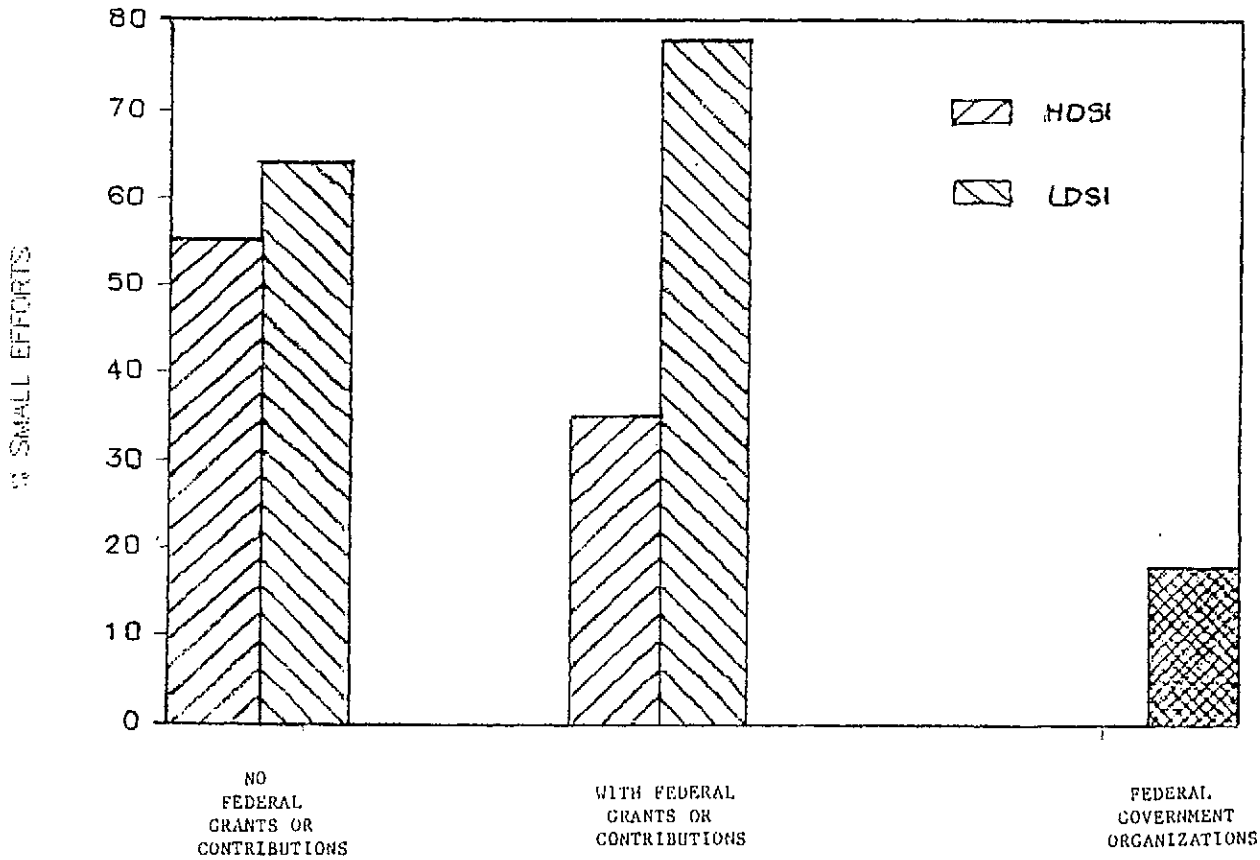
4. The hi-tech fields of microelectronics, software, computing technologies, informatics, CAD/CAM, robotics, flexible manufacturing, and articicial intelligence are served by several centres. These centres generally do not serve the large hi-tech industries in the communications, electronic equipment and computers sectors, but they serve the smaller industries that need to use the hi-tech products, but are unable to develop the expertise to select and adapt commercial systems. The size of the market for these adaptations is too small to elicit much commercial interest at present. Most of these smaller industries need to be served by a centre within a reasonable distance.

The numbers of HDSI centers substantially active in various technology fields is relatively small (mostly less than ten) (Figure 3.2 A). Many serve industry on a regional or provincial basis which would suggest that these numbers are not excessive. Also many industry sectors and types of services (demonstration, testing, availability of facilities and training) are involved. When large efforts of LDSI centres are added as well (Figure 3.2 B, 3.2 C, 3.2 D), most technologies are served by 16 centres or less.

FIGURE 3.2 E
PROPORTION OF SMALL (LESS THAN 100K) EFFORTS (% OF TOTAL NUMBER OF EFFORTS) IN FEDERAL LABORATORIES AND ORGANIZATIONS

Technological Field	Number of small (less than $100K) efforts % of total number of efforts
Biotechnology	14
Energy	22
Microelectronics	50
Software, computing technologies, informatics	22
CAD/CAM, robotics & flexible manufacturing	13
Instrumentation, sensing devices	6
Lasers, photonics, fibre optics	16
Metallurgy, metalworking, welding	16
Industrial materials	27
Chemical processes	33
Transportation & communication	0
Artificial intelligence	0
TOTAL number of efforts	219

FIGURE 3.2 F
FEDERAL FUNDING VS. SIZE OF EFFORT



Results in Figure 3.2 D also show that LDSI centres are somewhat more specialized than HDSI centres. On average, LDSI are involved in 2 technology fields, while HDSI centres cover almost 3. HDSI centres tend to get a higher proportion of their funds from industrial contracts than LDSI centres forcing them to have a broader base. Also, HDSI centres tend to be larger then LDSI centres, allowing them to cover more fields.

When all technology centres are considered (Figure 3.2 C), it would appear that many more small centres are involved in a number of technologies than are large centres. The latter appear to be more specialized, again suggesting fragmented activity in small technology centres.

Centres more closely tied to industry (Category HDSI) generally have larger efforts in technology fields than those more involved in technology development (Category LDSI) (Figure 3.2 C compare with Figure 3.2 A). This is surprising, since the critical mass for developing technology (Research and Development, an activity more likely to be found in LDSI centres) should be larger than for more direct service to industry. Generally, efforts in federally operated laboratories are larger (a high proportion of the efforts is over $100 K in size) (Figure 3.2 E)

The relation between support in the form of federal grants and contributions, and size of effort in various technology areas is shown in Figure 3.2. F and 3.2. G. Federally supported HDSI centres have a lower proportion of small efforts in technology fields than unsupported centres. The reverse is true for LDSI centres, suggesting an association between federal grants and contributions, size of effort and lesser emphasis on direct service to industry. In LDSI centres, government funding is associated with a high proportion of smaller centres in biotechnology, microelectronics, metallurgy and industrial materials. It should also be noted, that many centres with small efforts in technology fields and that are now (1984) not receiving or not acknowledging receipt of a federal grant or contribution, were started with federal funds.

FIGURE 3.2 G

PROPROTION OF SMALL (LESS THAN $100K) EFFORTS (% OF TOTAL NUMBER OF EFFORTS) IN HDSL AND LDSI CENTRES IN RELATION TO FEDERAL FUNDING. (FEDERAL LABORATORIES AND ORGANIZATIONS WERE EXCLUDED

Technological Field	Without federal grants and contributions		With federal grants and contributions	
	HDSI	LDSI	HDSI	LDSI
Biotechnology	40	50	80	92
Energy	50	73	27	60
Microelectronics	60	33	22	89
Software, computing technologies, informatics	50	100	33	75
CAD/CAM, robotics & flexible manufacturing	25	50	41	75
Instrumentation, sensing devices	50	100	50	93
Lasers, photonics, fibre optics	33	100	100	67
Metallurgy, metalworking, welding	75	67	0	100
Industrial materials	83	67	40	91
Chemical processes	86	33	27	71
Transportation & communication	60	67	33	62
Artificial intelligence	33	50	-	50
AVERAGE	54	65	35	78

Number of efforts in technology fields (small, less than $100K; large, more than $100K; federal laboratories and organizations exluded; based on results with 128 centres)

	HDSI		LDSI		TOTAL
	Small	Large	Small	Large	
Without federal grants or contributions	39	33	30	19	127
With federal grants or contributions	32	58	99	28	217
TOTAL	71	91	135	47	344

The in-depth survey of centers indirectly addressed the question whether or not centers were created in technology fields where there was no need for a center (obviously, organizations would not declare themselves redundant.) Most respondents felt that there were technology areas that needed to be better looked after, although not necessarily by another or new technology centers. None of the respondents identified a technology field or industry sector in which technology centers were not or could not be effective in serving small and medium sized industries (see also appropriate section in profile).

The question about the effective size of effort in a technology field in direct service to industry in technology centers, is a rather complex one. Results shown in Figures 3.2 A, 3.2 B, 3.2 C, 3.2 E and 3.2 F under A suggests fragmentation of efforts: over 50% of all efforts in technology fields are less than $100 K. In many instances, however, these efforts are a necessary part of another technology (for example, an instrument or sensor may be developed as part of solving a fermentation problem). The fact that HDSI centers tend to have a lower proportion of efforts less than $100 K than LDSI centres suggests that these small efforts are not as effective as is desirable, and that federal agencies giving grants and contributions should develop a more rational plan to avoid causing fragmentation.

It should be also noted that a high proportion of small efforts in LDSI centers may not reflect as much fragmentation as might appear at first sight. The calculation of efforts is based on a DSI index, which is the percentage of work done directly for, or in very close interaction with industry. In organizations, with a large effort in, for example, research related to image analysis, the direct service to industry (DSI) index may be small, (5%) and the effort directly useful or applicable in CAD/CAM technology may be $95K. The total effort of eventual rather than immediate use to industry, however, would be $1.7M.. For this reason, it is important that the fragmentation issue be studied in detail before solid conclusions can be drawn.

3.2.5 Conclusions

In most technology fields less than ten HDSI centres have a reasonably strong effort in support of mostly small industries. Considering the over 20,000 small and medium manufacturing industries in Canada and the large geographic differences, this does not seem to be a large number.

Centres that are mostly industry directed and generally maintain in-house expertise (HDSI) are almost all fully utilized or over-utilized. There is no evidence of proliferation.

No evidence was found to indicate that centres were created to fill non-existing gaps.

Evidence suggests that efforts in some centres are too small to be very effective. This may apply especially to many of the smaller centres doing technology development and adaption.

3.3 COORDINATION AND NETWORKING

3.3.1 Issue

Previous review work has suggested that there is a great deal of duplication among the technology centres. Such a suggestion implies that there is a lack of coordination of activities between technology centres, and that networks between centres and individuals are ineffectual in this regard.

3.3.2 Background

Given the number of highly specialized technology centres, their wide distribution of services to different clients and the variety of interests represented by different funding organizations, this question was highlighted by the study team for rigourous study and analysis. The following questions were asked of each survey participant:

1. Do you participate in formal or informal networks with:
    - other technology centres
    - government organizations and laboratories
    - educational centres
    - industrial groups/associations

   In your opinion, how useful are these networks?

2. How is technology diffusion and transfer coordinated between your tech centres and:
    - other industrial organizations
    - other tech centres
    - other government organizations and laboratories
    - other educational centres

3.3.3. Statement of General Findings

With only minor exceptions, networking was perceived as a very important link between technology centres and their clients. Some typical comments on the importance of networking were:

- "Informal and formal networks are essential to maintain a challenging and competitive intellectual environment, to assist technology transfer and stay aware of industrial requirements"
- "Essential to maintaining a world class research group of interest to industry"
- "Extremely useful in remaining up to date in new developments, in focussing the areas of endeavour and in preventing overlap and duplication"
- "They are absolutely critical. This is how you find out what is going on. What is being achieved and what needs to be done."

The key coordinating roles contributed by formal and informal networks may be summarized as follows:

1. Keep technology centres aware of each others programs.
2. Assist in role definition by avoiding overlap and duplication.
3. Keep the centre aware of industry needs.
4. Keep the centre aware of technological development in Canada and abroad.
5. Direct clients to technology centres which are likely to solve their problems.

It is noteworthy that responses of all technology centres followed the same positive response pattern. However a number of respondents expressed a need for improvements. Several felt that networks were not as productive as they could be given the time and effort expended, while others perceived the absence of a leadership element which could provide direction and coordination.

3.3.4 Interpretation and Analysis:

The most important network relationships (measured by frequency of occurrence and positive statements) were identified with industry. Many respondents have formal relationships with industrial groups, industry associations, professional societies or productivity committees. The importance of informal relationships with industry were stressed. Personalities and client relationships provide an important linkage for information exchange.

Nearly as many technology centres reported contact with the universities. Informal contacts exceeded formal contacts by a substantial margin although seminars and conferences were perceived positively as a basis of information exchange.

Networking between technology centres is a frequent occurrence. Several of the technology centres have organized into common groups. The 7 microelectronics centres, and CAD/CAM centres meet regularly with their peers to share and exchange information. Several of the industrial tech centres meet informally. The level of informal contact between CRIQ centres appears high. The CEOs of PROs meet regularly to exchange information and discuss mutual problems.

Networking with government organizations plays an important role. These relations tend to be more formalized. Government laboratories (such as the Institut de génie des matériaux and the Biotechnology Research Institute) organize network meetings or workshops on specific topics, to which research scientists, technologists and engineers in laboratories, technology centres and industry are invited. In some cases, the bond is established through a joint venture when the PRO is a partner. The Industrial Research Assistance Program (and now also PILP) has over the years developed an elaborate program to build "pipelines" between research laboratories, technology centres, universities, consulting firms and industries. This program, which includes IRAP personnel as well as personnel of technology centres and consulting firms by IRAP, has complemented and reinforced the informal and formal networks mentioned above. Examples were also provided where consultation with NRC or other government labs was important.

The mechanisms and processes for technology diffusion and transfer provide another perspective on the nature of coordination between centres.

Approximately one half of the respondent technology centres reported communications with industry. Several reported a combination of the following approaches to establishing the liaison. In descending order of importance the following processes were mentioned:

1. Direct contact with the client.

2. Communicating to industry through the centres Board of Directors or membership in an association

3. Building liaison through training sessions or seminars.

4. Publications, trade journals or publicity.

5. Establishing joint venture activities.

Approximately one-half of the respondent technology centres reported discussion and transfer through contact with other technology centres. In descending order of importance the following processes were described:

1. Most of the respondents reported that only limited to very limited contact occurred with other technology centres.

2. An equal number reported that networking provided an opportunity to exchange data, information and discoveries.

3. A minority of respondents found that conferences and seminars facilitated the exchange process.

4. A very small group reported joint projects as an exchange vehicle.

Contacts between technology centres and other government organizations and labs were less frequent than with industry and other technology centres. The forms the contacts took were:

1. Performing joint work through contracts where joint funding was the point of highest frequency.

2. Joint discussions, visits to labs, and briefing sessions followed.

Approximately one-half of the respondent technology centres reported diffusion and transfer through contact with other educational centres. It may be noted that a quarter of those replying identified concerns that technology transfer and diffusion would be better coordinated through greater efforts to communicate on a more formalized basis and with more frequency. In descending order of importance, the most frequently applied mechanisms were:

1. Networking with professors either personally or through meetings and regular communication channels.

2. Formal exchanges achieved through advisory committees, transfer agreements, exchanges of people and joint participation on various projects.

3. Seminars also provided an effective vehicle for transfer and diffusion.

3.3.5 Conclusion

In conclusion, the overall level of coordination between technology centres, as widened by the exchange of information through networking, is high. Centres with common interests tend to be linked formally while centres with more diverse client markets are joined informally. It is also noteworthy that the diffusion and transfer of technology between various organizational units is not only less frequent than networking but it is also targeted most directly at industry and least frequently at government, with other technology centres and universities falling between these two extremes. It is apparent that fragmentation accentuates the need for coordination. There is also substantial opportunity for improvement in coordination especially as it pertains to the diffusion and transfer of technological developments.

3.4 SKILLED HUMAN RESOURCES

3.4.1 Issue

A presumed key problem associated with the large number of tech centres is a fragmentation of available expertise and the diversion of expertise from private industry.

3.4.2 Background

In the Senate's Federal Government Support for Technological Advancement: An Overview, the Canadian Manufacturers Association is quoted as stating that "Hundreds of skilled researchers have been taken out of productive employment to work in these [government sponsored technology centers] centers.". Upon further investigation it appears that this statement was made based on the conjectured outcome of a perceived proliferation of centres.

As far as the present investigation has been able to ascertain, no systematic documentation of this occurence has ever taken place.

This study's collection of data was directed, inter alia, at gaining a qualitative understanding of the human resource problem as it applies to centres, specifically determining the extent to which the problem exists and its root causes. The means for arriving at this understanding involved establishing two points: (1) do the centres have difficulties in hiring expertise requisite to their missions and (2) once hired, are there problems in retaining the employees for a reasonable period of time?

FIGURE 3.4 A
QUESTIONS FORM INTERVIEWER GUIDE

TABLE 3.4 A

Q4.1 Do you have problems hiring retraining or contracting a sufficient number of persons to meet your current manpower needs.

	COUNTS	RESPONSES
	39	No
	37	Yes
	15	- Occasionally
	2	- A major problem
TOTAL	93	

Positive responses total 54= $\frac{54}{93}$ = 58 %

A major problem 2= $\frac{2}{93}$ = 2.15 %

2 respondents did not answer

Q. 4.2 Are these problems caused by:

	COUNTS	REASONS
	24	Shortage/Scarcity of skilled people
		Attraction to centre/motivation/reputation
	4	Quality/qualifications
	5	Workload fluctuation
	4	Shortage of funding
	5	Retention/movement to industry
	10	Other (location, low salary, new tech area, competition)
TOTAL	53	

$\frac{24}{53}$ = 45 %

These two questions touch on the broader issues of the size of Canada's pool of scientific and technological pool of expertise and its mobility in terms of cross-sectoral competition for skilled help.

3.4.3 Statement of General Findings

The survey data indicate that there is a human resource problem in staffing the majority (58%) of the centres although less than 2% said it was a major problem (refer to Figure 3.4.A). Reading beyond the hard numbers and into the words of the respondents, however, a number of sub-issues emerge that point to the complexity of the issue. These sub-issues were not pursued at length in the survey and will be commented on only generally in this report.

3.4.4 Interpretation and Analysis

Overwhelmingly, those who reported problems in hiring, retaining or contracting a sufficient number of persons stated that a shortage or scarcity of skilled people was at the root of their difficulties (refer to Figure 3.4.A). On a superficial level, this seems to point, by implication, to a general shortage of available talent. Closer examination, however, reveals that there are a number of factors which inhibit the successful recruitment of personnel notwithstanding the presence of an apparently adequate pool of skilled help. Furthermore there are also indications that, even though centres are involved in similar technological areas, they have different requirements in terms of the qualifications of their potential recruits. These qualifications can vary from strong "hands-on" engineering experience to what might be called a more esoteric intellectual capacity to pursue frontier research.

To facilitate the analysis of technology centres, this study has divided technology centres into two major categories. This division reflects the concern that technology centres should move towards self-sufficiency by relying as much as possible on industry financing. The basis of the division is the degree of direct service to industry (DSI) that the technology centre provides to industry. As a result, a high direct service to industry (HDSI) technology centre is defined as directing at least 50% of its activities toward direct, hands-on service to servicing industry; the low direct service to industry (LDSI) technology centre less than 50%. Consequently the technological skills required of a HDSI technology centre employee most appropriately address a narrow niche on the R&D spectrum: short-term responses to pressing, near-term industrial problems.

The data suggest that HDSI centres do generally experience problems in hiring and retaining employees, not necessarily owing to a lack of available personnel, but rather due to a lack of appropriately experienced personnel. The centre's role in serving industry restricts, by definition, the requisite breadth of its employees' abilities and expertise by limiting their activities to technological development or short-term research of a very applied nature. Absent, for the most part, are the long-term scientific challenges found in non-service, research-oriented centres where research rather than technical talent predominates. HDIS centres typically look to technical expertise and "hands-on" experience to meet obligations assumed through contracts. Staff are thus recruited for their problem-solving, technical skills rather than for the research abilities generally preferred by LDSI centres. This results in an organization structure dominated by short-term, goals-oriented, technically skilled personnel attuned to the needs, wants and desires of their contractual clients.

In fact, the matter of experience or quality rather than formal academic qualifications pervades the answers of those respondents who addressed the question relating to scarcity of talent. Several respondents noted that although university and college graduates are available in abundance, they are unsuited to the centres' task. In a number of instances, this problem of quality or a lack of experienced personnel has led to the establishment of training programs within the centres. While some centres viewed this action as a function within their mandates, others complained of the necessity of performing this function.

The latter group of centres bemoaned the self-defeating exercise of taking experienced staff away from critical revenue generation (i.e. accepting and meeting contractual commitments) in order that they might train new employees. At times this seems to be an almost permanent reassignment because once trained, new staff become potential recruitment targets for the centre's clients with whom they interact.

Respondents repeatedly complained of the negative impact that fiscal instability had upon the success of recruiting exercises and, again, the quality of candidates. The boom-or-bust cycle typical of contract-driven organizations mitigates against the hiring of high-level expertise normally resident in individuals occupying positions of seniority (experience) in other organizations. "Contract drought" has a severe impact on security of employment and is a primary cause of turnover both in terms of its direct impact in times of financial constraint and the psychological insecurity it creates in employees paid from contract income.

One respondent from a HDSI centre, when noting the centre's annual turnover rate of 25%, described the centre as an excellent training ground and a career stepping-stone to a more rewarding and stable career in industry. The extent to which personnel move from industry to the technology centres is not indicated by the data.

The general impression captured from the interviews was that centres do not put a strain on available human resources but may in fact alleviate a pressure point by training the manpower for which the centres' industrial clients have need; this, of course, to the detriment of the contract-driven centres themselves.
LDSI centres experience some problems similar to those of HDIS centres but also a number of different problems in hiring and retaining staff. In a number of technology fields, (e.g. microelectronics) there does appear to be a shortage of highly-qualified manpower both at a technical and scientific level. Generally speaking, however, the problem in government or university-based LDSI centres lies in the paucity of external, non-contractual funding, coupled with some shortages of intellectually motivated and research-oriented personnel. The emphasis in this instance, therefore, is not the lack of contract income, but the level of income or operational budgets originating from sources such as those of the Natural Sciences and Engineering Research Council (NSERC), the Provinces or core funding from the Federal Government. Low salary levels relative to those in industry are another consideration but this too is at least in part a reflection of funding problems.

Centres not primarily involved in direct service to industry (LDSI) tend to be a pool of expertise available to industry because of their efforts in R&D. Only one respondent stated that universities constituted a form of competition for human resources, few cited government laboratories.

Generally speaking, the survey data suggest that there is a problem with respect to shortages of skilled help but do not suggest that this is precipitated by an undue proliferation of technology centres of whatever definition. There may be several exceptions in highly-specialized areas, e.g. microelectronics and biotechnology. The data does not indicate that the centres compete with industry in a direct way but owing in many instances to an unstable and insecure funding environment, may represent a net source of talent, rather than a sink, certainly in the case of LDSI centres. Only six respondents in the survey population responded positively when asked if the existence of centres providing similar services resulted in more competition for skilled personnel.

This training function of technology centres bears closer examination, particularly with regard to the extent to which their missions are compromised or assisted by the necessity to <u>train</u> academically qualified but technically illiterate or inexperienced prospective employees. What is the source of raw talent? Of experienced skills? How do the needs of different types of centres differ one another? What is the extent of flow of talent between centres, industry and goverment? In what technological areas are there problems? Answers to these complex sub-issues do not emerge from the data gathered by this preliminary broad-brush approach to an examination of the issues. If deemed appropriate, more comprehensive studies may reveal the causes and effects of cross-sectoral competition for talent, if it exists. The data generated to date are inconclusive in a quantitative sense, in this regard.

3.4.5 Conclusions

The survey data present little evidence that there is a major problem with technology centres per se straining the availability of human resources available to industry and, indeed, to one another. There are staffing problems associated with more than one-half of the centres but for a number of reasons transcending the number of centres vis-à-vis a limited pool of talent available. There are indications that the flow of human resources may work to the benefit of industry as staff trained on centres' premises through in-house training programs move to the industrial sector during periods of contract income drought and for reasons of general in-centre fiscal instability.

Where difficulties occur beyond the realm of an unstable financial environment, shortages generally are found in a few highly specialized-fields, e.g. biotechnology or microelectronics, or where senior or "seasoned" professional staff are concerned. Most respondents did not experience problems with the recruitment of semi-skilled individuals, i.e. persons with the appropriate academic background but lacking very specific skills and a knowledge of the industrial milieu.

LDSI centres, particularly those on campus at universities, and in government laboratories may represent a source of talent and in the case of universities in particular, consider this aspect of their operations a legitimate interpretation of their missions.

3.5 FINANCING/SELF-SUFFICIENCY

3.5.1 Issue

Cabinet has expressed the desirability of having most of the centres achieve self-sufficiency within a reasonable time-frame. A partial exception was suggested for those centres whose primary role is general information dissemination and assistance to novice inventors or prospective small business people. In the case of these centres the criterion of total self-sufficiency need not apply.

3.5.2 Background

Before going any further it is necessary to establish the operational definition of self-sufficiency. In this regard a technology centre is deemed to be self-sufficient in terms of the Federal Government when it receives neither grants nor contracts from that government. Obviously to be completely self-sufficient, the centre would not receive funds from any government. In contrast to this negative definition a narrower but more positive definition, which is used in this paper, is that a technology centre is deemed to be self-sufficient when it receives its funds solely from industrial contributions and contracts. In addition it should be noted that the issue of self-sufficiency was not touched upon directly by any of the questionnaires; rather, the matter was approached indirectly.

In the investigated literature, although the definition of self-sufficiency may not be as rigorous as in the present paper, it can be assumed that self-sufficiency involves, as a minimum, the absence of government grants, contributions and subsidies. The literature addresses the question of self-sufficiency from the perspective that, should self-sufficiency be attained by a technology centre, what will be its impact on the work of the technology centre.

With regard to the former view the CMA is quoted in the Senate's Federal Government Support for Technological Advancement: An Overview as stating:

> The CMA believes that these centres and institutes should continue to provide services to industry, but they should all strive to become self-supporting within an agreed timeframe. Market and private sector links are essential if these centres are to contribute to and not put a drain on Canada's future economic and employment growth. Freed from the burden of excessive dependency on government, we expect that there will be improved co-ordination of activities and the centres will become more responsive to the real, not perceived, needs of industry.

Also, an analysis of NBRPC (The Operation and Future Role of the New Brunswick Research and Productivity Council, P.A. Lapp, 1983), suggested that NBRPC could exist and grow without a provincial grant. However, the analysis goes on to state that a strong scientific and technological core of capability is a sine qua non for a technology centre, such as a PRO. This capability is the "underwriter" of new industry initiatives in a technical rather than a monetary sense. Therefore:

> if the talents of the R and D core are to be directed towards the future needs of individual clients, a provincial grant is essential.

Problems with self-sufficiency are also noted in the analyses of the BC Research Council and the Ontario Research Foundation by Philip A. Lapp Ltd. This point is echoed in the Science Council of Canada's analysis of all PROs, Partners in Industrial Strategy: The Special Role of the Research Organizations:

> If it [PRO] is to address the needs of small and medium-sized enterprises through the provision of free or low-profit services, and also undertake longer-term research and development directed towards the economic

development of the province (exploratory R&D), reliance on contract income to too great an extent makes it difficult for the PROs to maintain themselves as viable organizations.

This argument can apply mutatis mutandi to federally-supported technology centres. This is shown in the Corporate-Higher Education Forum's recent publication Partnership for Growth: Corporate University Cooperation in Canada. It notes that in order to make new technology accessible to Canadian corporations, especially small and medium-sized firms, which do not mount their own research effort, seed money was provided by the Federal Goverment for university-based interface institutes.

> This effort accounts for the proliferation of Innovation Centres, Centres for Advanced Technology and Microelectronics Centres. The difficulty with these centres is that they are expected to provide on-going services to industry and also to become self-sustaining after a development period of five to seven years. Most of them are also expected to undertake applied and, in some cases, basic research as well. However, the current funding arrangements focus attention on the financial needs of the centre, diverting attention from ongoing fundamental research for the extension of knowledge.... we do not believe that the government funding format necessarily matches the ongoing needs of these institutes. Seed money is appropriate for those that have the scope for attracting future corporate affiliates and that have the potential for earning royalty revenues over the longer term. But seed money is not appropriate for centres which are expected to focus mainly on the transfer of technology to small and medium-sized firms and which therefore have little hope of becoming self-sustaining.

Bela Gold (Strengthening the Technolgical Competitiveness of Industries: Potential Contributions of Government), who sees a very limited role for government in enhancing the technological competitiveness of a nation's industries, sees a need for some continuing government financial input into technology centres involving universities and industries in "co-operative research on sub-commercial technologies".

Finally, with regard to the literature, it was suggested that by demanding self-sufficiency from government funding, problems of duplication can arise. In the Philip A. Lapp Ltd. 1979 study of the BC Research Council, it is stated that if the core research program were adequately funded by the province:

> "... then the technology transfer to industry can be pursued sensibly and directly and should remove most of the causes of conflict between BC Research, industry and business. The aim should be a complementary, cooperative relationship with consulting firms, few of which have research backing."

Thus virtually all the literature reviewed finds self-sufficiency more of a problem than an answer.

The data upon which this paper's analysis will be based were taken primarily from the in-depth interviews of representatives of approximately 100 technology centres. Although the question of self-sufficiency was not addressed explicitly during the course of the data collection, various aspects of the data reflect the technology centres' perception of self-sufficiency and its impact on their organizations. In addition, the data also give an indication of what the consequences of self-sufficiency might be.

In any case, if the possible termination of federal support of technology centres would be considered, it should be kept in mind that in terms of overall Federal R&D spending or even federal expenditures on federal laboratories, the amount expended on technology centres as defined in this report is relatively small.

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3.5.3 Statement of General Findings

In the sample there was apparently no one who was in favour of self-sufficiency. Furthermore some of those centres that came out against self-sufficiency (i.e. decreasing federal and/or provincial grants, contributions and subsidies) were those who were the closest to achieving it. However many respondents felt that technology centres had to be more responsive to the needs of industry and that this could be accomplished by increasing the organizations' dependency on contract funding. Some even said that their organizations would be useless in delivering services to industry if they were fully funded by government.

The lack of enthousiasm for the idea of self-sufficiency is indicated throughout the data. For example, of those sampled organizations that saw opportunities to improve their service and had an idea of how these opportunities could be realized, 34% felt that their funders should supply them with more financial resources, whereas only 8% felt these additional financial resources should come from the technology centre's clients. The others either looked at non-financial means to improve their services or didn't really address the question. (Of the respondents approached about the question of opportunities, 80% had an opinion).

The requirement for additional funding was voiced as a means to correct problems of over- or under-utilization, to correct gaps in the coverage of certain technologies, services or client communities by current technology centres and to correct manpower shortages. These will each be addressed separately in the detailed findings in the following section.

3.5.4 Interpretation and Analysis

3.5.4.1 Issue Analysis

As was noted earlier self-sufficiency was not expected to apply to technology centres whose primary role is general information dissemination and assistance to novice inventors or prospective small business people. This qualification applies primarily to management advisory institutes and other organizations dealing with management consulting vis-à-vis technology. Consequently these organizations were not reviewed in the present study. This study focused upon those technology centres which, might be candidates for self-sufficiency.

In addition, an analysis of the self-sufficiency concept as applied to technology centres suggests that its imposition would be incongruous with the rationale for the establishment of the centres. In this regard, if a Federal government initiative is necessary to stimulate technology diffusion due to a perceived failure of the private market to invest adequately in these activities, then require the agents of diffusion (technology centres) to become totally dependent on private sources of income would cause them to concentrate on those services for which the private sector is already willing to pay (refer to section 3.5.4.2) This would have the effect of reducing the services which are at once the raison d'être of these organizations and the policy objective of the federal government vis-à-vis encouraging technology diffusion.

3.5.4.2 Data Analysis

Initially, if the technology centres were to be encouraged to become self-sufficient, what would be the impact of withdrawing federal funding?

If both federal contract and grant dollars were withdrawn equally the

FIGURE 3.5 A
FEDERAL FUNDING TO TOTAL DOLLARS
BY REGION (EXCLUDING FEDS)

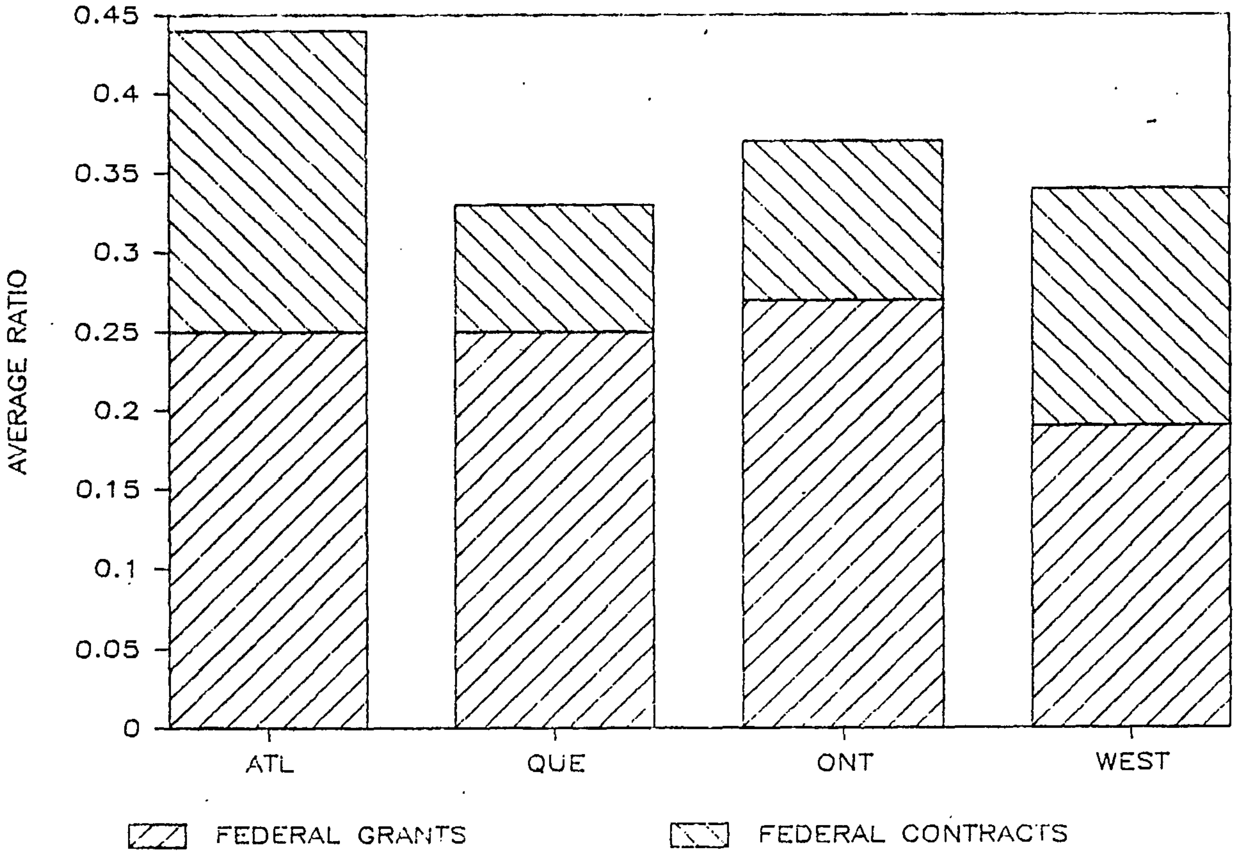
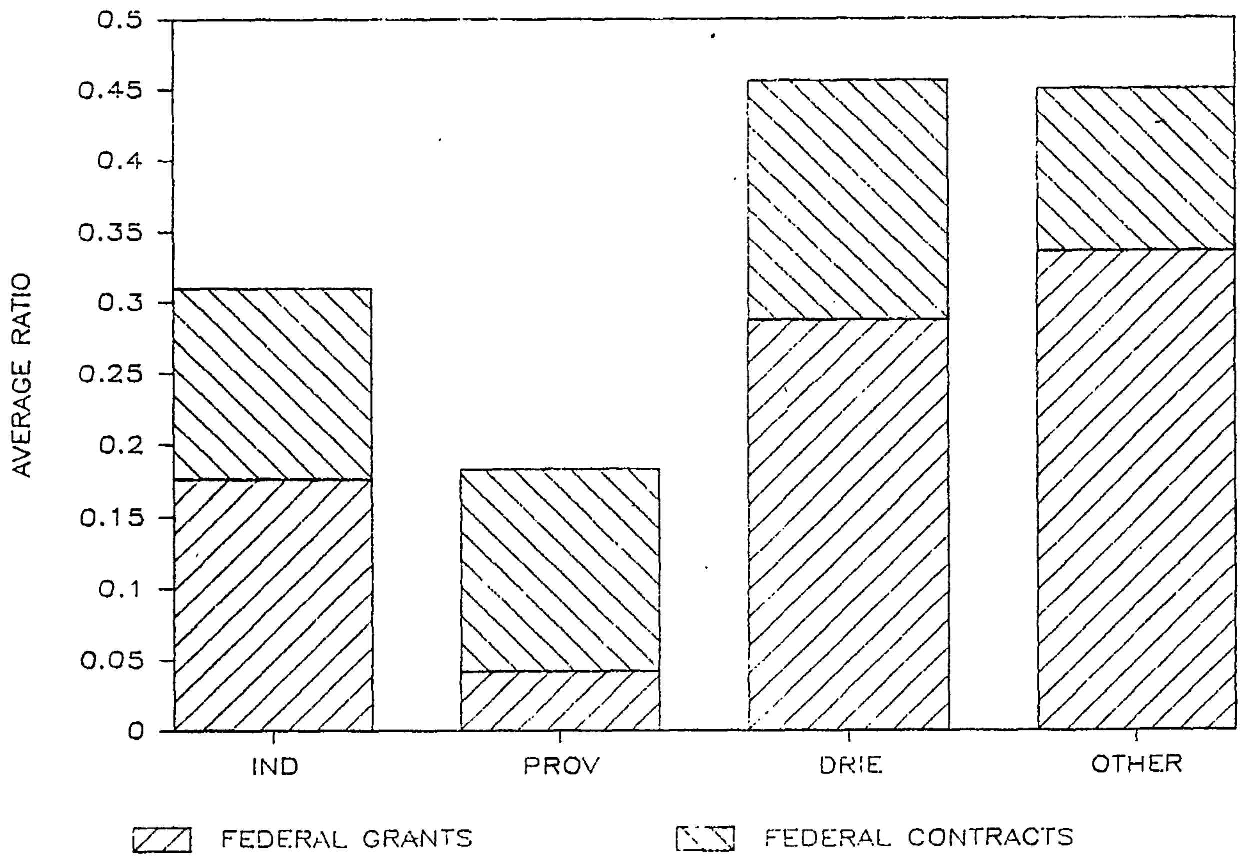


FIGURE 3.5 B
FEDERAL FUNDING TO TOTAL FUNDING
BY GROUP



impact would be relatively equal across the country. However, if only grant dollars were decreased then Central Canada would be more significantly affected than the Atlantic and Western Regions; technology centres in Ontario and Quebec receive relatively more federal grants than those in the other region. (Figure 3.5 A)

With regard to the various types of technology centres, those which are the most dependent on federal dollars obviously would suffer the most due to a government funding cut back. All technology centres would be seriously affected by a decline in federal funding.

A decline in either federal grants or contracts would affect the various technology centres differently because of the variations in the mix of the federal contract and federal grant component in the financial composition of the various types of technology centres. With regard to grant dollars, the DRIE and Other types of centres receive the largest portion of federal grants relative to their total income. A decrease in grants would have a greater impact on these centres than on others.

In the case of a cutback in federal contracts, the DRIE centres could again be most affected followed by the PROs. However, the PROs receive the least amount of federal funds relative to their overall budgets. It should be noted that the federal contract portion of the PROs budget would be much higher if they were not subject to exclusionary conditions with regard to federal contracts. (Figure 3.5 B).

In all cases, federal funds are a substantial portion of all technology centres budgets. This importance of federal funding, as compared to either provincial or industry funding, is underlined by the fact that by a ratio of 1.5:1 technology centres noted federal funds sustained their centres

FIGURE 3.5 C
% OF TECH CENTRES BY LEVEL OF DEPENDENCE ON INDUSTRY $

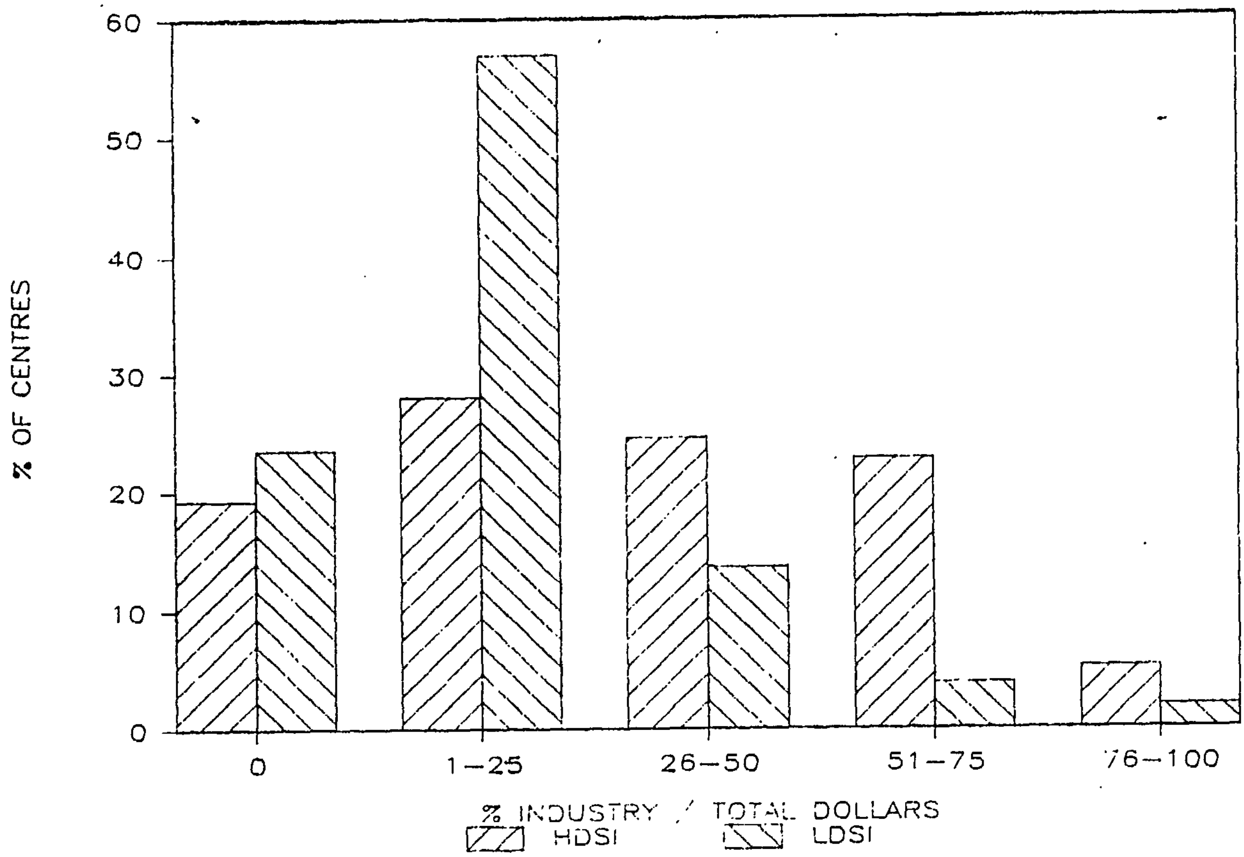


FIGURE 3.5 D
SERVICES PROVIDED AND SOURCES OF FUNDING
HDIS TECHNOLOGY CENTRES

HDIS Technology Centres

	Percent of Technology Center's Funding from Industry	Percent of Total Time Spent Providing the Noted Services					
		A R+D	B INFO	C DEMO	D TEST FAC.	E TESTING	F TRAINING
N= 20	0 - 25 %	32 %	6 %	27 %	5 %	6 %	19 %
10	25 - 50	47	9	12	6	12	14
12	50- 75	35	10	13	18	14	11
1	75 - 100	75	13	-	-	10	-

Note: KEY TO BUSINESS SIZE

Small=	1 - 49 employees
Medium=	50 - 100 employees
Large=	101 - 500 employees
Very large=	over 500 employees

as compared to provincial funds; the ratio was 3.5:1 in the comparison of federal to industry funding. Even where only HDSI centres are analyzed in order to eliminate the majority of federal laboratories, the respective ratios are 1.2:1 and 2.5:1.

Pursuing the question of industry support in more detail, it was established that at the present time, based on the total number of technology centres that identified the services they delivered to their clients, only 14% received more than 50% of their income from industry, either through contracts or grants. In fact 70% of the technology centres received 25% or less of their funds from industry (Figure 3.5 C) Even for the group of HDSI centres, 47% receive less than 25% of their funds from industry.

Industry funding does affect the types of service centres provide. For HDSI centres that receive less than 25% of the funding from industry, the demonstration and diffusion of technology is almost as important as R & D with subsequent technology transfer. Together with training, these centres spend approximately 78% of their time delivering these services. (Figure 3.5 D). As the HDSI centres become more dependent on industry funding the importance of diffusion and training decrease until in the case of centres that receive 50-75% of their income from industry, the supplying of research facilities for the use of the clients is the second most important activity after R & D (which includes technology transfer). This would suggest that a change in a centre's funding mix will lead to a change in the services delivered by the centre. As expected, LDSI centres are heavily involved in R&D, and provision of R&D facilities for use by clients.

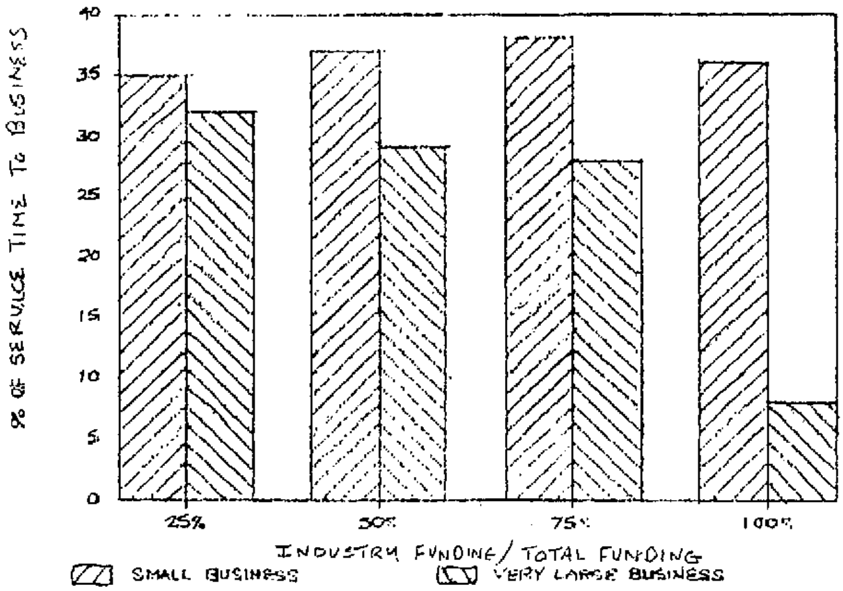
The relationship of clientele to the funding and category of technology centres does not vary that greatly. In general, where significant data is available, the primary client of technology centres is small business,

FIGURE 3.5 E
CLIENTELE AND SOURCES OF FUNDING
ALL TECHNOLOGY CENTRES

All Technology Centres

	Percent of Technology Center's Funding from Industry	Percent of Total Number of Clients by Client Size			
		SMALL	MEDIUM	LARGE	VERY LARGE
N= 48	0 - 25 %	35 %	16 %	17 %	32 %
16	25 - 50	37	18	16	29
8	50 - 75	38	22	12	28
2	75 - 100	36	24	31	8

FIGURE 3.5 F
RELATIONSHIP BETWEEN CLIENTELE AND SOURCES OF FUNDS



although it never represents a majority of the clients, followed, often closely, by very large business. (Figures 3.5 E and 3.5 F).

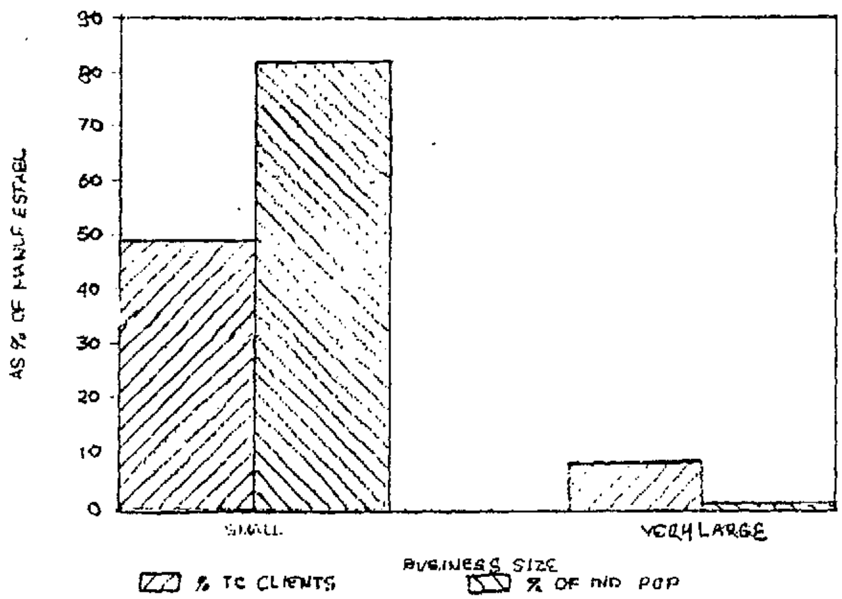
Given that the majority of businesses in Canada are small, one would expect that this would be reflected in the client mix of technology centres, i.e. the majority of clients being small business. However, while 82% of all Canadian manufacturing establishments are small businesses, only approximately 49% of the technology centres clients are small business. On the other hand, while very large businesses represent 1% of all Canadian manufacturing establishments, they represent approximately 9% of technology centre clients. (Figure 3.5 G; note a few clients are resource extractors rather than manufacturers - this does not change the picture).

Various reasons were given by the respondents for the relatively small proportion of Canada's small businesses which take advantage of the services of technology centres. These include the suggestion that small businesses are unable to afford the services of technology centres as well as a lack of knowledge on the part of small firms about the services offered by technology centres.

Returning to the question of funding, financial considerations are very much on the collective minds of the managers of technology centres in terms of the various problems facing technology centres.

Of the respondents who felt that their technology centre had a problem with either under - or over - utilization (approximately 54% of respondents), 28% felt that an aspect of the centre's financing was the cause; 15% specifically noted that there was insufficient funding from the funders including the Federal Government. Others said that they were having funding problems because small firms couldn't afford the centre's services or that the centre was excessively reliant on contracts.

FIGURE 3.5 G
TECH CENTRE CLIENT SIZE VS INDUSTRY POPULATION



Of the approximately 80% of the respondents who gave a detailed response, approximately 47% of those respondents who addressed the question of what corrective action should be taken in terms of over - or under - utilization looked to some form of new or varied financial support to address this matter; 19% looked to greater funding, including more funding from the federal government, to correct the problem. The form this additional funding might take according to some centres was core funding or capital funding. It was also suggested that grants should be made contingent upon revenues obtained rather than the reverse process whereby grants are withheld or cut as an organization succeeds. These grants would be required because success entails the acquisition of more capital equipment.

Although almost half of the respondents did not venture a definite opinion with regard to their perception of other technology centres' utilization factor, of those that did address the question:

° 20-30% saw over - or under - utilization in the university centres federal government laboratories and provincial research organizations;

° 14% saw over - or under - utilization in industry centres.

While 19% looked primarily to either insufficient funding from funders or inappropriate funding from funders as the cause of utilization problems, 22% looked to some change in the centre's funding to correct the situation. The changes they suggested included additional start-up funds or untied aid. In addition, 13% looked to some form of government assistance in this regard, although not necessarily of a financial nature.

The reason for gaps in the coverage of certain technologies, services, or client communities by current technology centres was generally considered a financial problem (almost 50% of the 73% respondents). Specifically 33% of the respondents who addressed this issue felt the existing gaps were prevented from being filled due to a lack of financial resources; 11% of the respondents felt that the misallocation of financial resources prevented the bridging of the existent gaps.

When looking at the question of why a technology centre should fill the gap, 40% of the respondents gave reasons that implied that individual firms would not be able or willing to pay for or carry out the work required to fill the gaps. For example they viewed the technology as being too risky, too costly, too basic/long-term for individual companies or the technology has broad applicability to many sectors. In addition 14% felt that industry problems, such as fragmentation, small size, short-term focus and general lethargy, necessitated the involvement of technology centres. However, it should also be noted that 44% of all the respondents did not venture a definite opinion, while 9% of all the respondents felt a technology centre should not fill the gap, leaving 47% of the respondents looking to technology centres to fill the gap.

3.5.5 Conclusions

The attainment of self-sufficiency in a reasonable period of time will be a problem since 70% of the technology centres with high direct service to industry (HDSI) receive 50% or less of their total funding from industry contracts or grants. In fact almost half of the HDSI technology centres receive 25% or less of their total funding from industry contracts or grants.

Beyond this, the question arises whether self-sufficiency should be the goal in light of the impact high dependency on industry funding apparently has on the type of service delivered. It would appear that the more proactive aspects of technology transfer and diffusion, both direct and indirect (i.e. training) decrease in importance, while the more reactive aspects (i.,e. supplying test facilities or performing testing) increase in importance.

In other words there is an indication that the greater the degree of self-sufficiency there is on the part of a technlogy centre, the greater the likelihood the technology centre will realign its services to those for which the private sector is already willing to pay and will reduce investment in the services which were the raison d'être of these institutions in the first place. A corollary of this point is that the move towards self-sufficiency can lead to a duplication of services between technology centres which are very dependent on industrial contracts and the private sector. Although these technology centres do not like to take work away from private consultants, if a company approaches the centre for routine analysis, the work will be accepted since the income is required.

Based on anecdotal information provided, the situation of some technology centres that are very dependent on industrial contracts can best be exemplified by a boom-bust cycle. When there is a large demand on the services of the centre the overhead is easily covered but the centres's resources may not be able to keep up with the demand and additional resources may have to be acquired. With the inevitable downturn in demand the centre finds itself carrying a large overhead. It may have to lay-off scientific and technical personnel to adjust to this leaner situation. Yet three months later the centre may require the services of these people again only to find that they have taken employment elsewhere. Centres felt that government funding would be useful in smoothing out these cycles. Government funding would also allow centres to acquire an in-depth capability rather than the wide breadth of knowledge but shallow capability they now possess in some cases. Smaller centres would particularly benefit from a lessening of the boom-bust cycle.

Notwithstanding the above, should self-sufficiency be pursued, more business enterprises must be encouraged to make use of the technology centres. Since small business manufacturing establishments are under-represented in the technology centres' client base relative to their place in the overall economy, it would appear appropriate to encourage these establishments to take advantage of technology centre services. Unfortunately this may pose more of a hinderance than a boost to the goal of self-sufficiency. If one accepts the suggestion that small business cannot afford to pay the full price of some services of technology centres then, if the clientele mix becomes more and more similar to that of the overall industry population, the domination of small business in the centres' client base would pose financial problems for those centres which become more dependent on industry funding. Although there are no objective data concerning this proposition, there are some anecdotal references to this problem.

Approaching the small business factor from another perspective, it has been suggested that small business cannot be encouraged to use technology centres other than by means of financial incentives since small business cannot afford to pay for these services. The closest objective data dealing with this perception is the very fact that small business establishments are under-represented in the client base; obviously, there are other possible explanations for this under-representation.

Even if increasing the participation level of small manufacturing establishments is problematic, and medium, large and very large manufacturing establishments are relatively over-represented in the client base, the absolute numbers of Canadian medium, large and very large manufacturing establishments are still high enough to make it worth while for the technology centres to pursue more of these firms.

Finally, it will be a difficult task to get the technology centres on side vis-à-vis total self-sufficiency. This is reflected in the fact that with regard to such problems as over-utilization, a number of centres felt that they did not receive enough funds from their funding organizations, including the federal government as opposed to looking to industry for support. Furthermore when the technology centres were asked how they might realize new opportunities to improve their services, a significant minority looked to additional funding from their funding organizations. Therefore, if total self-sufficiency is to be pursued then a concerted effort must be expended to bring those technology centres that are far from being self-sufficient on side, both philosophically and financially.

In light of the problems it might be appropriate to look at the reason for proposing self-sufficiency. If the reason is to make technology centres more responsive to market needs, it might be more appropriate to encourage the increase of the industry funding relative to federal government funding rather than moving towards total self-sufficiency. Alternatively it might be better to redirect the funds designated for technology centres to their clients.

REVIEW OF SELECTED PROJECTS

4.1 INTRODUCTION

4.2 TASKS

4.3 LIMITATIONS OF THE SURVEY

4.4 SYNTHESIS OF SURVEY RESULTS

4 REVIEW OF SELECTED PROJECTS (SUCCESSES AND BENEFITS)

4.1 INTRODUCTION/MANDATE

A review of selected technology centre projects was conducted in order to characterize products/projects performed by technology centres for clients in industry with an emphasis on successful outputs and benefits accrued to client firms.

4.2 TASKS

The major tasks involved in undertaking the review were:

- organization and classification of the "universe" of projects and tech centres (TCs);
- selection of a sample of TCs and projects to be used in a telephone interview survey;
- undertaking the telephone interview survey;
- producing a synthesis of the results of the survey.

4.3 LIMITATIONS OF THE SURVEY

It should be emphasized that this survey is based on a selection of projects which have been deemed "successes" by the technology centres (TCs). The survey cannot, therefore, provide conclusions on the overall effectiveness of TCs because it does not include representation from the "failures", nor does it estimate the total costs involved in delivering technology centre services.

4.4 SYNTHESIS OF SURVEY RESULTS

As a result of the information collected, a synthesis of survey results can be organized into the following broad categories:

1. Timing and length of projects
2. Method of project initiation
3. Work involved in project preparation
4. The sources of funding
5. The cost of projects
6. Use of resources (non-dollar) on the projects
7. The benefits that ensued from the projects
8. The opinions of TC clients on the success of the projects and factors contributing to that success
9. The views of clients on TCs
10. Discrepancies in information provided by TCs and clients

4.4.1 Timing and Length of Projects

The majority of projects (approximately 90%) which were surveyed had been executed by the TC during the last five years. For approximately half of the projects the duration of the involvement of the TC had been less than one year.

4.4.2 Method of Project Initiation

In almost 50% of the projects, the TC was involved in initiating the project either on its own or jointly with the client; in the other cases the client approached the TC with a request for its services. This implies that in about half of the cases, the TC acted pro-actively in developing a project and not simply as a reactive organization.

4.4.3 Work Involved in Project Preparation

The most common activities involved in project preparation were:

- o discussions between TC and client;
- o drafting of proposal by TC;
- o investigation of funding sources by the TC and/or client;
- o drafting of a contract or agreement;
- o preliminary literature review and information gathering between the TC and client.

Other types of preparatory work mentioned were preliminary market research, preliminary design work, development of testing facilities and laboratory work.

4.4.4 The Sources of Funding

The clients were involved, in some measure, in the funding of a high proportion (more than 90%) of projects; in about 40% of cases, however, funding was provided jointly by the client and a federal government and/or provincial program.

There were indications in some of the joint client/government funding projects that the project might not have been executed without the government financial support. In about 20% of the projects the TC itself was involved in providing funding.

4.4.5 The Cost of Projects

A distribution of the projects for which a dollar value of costs incurred by the TC and/or client is available is shown in the following:

$000	% of Total Projects
Less than 50	53
50 - 100	18
100 - 500	18
500 - 1,000	10
More than 1,000	1

There was therefore, a wide range of size of projects undertaken by the TCs. Although more than half of the projects were less than $50,000 approximately 30% were more than $100,000 and 11% were more than $500,000.

4.4.6 Use of Resources (Non-Dollar) on the Project

The majority of the projects (56%) were executed jointly by the client and TC with contributions of human resources from both parties; in the rest of the projects the TC acted alone in providing non-dollar resources.

4.4.7 The Benefits that Ensued from the Projects

Two-thirds of the projects surveyed had already realized benefits to the clients in terms of one or more of the following:

- o increased product sales;
- o increased productivity;
- o greater expertise within the organization.

In the balance of the projects the benefits were still unrealized; in many of these, however, there were indications of significant potential benefits in the near future usually through the introduction of a new product or improved production process.

In addition, 20% of the projects identified spin-off benefits resulting from the original project.

4.4.8 The Opinions of TC Clients

The factors which were most often mentioned by the TC clients as contributing to the success of the projects were:

- the knowledge and expertise that resides within the TC - this was the single most frequently mentioned success factor;
- the co-operation during the execution of the project between the client and the TC;
- clear objectives for the project and a well defined terms of reference;
- where a new product was involved, the "fit" of the product to market requirements;
- the commitment of the TC to the project;
- the proximity of the TC to the client;
- the availability of external funding to the client;
- the specialized facilities and equipment provided by the TC.

4.4.9 The Views of Clients on TCs

In general, clients responded very favourably to their association(s) with TCs. They felt that the TCs had made a very positive contribution to the success of the project and any of the clients did not know of alternative sources of similar expertise. The TCs ability to provide specialized facilities and expertise which was not generally available and to act as a focus for new ideas put TCs in a favourable light in the minds of many clients. There were may comments and criticisms of TCs, however, form the clients some of which are recorded below:

- they are often slow, cumbersome, and bureaucratic to deal with;
- their services were more expensive than expected;
- they should be more business/market oriented rather than just centres of research and theoretical ideas;
- there is a need for more communication and information about TCs services and capabilities;
- clients in Quebec stressed the importance of being able to obtain TC services in French;
- the TCs were often bad at project management and projects took longer than expected to complete;
- smaller firms relied on external funding to make use of TC services;
- the scientific research staff of TCs often did not fit well within an industrial setting;

- o smaller companies stressed the importance of the technical support provided by the TC as a factor in the companies' continued survival;

- o TCs should remain as advisors and providers of research capabilities and not usurp the role of industry;

- o insufficient "focussed" dissemination of information by TCs.

4.4.10 Discrepancies in Information

In general, there were no large discrepancies in the information on projects provided by the TCs and the clients. Those discrepancies which did occur were often due to a lack of readily available information or to individuals working from memory. Most of the TCs were aware of the successful nature of a project although they were often unaware of the degree of that success. Only one of the projects had, subsequent to the work performed by the TC, proved to be unsuccessful.

APPENDIX A - Study Participants

APPENDIX B - Individual Examination of Overlap/Duplication

APPENDIX C - The Special Case of Federal Labs

APPENDIX A

TECH CENTRE RESOURCE REVIEW TEAM

Study Participants

Status	Name	Organization
Team Leader	Ed Hahn	DRIE
Project Manager	Steve Montague	DRIE
Professional Staff	Bob McDonald	DRIE
	Yvan Bédard	DRIE
Professional Secondments	John Coleman	NRC
	Yuri Daschko	MOSST
	Luc Lalonde	MOSST
	Paul Latour	NSERC
	Bert van den Berg	NRC
Principal Consultant	Verne Chant	J.F. Hickling
Consultants	Jim Cousens	J.F. Hickling
	Mark Rosenberg	J.F. Hickling
Interviewer/Secondment	Roland Lussier	DRIE
	Guy Gallant	DRIE
	Louise Williamson	DRIE
	Marie-Josée Thivierge	DRIE
Technical Support	Bruce Stewart	COSEP
	Kim Barton	Systemhouse
	Luc Van Baaren	J.F. Hickling
	Thérèse Gagnon	Barbara Personnel

In addition to the above-mentioned team members, valuable contributions were also made by Tom Hopwood of DRIE, Roger Heath of MOSST, and Humphrey Stead, Bert Plaus, Mary Lynn Redmond, and Doug Rombough of Statistics Canada.

APPENDIX A (Continued)

Organizations Included in Resource Review

KEY

Group: F = Federally Managed
P = Provincially Managed
I = Industry Managed
U = University or Other

ORGANIZATIONS INCLUDED IN TECH CENTRE STUDY
(High Direct Service to Industry)

TECHNOLOGY CENTRE LISTING

		GROUP
Industrial Technology Centre	Manitoba Research Co	P
ACOUSTICS SECTION		F
AUTOMATED FORMING PROCESSES	INDUSTRIAL MATERIALS	F
Biological Production of Fuels Unit	Division of Biologic	F
Biotechnology Research Institute		F
CERAMICS AND COATINGS	INDUSTRIAL MATERIALS	F
Chemical Physics Unit	Division of Chemistr	F
Computer Technology Unit	Division of Electric	F
DAVID FLORIDA LABORATORY	CRC/DOC	F
Division of Building Research		F
Engine Laboratory	Division of Mechanic	F
Gas Dynamics Laboratory	Division of Mechanic	F
High Speed Aerodynamics Unit	National Aeronautica	F
Hydraulics Laboratory	Division of Mechanic	F
INDUSTRIAL RESEARCH ASSISTANCE PROGRA	NRC	F
Information Science Unit	Division of Electric	F
INSTITUTE FOR MARINE DYNAMICS	NATIONAL RESEARCH CO	F
Low Speed Areodynamics Unit	National Aeronautica	F
Low Temperature Laboratory	Division of Mechanic	F
Manufacturing Technology Centre	Division of Mechanic	F
MECHANICAL AND OPTICAL PHYSICS SECT	PHYS/NRC	F
Metallic Corrosion and Oxidation Un	Division of Chemistr	F
METALLIC MATERIALS	INDUSTRIAL MATERIALS	F
POLYMER AND COMPOSITE MATERIALS	INDUSTRIAL MATERIALS	F
Power Engineering Unit	Division of Electric	F
Program for Ind/Lab. Project	National Research Co	F
Railway Laboratory	Division of Mechanic	F
SERVICE DE LA CARTOGRAPHIE	MIN DE L'ENERGIE ET	F
Wastewater Technology Centre		F
BREWING & MALTING BARLEY RES INST		I
CANADIAN GAS RESEARCH INSTITUTE		I
CANADIAN INSTITUTE OF METALWORKING		I
CANADIAN PLASTICS INSTITUTE		I
CANOLA COUNCIL OF CANADA		I
COFT R&D LABORATORY		I
COMPUTER INTEGRATED MANUFACTURING		I
FOREST ENG RESEARCH INST OF CANADA		I
FORINTEK CAN CORP EASTERN LAB		I
FORINTEK CANADA CORP WESTERN LAB		I
Industrial Applications of Microele	University of Manito	I
PETROLEUM RECOVERY INSTITUTE		I
POS Pilot Plant Corporation	University of Saskat	I
Pulp and Paper Research Institute o	McGill University	I
WELDING INSTITUTE OF CANADA		I
Air Pollution Centre	Ontario Research Fou	P
APPLIED SCIENCES DIVISION	ALBERTA RESEARCH COU	P
Biotechnology and Chemical Engineer	Ontario Research Fou	P
BIO-ENGINEERING/FISHERIES TECHNOL	BRITISH COLUMBIA RES	P
Canadian Food Products Development	Manitoba Research Co	P
Centre de recherche industrielle du	(PRO)	P
Centre for Alternate Fuel Utilizati	Ontario Research Fou	P
CHEMICAL TECHNOLOGIES DIVISION	BRITISH COLUMBIA RES	P
ENVIRONMENT AND HEALTH DIVISION	BRITISH COLUMBIA RES	P
Glass and Ceramics Technology Centr	Ontario Research Fou	P
Industrial Technology Transfer Sect	Saskatchewan Researc	P
MANUFACTURING TECHNOLOGY CENTRE		P

TECHNOLOGY CENTRE LISTING

New Brunswick Research and Producti	(PRO)	P
Nova Scotia Research Foundation Cor	(PRO)	P
OIL SANDS RESEARCH DEPARTMENT	ALBERTA RESEARCH COU	P
Ontario Auto Parts Centre		P
Ontario CAD/CAM Centre		P
Ontario Centre for Farm Machinery a		P
Ontario Centre for Microelectronics		P
Ontario Robotics Centre		P
PHYSICAL TECHNOLOGIES DIVISION	BRITISH COLUMBIA RES	P
Services Sector	Saskatchewan Researc	P
Applied Microelectronics Institute	Technical University	U
ATLANTIC ANALYTICAL SERVICES		U
Atlantic Industrial Research Instit	Technical University	U
BC MICROELECTRONIC SOCIETY		U
Bras d'Or Institute	University College o	U
Canadian Institute of Fisheries Tec	Technical University	U
Canadian Institute of Guided Ground	Queen's University	U
Centre de developpement technologiq	University de Montre	U
CENTRE DE RECHERCHE INFORMATIQUE	DE MONTREAL	U
Centre de recherche sur les transpo	Universit{ de Montr{	U
Centre de recherches en nutrition	Universite Laval	U
Centre d'analyse/service pour l'ind	Universite de Moncto	U
Centre d'Innovation Industrielle	University de Montre	U
Centre for Advanced Technology Educ	Ryerson Polytechnica	U
Centre for Building Studies	Concordia University	U
Centre for Cold Ocean Resources Eng	Memorial University	U
CENTRE FOR FLEXIBLE MANUFACTURING	MCMASTER UNIVERSITY	U
Centre for Industrial Development	Ryerson Polytechnica	U
Centre for Marine Geology	Dalhousie University	U
Centre for Regional Development	Lakehead University	U
Centre for Research in Engineering	University of New Br	U
Centre for Resource Studies	Queen's University	U
Computer Communications Network Gro	University of Waterl	U
Computer Systems Group	University of Waterl	U
Dairy Herd Analysis Centre	McGill University	U
Department of Mining and Mineral Pr	University of Britis	U
Edmonton Radiopharmaceuticals Centr	University of Albert	U
Energy Research Institute	Simon Fraser Univers	U
Energy Research Institute	University of Regina	U
Geotechnical Research Centre	McGill University	U
Group for Computing Research	University of Wester	U
GROUP POUR L'AVANCEMENT PRODUCTIQUE	LAVAL UNIVERSITY	U
HYBRIDOMA CENTRE	UNIVERSITY OF WINDSO	U
INRS Telecom Centre	Universite du Quebec	U
Institute for Coal Research	University of Albert	U
Institute for Groundwater Research	University of Waterl	U
Institute of Oceanography (Aquatron	Dalhousie University	U
Laboratory for Communications and C	Simon Fraser Univers	U
McMaster Institute for Polymer Prod	McMaster University	U
MECH ENG CAD & ROBOTICS GROUP	MCGILL UNIVERSITY	U
Microelectronics Centre	Dalhousie University	U
Microelectronics Centre	Universite de Sherbr	U
Microelectronics Centre	University of New Br	U
NB MANUFACTURING TECH CENTRE	NB COMMUNITY COLLEGE	U
Northeastern Ontario Occupational H	Laurentian Universit	U
NS Computer Aided Design Centre	Technical University	U

TECHNOLOGY CENTRE LISTING

O-C Research Institute	Carelton University	U
Piezoelectricity Research Laborator	York University	U
Science Industrial Research Unit	Concordia University	U
Surface Physics Laboratory	Simon Fraser Univers	U
Surface Science Centre	University of Wester	U
Systems Analysis, Control and Desig	University of Wester	U
Textile Testing Service	University of Manito	U
The Atlantic Coal Institute	University College o	U
The Carbohydrate Research Institute	Queen's University	U
The Manufacturing Technology Centre	University of New Br	U
Transport Institute	University of Manito	U
Transportation Group	University of New Br	U
University of Toronto Microelectron	University of Toront	U
Water Analysis Facility - Departmen	Memorial University	U
Waterloo Centre for Process Develop	University of Waterl	U
Waterloo Polymer Research Institute	University of Waterl	U

ORGANIZATIONS INCLUDED IN TECH CENTRE STUDY
(Low Direct Service to Industry)

		GROUP
River Road Environmental Technology	Environment Canada	F
Atlantic Region	AG CAN	F
Research Station	AG CAN	F
Research Station	AG CAN	F
Research Station	AG CAN	F
Experimental Farm	AG CAN	F
Research Station	AG CAN	F
Sen. Herve J. Michaud Experimental	AG CAN	F
Quebec Region	AG CAN	F
Research Station	AG CAN	F
Experimental Farm	AG CAN	F
Experimental Farm	AG CAN	F
Research Station	AG CAN	F
Research Station	AG CAN	F
Experimental Farm	AG CAN	F
Food Research Station	AG CAN	F
Ontario Region	AG CAN	F
Animal Research Centre	AG CAN	F
Ottawa Research Station	AG CAN	F
Experimental Farm	AG CAN	F
Experimental Farm	AG CAN	F
Research Station	AG CAN	F
Research Station	AG CAN	F
Research Centre	AG CAN	F
Research Station	AG CAN	F
Smithfield Experimental Farm	AG CAN	F
Research Branch Headquarters	AG CAN	F
Institute Headquarters	AG CAN	F
Biosytematics Research Institute	AG CAN	F
Chemistry and Biology Research Inst	AG CAN	F
Engineering and Statistical Researc	AG CAN	F
Food Research Institute	AG CAN	F
Land Resource Research Institute	AG CAN	F
Research Program Service	AG CAN	F
Prairie Region	AG CAN	F
Research Station	AG CAN	F
Research Station	AG CAN	F
Research Station	AG CAN	F
Research Station	AG CAN	F
Research Station	AG CAN	F
Experimental Farm	AG CAN	F
Research Station	AG CAN	F
Research Station	AG CAN	F
Research Station	AG CAN	F
Research Station	AG CAN	F
Experimental Farm	AG CAN	F
Research Station	AG CAN	F
Pacific Region	AG CAN	F
Research Station	AG CAN	F
Experimental Farm	AG CAN	F
Research Station	AG CAN	F
Research Station	AG CAN	F
Research Station	AG CAN	F
Research Station	AG CAN	F
Systems and Consulting Directory	AG CAN	F

Libraries Division	AG CAN	F
Canadian Grain Commission - Grain T	AG CAN	F
Animal Diseases Research Institute	AG CAN	F
Animal Pathology Laboratory	AG CAN	F
Animal Pathology Laboratory	AG CAN	F
Animal Pathology Laboratory	AG CAN	F
Animal Pathology Laboratory	AG CAN	F
Animal Pathology Laboratory	AG CAN	F
Animal Pathology Laboratory	AG CAN	F
Animal Diseases Research Institute	AG CAN	F
Laboratory Services Division	AG CAN	F
CANADA CENTRE FOR MINERAL AND	Western Laboratory -	F
ELECTRICAL AND TIME STANDARDS		F
Electron Physics Unit	Division of Electric	F
Electronics Engineering Unit	Division of Electric	F
HEAT AND THERMOMETRY SECTION	DIVISION OF PHYSICS	F
LASER AND PLASMA PHYSICS SECTION		F
Molecular Genetics Unit	Division of Biologic	F
Molecular Spectroscopy Unit	Division of Chemistr	F
PHOTOGRAMMETRIC RESEARCH SECTION		F
PHOTOMETRY AND RADIOMETRY SECTION		F
Plant Biotechnology Institute		F
STRUCTURES AND MATERIALS LABORATORY	NATIONAL RESEARCH CO	F
Technical Research Division	NATIONAL FILM BOARD	F
Textile Chemistry Unit	Division of Chemistr	F
ALBERTA MASONRY INSTITUTE		I
ALBERTA SULPHUR RESEARCH LTD		I
SULPHUR RESEARCH GROUP		I
ADVANCED TECHNOLOGIES DEPARTMENT	ALBERTA RESEARCH COU	P
CAD/CAM Centre	Sakatchewan Research	P
Centre for Powder Metallurgy	Ontario Research Fou	P
EXTRACTIVE METALLURGY	BRITISH COLUMBIA RES	P
INDUSTRIAL DEVELOPMENT DEPARTMENT	ALBERTA RESEARCH COU	P
INSTITUTE OF MAN AND RESOURCES (PEI		P
NATURAL RESOURCES DIVISION	ALBERTA RESEARCH COU	P
RESOURCE DIVISION	SASKATCHEWAN RESEARC	P
Resources Sector	Saskatchewan Researc	P
The Canadian Centre for Advanced In	Saskatchewan Researc	P
Aerospace Medical Research Unit	McGill University	U
Alberta Microelectronics Centre	University of Albert	U
Bamfield Marine Station	University of Victor	U
Building Engineering Group	University of Waterl	U
Cancer Research Laboratory	University of Wester	U
Centre de recherche en petes et pap	Universite du Quebec	U
CENTRE DE TECHNOLOGIE MANUFACTURIER		U
Centre for Earth Resources Research	Memorial University	U
Centre for Energy Studies	Technical University	U
Centre for Remote and Offshore Medi	Memorial University	U
Centre for Water Resource Studies	Technical University	U
Computer Systems Research Group	university of Toront	U
Department of Mining and Mineral Pr	University of Britis	U
INSTITUT D'ORDINIQUE DU QUEBEC	COLLEGE LIONEL GROUL	U
Institut national de la recherche s	Universite du Quebec	U
Institute for Computer Research	University of Waterl	U
Institute for Enviromental Studies	University of Toront	U
Institute of Bio-Medical Engineerin	University of Toront	U

Institute of Materials Research	McMaster University	U
ISOTRACE Laboratory	University of Toront	U
Marine Sciences Research Laboratory	Memorial University	U
MINING DEV & MINERALS EXPLORATION	LAURENTIAN UNIVERSIT	U
Newfoundland Institute for Cold Oce	Memorial University	U
O-C Centre for Geoscience Studies	Carleton University	U
Statistical Laboratory	University of Wester	U
Taiga Biological Station	University of Manito	U
The Canadian Marine Transportation	Dalhousie University	U
The Fire Science Centre	University of New Br	U
The Industrial Research Institute	University of Windso	U
Veterinary Infectious Disease Organ	University of Saskat	U
Westwater Research Centre	University of Britis	U
Y100	University of Toront	U

APPENDIX B

INDIVIDUAL EXAMINATION OF POTENTIAL OVERLAP/DUPLICATION CASES

Appendix B

In the 35 cases where more than one technology centre occupied the same square in the technology field/industry sector matrix, a potential overlap situation existed. Each case was examined for other factors such as specialization not evident at the matrix's broad level, or other bases for differentiation such as type of service or geographic region. Details of the examination are provided in this appendix.

Biotechnology

Centres providing direct, hands-on biotechnological service to industry at a level of effort exceeding one person-year in any given sector are operating in at most six of them, namely (1) agriculture, (2) food, beverages and tobacco, (3) paper and allied products, (4) pharmaceuticals and medicines, (5) other chemical products, and (6) scientific and professional equipment.

In the first and third of these there is no more than one centre providing services, so that duplication cannot be present. In the second, fourth, fifth, and sixth the ostensible duplication can be resolved on further examination as follows:

a) Food, Beverages, and Tobacco: Two centres provide biotechnology services to this sector. One specializes in the development of new techniques for protein engineering and related areas involving high technical risk due to an extended (5+ year) time horizon. The other specializes in the modification and application of existing biotechnology processes to lower-risk, short-term industrial problems such as the conversion of wood to alcohol by fermentation. Both centres report full utilization of resources. Overlap and duplication are conspicuous by their absence.

b) Pharmaceuticals and Medicines: Two centres provide biotechnological services to this sector, the same two as noted above. One specializes in the development of new techniques for drug production by mammalian cell genetics and related areas with high technical risk due to an extended time horizon. As before, the second specializes in the modification and application of existing processes to lower-risk, short-term industrial problems, which in this sector include genetic modification of micro-organisms. Here, too, overlap and duplication are conspicuously absent.

c) Other chemical products: Once again the same two centres provide biotechnological services in this sector. The same distinction exists between the one's specialization in the development of new methods on one hand, and the other's specialization in applications of existing methods on the other. Duplication and overlap are not present.

d) Scientific and Professional Equipment: The same two centres are active in this sector as well. Their work involves the development of sensor systems to monitor and control the individual biotechnological processes on which the centre is working. As a result the content of this activity is driven by, and is as specialized as, the different research areas that each centre pursues. Duplication and overlap are automatically avoided.

Microelectronics

Centres providing direct, hands-on microelectronics technology services to industry at a level of effort exceeding one person-year in any given sector are active in at most ten of them, namely (1) wood products and furniture, (2) paper and allied products, (3) metal fabricating, (4) machinery and equipment, (5) aircraft and aircraft parts, (6) other transportation equipment, (7) communications and electronic equipment, (8) office equipment and computers, (9) scientific and professional equipment, and (10) utilities.

In the first, second, third, fifth, sixth, eighth, and ninth there is no more than one centre apiece so that duplication cannot be present. In the others, the ostensible duplication can be resolved as follows:

a) Machinery and Equipment: Two centres provide microelectronics technology services in this sector. One specializes in the development and use of microelectronics-based systems for diagnostic testing of combustion plasmas in gas turbine engines used for industrial pumping applications. The other provides services related to the application of microelectronic control systems for general machinery. There is no overlap or duplication.

b) Communications and Electronic Equipment: Four centres provide microelectronics technology services in this sector. Three of them are located in separate provinces and have provincial mandates and provincially-limited scopes of operation. Two of the three report full utilization of either human or physical resources, so that their provincial client bases can be interpreted as viable entities for market segmentation purposes (i.e., there is no client overlap). The third reports only 90% utilization of human resources, but it operates in Atlantic Canada where the size of the industrial base may be the governing factor. Moreover, it reports that the presence of other provincial centres has <u>increased</u> its level of business by raising general awareness of technological opportunities. The fourth centre is located in the same province as one of the first two, but specializes in a very narrow service segment, namely the transformation of clients' conventional electronic circuits into equivalent microcircuits. It leaves to other centres the provision of any services related to applications for microelectronics and to the design of original circuits. No overlap/duplication is apparent.

c) Utilities: Two centres provide microelectronics technology services in this sector. One concentrates on DC power transmission detectors and circuits for the hydro utility in its province. The other concentrates on microelectronics applications for the different conditions in its province. No overlap or duplication is evident.

Software, Computing, Informatics (SCI)

Centres providing direct, hands-on service in software, computing, or informatics at a level of effort exceeding one person-year in any given sector are active in at most twelve of them. These are (1) mines and oil wells, (2) rubber and plastics processing, (3) paper and allied products, (4) machinery and equipment, (5) aircraft and aircraft parts, (6) communications and electronic equipment, (7) office equipment and computers, (8) other manufacturing, (9) construction, (10) communications services, (11) utilities, and (12) other services.

In the first, fourth, fifth, eighth, tenth, eleventh, and twelfth of these sectors there is no more than one centre apiece so that duplication can be ruled out. In the others, the ostensible duplication can be resolved as follows:

a) Rubber and Plastic Products: Two centres provide SCI technology services in this sector. One specializes in the processes by which feedstocks are converted into polymers as raw plastic materials. The other specializes in the processes by which such raw plastics are subsequently molded into finished products, e.g., for consumers. There is no duplication or overlap present.

b) Paper and Allied Products: Two centres provide SCI technology services in this sector. One specializes in image processing software for automated measuring of such quantities as fibre lengths in paper slurries, and in software for real time process control. The other specializes in the development of software for simulators used in operator training. No duplication or overlap is present.

c) Communications and Electronic Equipment: There are two centres providing SCI technology services in this sector. One specializes in digital software for coding and decoding of video signals in television broadcasting, while the other confines itself to general-purpose software for the implementation of computing and control systems. Here again, there is no duplication or overlap present.

d) Office Equipment and Computers: Two centres provide SCI technology services in this sector. One specializes in digital software for computer equipment used in television broadcasting. The other covers a wide variety of areas, none of which includes broadcasting. No overlap or duplication is apparent.

e) Construction: Two centres provide SCI technology services in this sector. One specializes in systems related to the management and control of processes by which buildings are constructed, including computer-aided building design and life-cycle costing and management information systems for building planners. The other specifically avoids working in the field of construction management, and specializes in simulating performance capabilities of new building systems to derive technical specifications for engineers and architects. No duplication or overlap is present.

CAD/CAM, Robotics, Flexible Manufacturing (CRF)

Centres providing direct, hands-on service in CAD/CAM, robotics, or flexible manufacturing at a level of effort exceeding one person-year in any given sector are active in at most eleven of them. These are (1) rubber and plastic products, (2) wood products and furniture, (3) metal fabricating, (4) machinery and equipment, (5) aircraft and parts, (6) other transportation equipment, (7) communications and electronic equipment, (8) office equipment and computers, (9) other electrical equipment, (10) other manufacturing equipment, and (11) utilities.

In the first, second, fifth, eighth, ninth, and tenth of these there is no more than one centre apiece, so that duplication and overlap can be ruled out. In the others, the ostensible duplication can be resolved as follows:

a) Metal Fabricating: Nine centres provide CRF technicological services in this sector. Four of them specialize in CAD/CAM while the other five specialize in robotics and flexible manufacturing. Of the five concentrating on robotics, one is unique because it specializes in control systems specifically aimed at maintaining and improving the strength and integrity of robotically-welded joints. Another is unique because it specializes in research on new software and systems for communication between, and coordination of, robots and machine tools using microcomputer interfaces. Two others concentrate on applications-related research, demonstration, and consulting to corporate management on the feasibility, selection, adaptation, and implementation of off-the-shelf robots, but they both are provincial in mandate and scope of operations, and the two are situated some 1,500 km apart. The fifth centre was started less than a year ago and reports that its equipment is still being installed. It is premature to determine its area or areas of specialization. No overlap is evident.

Of the four centres concentrating on CAD/CAM, three are provincial in mandate and scope of operations and are situated some 1,000 km and 3,000 km apart. Two of them report full utilization of staff resources, and the third reports over-utilization with extensive use of overtime. However, the fourth centre is situated less than 100 km from the third one, and reports considerable under-utilization of physical and human resources due to the loss of business since the third one opened up. However, its under-utilization is also related to its own recent move to considerably larger facilities, designed to permit future expansion, at a new location further away from main transportation links. Future growth in business should reduce and may eliminate the current under-utilization. There may eventually be enough clients within the 100 km radius to occupy both centres. It should be noted that metal fabricating companies tend to be small and locally-oriented. It should also be noted that the fourth centre has been operating for nearly fifteen years with financial assistance from the federal government, and that the third centre opened less than four years ago as a wholly-provincial initiative with no federal sponsorship.

b) Machinery and Equipment: Five centres provide CRF technology services in this sector. Three specialize in CAD/CAM, while the other two specialize in robotics and flexible manufacturing. Of the latter two, one concentrates on research-based services to firms that manufacture robotics-related equipment. It specializes in improving the performance of robot systems vis-à-vis the robots' interfacing with computers and with their environment. The second centre concentrates on technical services to firms that use robots to manufacture other equipment. It provides services in demonstration and consulting on the feasibility, selection, adaptation, and implementation of off-the-shelf robots. No overlap or duplication is present in robotics. The three centres specializing in CAD/CAM are the same ones noted in the previous sector, metal fabricating. All are provincial in mandate and scope of operations, and are situated some 1,000 km and 3,000 km apart. No overlap is evident in CAD/CAM.

c) Other Transportation Equipment: Three centres provide CRF technological services in this sector. Two of them are provincial in mandate and scope of operations, and are situated some 3,000 km apart. One reports full utilization of resources and the other reports over-utilization with extensive use of staff overtime. No overlap is evident. The third began operations within the past year, and it is premature to determine its specialization in terms of technical subject area or type of service.

d) Communications and Electronic Equipment: Three centres provide CRF technological services in this sector. Two of them concentrate on CAD/CAM while the other is unique because it concentrates on robotics. Of the two providing CAD/CAM services, both are provincial in mandate and scope of operations, and both report full or greater than full utilization. No overlap or duplication is apparent.

e) Utilities: Two centres provide CRF technological services in this sector. One specializes in CAD/CAM and the other in robotics. There is no overlap or duplication.

Instrumentation and Sensing Devices

Centres providing direct services in instrumentation and sensing devices technology at a level of effort exceeding one person-year in any given sector are active in at most eleven of them. These are (1) mines and oil wells, (2) rubber and plastic products, (3) metal fabricating industries, (4) machinery and equipment, (5) aircraft and aircraft parts, (6) communications and electronic equipment, (7) pharmaceuticals and medicines, (8) other chemical products, (9) scientific and professional equipment, (10) transportation services, and (11) utilities.

In all of these sectors there is no more than one centre apiece so that duplication and overlap can be ruled out.

Lasers, Photonics, and Fibre Optics

Centres providing direct services in lasers, photonics, and fibre optics technology at a level of effort exceeding one person-year in any given sector are active in at most three of them. These are (1) rubber and plastic products, (2) metal fabricating industries, and (3) aircraft and aircraft parts.

In all of these sectors there is no more than one centre apiece so that duplication and overlap can be ruled out.

Metallurgy, Metalworking, and Welding (MMW)

Centres providing direct, hands-on MMW service to industry at a level of effort exceeding one person-year in any given sector are operating in at most eight of them. These are (1) mines and oil wells, (2) paper and allied products, (3) printing and publishing, (4) primary metal products, (5) metal fabricating industries, (6) machinery and equipment, (7) aircraft and aircraft parts, and (8) utilities.

In the second, third, and seventh of these sectors there is no more than one center apiece so that duplication can be ruled out. In the others, the ostensible duplication can be resolved as follows:

a) Mines and Oil Wells: Two centres provide MMW services in this sector. The first specializes in welding, and provides technological assistance related to maintaining and improving the strength and integrity of welded joints. By contrast, the second is involved in general metallurgy, for example as related to the behavior of structural materials. Duplication and overlap are not present. One centre reports being fully utilized, and the other over-utilized.

b) Primary Metal Products: Two centres provide MMW services in this sector as well. One of them is the centre specializing in welding as noted above. The other is involved predominantly in metalworking, and it provides expertise in heat treating, machining, metal cutting by laser beams, high pressure water jets, electrical discharge machining, and electrochemical machining. Duplication and overlap is conspicuously absent. Both centres report being over-utilized and unable to keep up with demand.

c) Metal Fabricating Industries: There are six centres providing MMW services in this sector. Only one of them specializes in welding. It is the same centre noted in the preceding two paragraphs and is unique on account of its speciality. Another three of the centres focus on metallurgy, but provide different services from each other because one specializes in improving the corrosion resistance properties of metallic items built for acidic and caustic environments, the second specializes in developing new methods to improve the strength and formability of metallic materials, and the third specializes in providing expertise in the application of existing materials for specific industrial uses. The final two centres focus on metalworking, and so provide different services from the five previously-mentioned centres. Moreover, they provide different services from each other because one specializes in the demonstration to corporate managers and engineers of the capability and applicability of heat treating, machining, and metal cutting by laser beams, high pressure water jets, electrical discharge machining, and electrochemical machining, while the other specializes in the training of technicians and machine shop operators in areas like CNC machining and CAD/CAM operations on the shop floor. No centre duplicates or overlaps the others. Only one centre, the last one, reports any significant amount of underutilization but this is not attributable to overlapping or duplicated activities with any of the centres mentioned in this sector.

d) Machinery and Equipment: There are five centres operating in this sector. One of them is unique because it focuses on metalworking while the other four focus on metallurgy. Of the four, three have been noted previously: one specializes in corrosion resistance of equipment built for acidic and caustic environments, the second specializes in developing new methods to improve the strength and formability of metallic materials, and the third specializes in providing general expertise in the application of materials for specific industrial uses. The fourth centre offers similar services to the third, but the two have essentially provincial mandates and scopes of operation, and are situated about 3,000 km apart. As a result they serve geographically different client communities. No overlap or duplication is evident among the centres serving this sector. All five report full utilization.

e) Utilities: There are two centres providing MMW services to the utilities sector. These are the same two centres noted above for the mines and oil wells sector, and the same differences between them apply here.

Industrials Materials

Centres providing direct, hands-on service in industrial materials technology at a level of effort exceeding one person-year in any given sector are active in at most nine of them. These are (1) rubber and plastic products, (2) metal fabricating industries, (3) machinery and equipment, (4) aircraft and aircraft parts, (5) other transportation equipment, (6) communications and electronic equipment, (7) non-metallic mineral products, (8) construction, and (9) utilities.

In the fourth, fifth, sixth, seventh, eighth, and ninth there is no more than one center apiece so that duplication and overlap can be ruled out. In the others, the apparent duplication can be resolved as follows:

a) Rubber and Plastic Products: Two centres provide industrial materials technology services in this sector. One of them specializes in research with a high technical risk due to its long time horizon. The work relates to developing new and improved plastic and composite materials, and the methods by which they are molded into finished products. The other specializes in the application of existing plastics to meet short-term user problems. No duplication or overlap is evident.

b) Metal Fabricating: Five centres provide industrial materials technology services in this sector. One of them is unique because it specializes in demonstration of new processing techniques (e.g., cutting and heat treating) in relation to industrial materials, while the other three specialize in research. One of these three is unique compared to the others because it specializes in research involving high technical risk and a long time horizon aimed at the development of new and improved materials with greater fatigue resistance, high temperature strength retention, and improved abrasive wear resistance. The other two focus on the adaptation and modification of existing materials to lower risk, short-term application problems. These two are essentially provincial in mandate and scope operations, and deal with regional metal fabricating firms. No overlap or duplication is evident.

c) Machinery and Equipment: Five centres provide industrial materials technology services in this sector. One of them is unique because it specializes in providing industrial materials expertise to those firms which design and make new types of cutting and heat treating equipment. By contrast, the other four provide technological assistance to firms which use industrial materials in building a variety of other kinds of machinery and equipment, and which may use cutting, heat treating, and related types of equipment in the process. Of the four, one is unique because it specializes in research involving high technical risk and a long time horizon for the development of new and improved materials. The other three focus on lower-risk, short-term materials application problems. All of these three are provincial in mandate and scope of operations, and deal with regional machinery and equipment manufacturers. One emphasizes work on agricultural equipment for Western requirements. Another emphasizes work on equipment used in fishing. The third emphasizes general industrial machinery. No duplication or overlap is evident.

Chemical Processes

Centres providing direct, hands-on services in chemical process technology at a level of effort exceeding one person-year in any given sector are active in at most ten of them. These are (1) agriculture, (2) forestry, (3) mines and oil wells (4) food, beverages, and tobacco, (5) rubber and plastics products, (6) paper and allied products, (7) non-metallic mineral products, (8) petroleum and coal products (9) pharmaceuticals and medicines, and (10) other chemicals and chemical products.

In the first, second, third, seventh, and ninth of these sectors there is no more than one centre apiece so that duplication can be ruled out. In the others, the ostensible duplication can be resolved as follows:

a) Food, Beverages, and Tobacco: Two centres provide chemical process technology services in this sector. Both have essentially provincial mandates and scopes of operation, and are situated some 1,000 km apart. One is concerned primarily with seafoods and fruits and the other with dairy products, meats, and vegetables. No duplication or overlap is evident.

b) Paper and allied products: Two centres provide chemical process technology services in this sector. One specializes in improving the chemistry of the production process, while the other is involved primarily with the application of control systems and the related monitoring techniques. One reports full utilization of its resources and a resulting inability to cover its technical fields at a pace commensurate with industry's needs. The other reports having to spend an excessive amount of time promoting its services to potential clients, but this is due mainly to the recent loss of core funding from its sponsoring organization and the resulting need to increase its contract revenue over previous levels.

c) Rubber and Plastic Products: Two centres provide chemical process technology services in this sector. One specializes in providing analytical testing services with expertise in the interpretation of results at the molecular structure level, while the other specializes in polymer reaction engineering and computer control as a means to improve the process by which polymers are made. In other words, the former centre helps industry analyze the chemical composition of polymers once they have been made, and the latter centre helps industry improve the processes needed to make them. No overlap or duplication is evident.

d) Petroleum and Coal Products: Four centres provide chemical process technology services in this sector. All four have essentially provincial mandates and scopes of operation, and three are concerned with processing of indigenous (intraprovincial) resources. It should be noted that the chemical properties of unprocessed petroleum and coal vary substantially from one province to another so that entirely different processing methods are necessary. Of the three centres involved with their provinces' indigenous resources, one specializes in high temperature pyrolysis and chemical processing of intraprovincially-mined coal. Another specializes in agglomeration of coal for use in coal/liquid fuel mixtures, and in coal cleaning, both in relation to intraprovincially-mined coal. The third specializes in agglomeration of coal for transportation by pipeline. No duplication or overlap is present in these centres' work on coal. With respect to petroleum, one of these three centres undertakes technical work related to upgrading and refining, but focusses on heavy oils. The fourth centre specializes in processes for catalytic conversion of light oils. No duplication or overlap is evident.

e) Other chemical Products: Three centres provide chemical process technology services in this sector. One of them is unique because it specializes in the development of new processes for the biotechnological production of chemicals. The other two concentrate on non-biological processes. One specializes in petrochemicals and the other works in general industrial chemicals. In addition, both of them have essentially provincial mandates and scopes of operation and are situated some 3,000 km apart. No overlap or duplication is apparent.

Transportation and Communications (T&C)

Centres providing direct services in transportation and communications technologies at a level of effort exceeding one person-year in any given sector are active in at most ten of them. These are (1) mines and oil wells, (2) machinery and equipment, (3) aircraft and aircraft parts, (4) other transportation equipment, (5) communications and electronic equipment, (6) office equipment and computers, (7) other manufacturing industries, (8) transportation services, (9) communications services, and (10) all other services.

In the second, sixth, seventh, ninth, and tenth of these sectors there is no more than one centre apiece so that overlap and duplication can be ruled out. In the others, the ostensible duplication can be resolved as follows:

a) Mines and Oil Wells: Four centres provide T&C technology services in this sector. One of them is unique because it specializes in research and testing of the stability of offshore drilling rigs and shuttle tankers. Another is unique because it specializes in developing methods for the adaptation and use of propane, methanol, and other alternate fuels in land vehicles. The third is unique because it specializes in technology related to extraction/transportation problems of tar sands. The fourth is unique because it specializes in research and application of methodologies for measuring natural resource inventories (reserves). No overlap or duplication exists.

b) Aircraft and Aircraft Parts: Two centres provide T&C technology services in this sector. One specializes in the flow of gases and the combustion and thrust parameters of gas turbine aircraft engines, while the other specializes in the structural strength, damage tolerance, and resistance to crack propagation and exfoliation of parts used in aircraft wings, fuselages, and landing gear. No overlap or duplication is present.

c) Other Transportation Equipment: Two centres provide T&C technology services in this sector. The two are entirely different because one specializes in methods for the use of propane, methanol, and other alternate fuels in land vehicles -- it is the same center as noted in sector (a) above -- while the other specializes in vehicle dynamics and the structural integrity of railway locomotives and coaches as well as highway trucks. No duplication or overlap is present.

d) Communications and Electronic Equipment: Two centres provide T&C technology services in this sector. One specializes in digital communications technology for broadcasting, while the other specializes in the application of (micro)electronic equipment for diagnostic testing of combustion plasmas in gas turbine aircraft engines. No overlap or duplication exists.

e) Transportation Services: Two centres provide T&C technology services in this sector. One specializes in technology related to the use of alternate fuels by transportation companies in their fleets of cars and trucks, while the other specializes in freight car dynamics on railways and the interaction and wear of wheels and rails. No overlap or duplication is present.

Artificial Intelligence

Centres providing direct services in artificial intelligence technology at a level of effort exceeding one person-year in any given sector are active in at most two of them. These are (1) machinery and equipment and (2) transportation services (aerial surveying).

In each of these sectors there is no more than one centre apiece so that duplication and overlap can be ruled out.

APPENDIX C

The Special Case of Federal Laboratories

1) CANMET (Energy, Mines and Resources)

I- Mission and Activities

CANMET is the major technological research arm of the Department of Energy, Mines and Resources. Established in 1907 as the Mines Branch, it served to meet the R&D needs of the new and growing Canadian Mining industry. Reorganized in 1974, it was re-named to reflect the addition of activities in mineral and energy technology over the years.

Research areas covered include mining technology, mineral extraction, metallurgy and the utilization of metals and alloys, energy conservation, heavy oils and oil sands development, coal utilization and conservation, uranium recovery, and energy transportation.

CANMET's activities include coordination of federal research efforts, promoting and supporting R&D in industry and universities, conducting applied research and engineering development, identifying technological opportunities, providing unique testing and laboratory facilities to industry, and transferring technology to the private sector.

CANMET is also involved in the development, testing and authorization of all explosive materials used in Canada as required by the Explosives Act, and works with the CSA on a number of certification standards. A substantial portion of CANMET's efforts are also devoted to the reduction of health and safety problems in mining, and to minimizing environmental impacts of effluents from the mining and mineral processing industries, and the burning of coal as an alternative fuel.

CANMET has laboratories in the National Capital Region, in Elliott Lake, Ontario, Edmonton, and Sydney, Nova Scotia, serving specific segments and technological needs of the hard rock and coal mining and processing industries, as well as oil sands mining and extraction, and petroleum industries.

In 1981, the Office of Technology Transfer was created within CANMET. Its activities focus on intellectual property and assistance to line divisions of CANMET in relation to patent and licensing applications, special information packages, market studies and industry assessments. It also ensures that the planning of research projects includes consideration of eventual technology transfer. All these tasks are performed through contracts with universities and the private sector (approximately 20 percent of total budget) and in-house facilities and laboratories.

II- Advisory Committees

CANMET has an industrial advisory body, the National Advisory Committee on Mining and Metallurgical Research (NACHMR), created in 1968 by Order-in-Council. The committee provides a link between CANMET and the user community, and advises the Minister of EMR on energy, coal, mining, mineral and metallurgical research, and on the coordination of federal research programs with others, including university and provincial research activities.

NACMMR is co-chaired by a senior official of EMR and an industry representative appointed by the Minister of EMR. Its numbers include representatives of the Canadian mining, mineral, metallurgical and energy industry, provincial governments and research agencies, and university scientists. Altogether, some sixty or more scientists and professionals are involved.

III- Resources

Expenditures	83-84	84-85	85-86
Salaries and Wages	27.1	28.9	30.3
Other OEM	27.3	32.6	34.2
Grants and contributions	0.2	0.5	0.1
Capital	11.0	12.4	10.1
TOTAL	60.6	74.4	74.7
Person years	801	797	803

IV- Cost Recovery

Costs are recovered from clients, both inside and outside of government, for specific scientific and technical services provided by CANMET on request, including most of the testing and certification functions routinely performed. At present, the funds accruing from cost recovery are credited directly to the Consolidated Revenue Fund. Total cost-recovery amount should reach $1.5 million in 84-85.

2) AGRICULTURE CANADA

1- <u>Mission and Activities</u>

A. Research Branch

The research arm of Agriculture Canada serve Canada's agricultural industry, as well as providing technical support for the Department's responsibilities. Areas of research include land resources, plant and animal breeding, agricultural engineering, plant and animal diseases, biochemistry, statistics, biosystematics and food research. While the research emphasis is on service to the Department's enforcement and support responsibilities to the farming community and associated industries, a substantial part of the resources is devoted to medium- to long-term research for the benefit of Canadian agriculture generally.

Agriculture Canada operates 53 laboratories and field stations in all provinces, in all major agricultural areas. In cooperation with provincial laboratories and stations, they serve individual farmers and work on the solution and prevention of national and regional agricultural problems.

B. Food Production and Inspection Branch

Research and Advisory Service: Consultative and diagnostic services are provided by two institutes, six laboratories and one headquarters establishment, serving all regions of Canada. These services provide laboratory testing for meat safety and disease confirmation for foreign animal diseases, brucellosis, tuberculosis, reportable and other diseases of national concern, as well as testing for export, import and artificial insemination purposes. These services also provide diagnostic support for provincial, institutional and private practitioners, departmental and other federal agency programs.

Disciplines involved in these services/programs include chemistry, biochemistry, bacteriology, immunology, pathology, and virology.

- Inspection and Control of Facilities and Food Products: Laboratories involved in this activity are responsible for ensuring the safety, quality and nutritive value of edible agricultural products. These laboratories provide physical, chemical and biological testing services in support of inspections, quality and safety assurance programs of the Food Production and Inspection Branch, on food products (meat, egg, dairy, fruit and vegetable products) and agricultural inputs (feeds, fertilizers, seeds and pesticides). Analytical methodology research is conducted in order to maintain state-of-the-art quality service on a timely and reliable basis.

C. Canadian Forestry Service

The major objective of the Canadian Forestry Service is to promote and enhance, on the basis of sound ecological principles, the sustained economic utilization of Canada's forest resources. The Canadian Forestry Service carries out its various responsibilities at its National Capital Regional Head-quarters, at six regional research centres, and two national research institutes across Canada.

These centres (with the exception of CFS-Headquarters) undertake research in the areas of forest environment, production, utilization, and forest protection from fire, insects, and disease; publish results; and provide technical advice, scientific information, and specialized services to federal departments and agencies, the provinces, and the forest and wood products industries.

D. Other Related Laboratories, Ag. Can

Canadian Grain Commission - Grain Testing and Research: This laboratory fulfills its objective of providing developmental, scientific support and survey information for the Canadian Grain Commission by undertaking the following activities: conducting quality surveys; varietal studies; and performing basic and applied research on new grain crops and on grains marketed.

II- Advisory Committees

The Department has established a series of coordinating committees in several areas, which help the Research Branch set priorities and prevent overlap and duplication of effort with universities and other research organizations.

III- Resources

Total expenditures (intramural and extramural) by Agriculture Canada's internal laboratories amounted to about $335 million in 1984. The total person-year utilization for the same group was approximately 5,151 PYs of which 2,557 PYs were scientific/technical in 1984.

Total Expenditures in Support of Science and Technology Activities by Departmental Programs:

Programs	
Administration	$ 14,853,000
Agri-Food Development	220,000,000
Agri-Food Regulation and Inspection	50,442,000
Canadian Forestry Service	58,000,000
Canadain Grain Commission	6,668,000
Total	$350,043,000

3) DEPARTMENT OF ENVIRONMENT

I- Mission and Activities

A. Atmospheric Environment Service

The AES provides Canada's national weather service and responds to the needs of Canadians through programs aimed at reducing the adverse impacts of weather, maximizing the economic benefits accruing from accurate prediction of weather elements, and reducing the harmful effects of human activities on the atmosphere.

Six AES centres provide meteorological services to specific geographical regions across Canada, while the AES Headquarters concentrates on the following activities: air quality and inter-environmental research, climatological services, ice services, meteorological standards, EDP Services, meteorological stores, financial services, and personnel services.

B. Environmental Protection Service

The objectives of the Environmental Protection Service are to ensure that human activities are conducted in a way that will achieve and maintain a state of the environment necessary for the health and well being of man, the health and diversity of species and of ecosystems and the sustained use of natural resources for social and economic benefit.

There are five EPS centres and a national headquarters serving specific geographical regions across Canada. These centres' activities include: site inspection, sample analysis, control measures development, technology development and transfer, environmental emergency coordination, socio-economic impact assessment, and interpretation of the relative significance of different environmental threats.

o <u>Other EPS-Related Centres:</u>

- <u>River Road Environmental Technology Centre</u>

Among the services provided by this centre, vehicles' emission testing is the most industry-oriented.

- <u>Wastewater Technology Centre</u>

The Wastewater Technology Centre provides industry and government cost-effective treatment technologies for the reduction and/or containment of wastewater pollution problems. Over half of the centre's activities are industry-oriented in technological fields such as wastewater treatment, residue management, energy, and biotechnology.

C. Environmental Conservation Service

Centres attached to the Environmental Conservation Service contribute to the fulfillment of the ECS' primary objective of conserving and enhancing Canada's renewable resource of water, land and wildlife and their related ecosystems, and promoting their wise use in a sustainable manner.

Twenty-eight internal establishments perform and/or administer scientific activities in support of lands, wildlife, and inland waters conservation.

D. Parks Canada

Approximately fourteen Parks Canada internal establishments perform and/or administer scientific activities. These include systems planning research to identify and assess the potential of landscape and marine areas for new national parks or protected areas, and usually involves a thorough investigation of the biological, geological, physiological (oceanological) features of the area. Once a park is established, detailed natural science research and inventories are undertaken to ensure that the resources will be adequately protected and accurately interpreted to visitors.

II- Resources

Total intramural and extramural expenditures by the 54 DOE scientific establishments amounted to approximately $286 million in 1984. These establishments accounted for about 3,757 PYs of which 1210 PYs were scientific and technical personnel.

Total Expenditures in Support of Science & Technology Activities by Departmental Programs:

Programs	Expenditures
Administration	$ 502,000
Environmental Services	272,759,000
Parks Canada	12,812,000
	$ 286,073,000

4) DEPARTMENT OF COMMUNICATION

I- Mission and Activities

The Department of Communications' Research and Technology Applications and Industry Support are the two activities that develop technologies and promote their exploitation by industry. The bulk of this work is carried out by the following scientific establishments of DOC:

Communications Research Centre (CRC): The CRC's principal objective is to advance Canada's research and development in the areas of telecommunications, space and information science and technology. Research and development work is carried out in broadcasting and telecommunications, information technology and systems, transmission of electromagnetic signals and the environmental conditions affecting these signals, and space technology applications. Approximately half of the Centre's activities are conducted in support of industry.

David Florida Laboratory: Established in 1972 as a component of the Communications Research Centre, the David Florida Laboratory operates as a national facility for the environmental testing and integration of spacecraft and spacecraft components with equal access offered to all Canadian aerospace companies. DFL also supports the government's policy of developing in Canada a prime contractor, capable both of satisfying domestic satellite communications needs, and of bidding competitively in the international marketplace. 85% of DFL's time and effort is devoted to activities in support of industry.

Canadian Workplace Automation Research Centre: Established in June 1984, the Canadian Workplace Automation Research Centre has been mandated by DOC to conduct research into systems of organization communication and integrated information processing and their applications in administration, both government and private. The centre undertakes two kinds of activities: scientific research and diffusion of information on office automation. The dominant principle underlying research at the centre is a user orientation whereby new technology is applied to actual working situations.

Three research laboratories and one diffusion service undertake scientific activities which can be conveniently grouped into four reasonably orthogonal areas: integrated systems R&D, advanced workplace technology R&D, organizational/societal research, and science dissemination and intelligence network operations.

II- Advisory Committees

Canadian Workplace Automation Research Centre: The Centre has two major advisory bodies, one representing the private sector and a second representing the interest of the Federal Government. The private sector advisory committee consisting of 13 members from industry advises the Centre on the priorities, programs and steps to undertake in order to ensure effective coordination among the government, the private sector and the universities. The second advisory body, namely, the Interministerial Advisory Committee is chaired by the Secretary of MOSST. The committee's participants are mainly Assistant Deputy Ministers responsible for the internal scientific activities of their respective department. The Interministerial Advisory Committee constitutes an effective mechanism whereby Ministries may voice their concerns and influence the Centre's programs.

III- Resources

The total cost of carrying out activities by the internal scientific establishments of DOC was approximately $84 million in 1984. Of this total, $53 million was devoted to intramural expenditures. The total number of PYs of these establishments amounted to 613 of which 242 PYs consisted of scientific and other professional personnel.

IV- Cost Recovery

The two principal centres in which a significant cost recovery effort is undertaken are the David Florida Laboratory and the Communications Research Centre. For instance, industry avails itself of the specialized test equipment in the David Florida Laboratory in accordance with fees set annually and based upon cost studies. DFL cost recovery is only partial. Fees are sometimes waived to improve the competitive position of Canadian firms bidding in the international marketplace. The Communications Research Centre recovers a significant portion of costs for Research & Development services provided to industry. Total revenue from this source in 1984 amounted to approximately $5 million.

5) NATIONAL RESEARCH COUNCIL OF CANADA (NRC)

I- Mission and Activities

NRC is the federal government's largest and most diversified scientific research organization, and undertakes eight principal types of activities including research and development; technology transfer; the provision of specialized technical advice; the management of scientific and technology based industrial development programs; the acquisition, storage, and dissemination of scientific and technical information; the maintenance and application of Canada's national physical standards such as length, mass, time, radiation, and light intensity; the provision of specialized testing and analytical services; and the maintenance and operation of research and testing facilities such as wind tunnels, hydraulics (wave) tanks, and observatories. The work is done in support of health, food and forestry, industrial development, transportation, public safety, the advancement of knowledge, and various other application areas.

NRC operates sixteen laboratory divisions that undertake work in selected areas of physics, chemistry, biology, biotechnology, electrical engineering, mechanical engineering, aeronautical engineering, astrophysics, space science, industrial materials, buildings engineering, marine dynamics, and microstructures related to electronic and other materials. The laboratory facilities are located in the National Capital Region as well as in Victoria, Vancouver, Penticton, Saskatoon, Churchill, Toronto, Algonquin Park, Montreal, Halifax, and St.John's. In addition, NRC operates Canada's national scientific and technical library, located in Ottawa, and an Industrial Development Office with headquarters in Ottawa and field offices that provide technical outreach to industry in all major cities across the country. It also funds and helps direct two major non-federally-owned facilities for optical astronomy and intermediate energy particles physics, as well aas several large-scale extramural research programs in nuclear fusion and wind energy turbines.

The Council's mission is to provide results and expertise that derive from these scientific and technical activities in support of industry, universities, governments, technology centres, educators, the general scientific community, and individual Canadians. An example of the latter would be homeowners who make use of technical information from the Division of Building Research on insulation, windows, moisture infiltration, and other related subjects.

With respect to the industrial community, NRC's principal clients include Canada's medium and high technology industry sectors, including manufacturers of communications equipment, microelectronics, computing and office equipment, aircraft and aircraft engines, aerospace equipment, pharmaceuticals, scientific instruments and professional equipment, chemical products, industrial machinery, and land transportation equipment. Medium and high technology companies in the resource and service industry sectors are also major clients. The Council also undertakes outreach services to lower-technology industry and especially to small companies through a network of field advisory services linked with provincial research organizations, with other research institutes, and with consulting engineering firms across Canada.

II- Advisory Committees

NRC was established in 1916. Since then its activities have been overseen by a governing Council, comprised of prominent representatives from Canada's industry, university, and government sectors. NRC also relies on advice about the content and application of its programs from 38 associate and advisory committees with members drawn from Canadian industry, universities, and governments; and it undergoes regular assessments of the scientific calibre of its work by peer review committees drawn from similar Canadian and foreign similar sources. All told, nearly 1,000 external experts are involved each year in providing technical and strategic inputs through the committees.

III- Resources

Expenditures

	1983-84	1984-85	1985-86
Salaries and wages	135.1	150.0	150.7
Other operating	103.9	133.5	105.0
Grants and contributions	91.4	117.3	115.2
Capital	76.5	120.6	90.4
	406.6	521.2	461.3
Person-Years	3,424	3,568	3,499

IV- Cost Recovery

Costs are resourced from clients for specific tests and services, and the use of NRC facilities, wherever the client in question is the sole beneficiary of the work. Treasury Board regulations correctly limit cost recovery from other federal government departments to incremental costs only. Revenues are credited by NRC towards its operating costs under a Parliamentary net-voting procedure. Total revenues credited to the vote in 1985-86 are estimated at $18.0 million.

6) DEPARTMENT OF FISHERIES AND OCEANS

I- Mission and Activities

The Department of Fisheries and Oceans has one set of activities, the Fisheries Development Program, which pertains to technological diffusion.

The fisheries development work-activity comprises projects which are undertaken to provide for:

- o the more efficient exploitation of fishery resources and for the exploration for and development of new fishery resources;
- o the introduction and demonstration to fishermen of new types of fishing vessels and fishing equipment and of new fishing techniques; and
- o the development of new fishery products and for the improvement of the handling, processing and distribution of fishery products.

A bait service for fishermen in Newfoundland, foreign arrangements, job creation and improvements in vessel and dockside technology are also provided for by this work-activity.

The Fisheries Development Program is subdivided into geographic components: Atlantic, (including Quebec), Ontario, the West, and Pacific regions.

Technological development, development planning, analysis and program implementation are implemented by each of the regions working in cooperation with the provinces and the fishing industry. Coordination is facilitated by industry advisory committees, and federal/provincial advisory committees.

The technological development group concentrates on developing new technology, testing and modifying known technology and transferring these technologies to the fishing industry. This work is problem-oriented and is part of the overall development strategy.

II- Advisory Committees

The Fisheries Development Program does not have permanent committees on technology or technology transfer. Ad hoc committees are appointed as required to deal with various federal and provincial issues.

III- Resources

Fisheries Development Program (Atlantic - including Quebec)

TOTAL PYs	1983/84	1984/85	1985/86	1986/87	1987/88
	46	51	51	51	51
	($000s)	($000s)	($000s)	($000s)	($000s)
- Salaries (approx.)	1,738	1,938	1,938	1,938	1,938
- Other O&M	5,622	5,796	5,796	5,796	5,796
- Capital	572	570	570	570	570
- Grants and Contributions	1,509	1,362	1,362	1,362	1,362
TOTAL	9,441	9,666	9,666	9,666	9,666
Total net of Salmon Buy-Back Program	9,441	8,666	8,566	8,156	8,156

Special Programs

TOTAL PYs	1983/84	1984/85	1985/86	1986/87	1987/88
	98	93	96 [a]	103 [a]	97 [a]
	($000s)	($000s)	($000s)	($000s)	($000s)
- Atlantic Fisheries Ice-Making Infrastructure Program	-	4,474	4,711	231	231
- N.B. ERDA Sub-Agreement	-	160	10,558	5,370	4,285
- N.S. ERDA Sub-Agreement	-	-	3,200	4,575 [b]	5,775 [b]
- P.E.I. ERDA Sub-Agreement	-	475	1,900	1,525	1,300
- Quebec ERDA Sub-Agreement	-	-	1,380 [c]	7,480 [c]	10,780 [c]
- Special Recovery Capital Projects Program (SRCPP)	3,482	34,142	4,176	-	-
- Southeast New Brunswich	500	500	80	-	-
- PEI Federal Fevelopment Stra.	3,355	1,000	-	-	-
- Coastal Labrador Dev. Program	3,400	4,980	775	1,405	-
- Development Programs in Quebec	683	7,618	12,234	12,079	3,747
Employment Programs	13,744	7,353	5,000 [c]	15,000 [c]	15,000 [c]
TOTAL [e]	25,214	60,702 [d]	44,014 [d]	47,305 [d]	41,118 [d]

a Includes estimated PYs for the anticipated Quebec ERDA sub-agrrement and the FOSTER Program; see Note c.

b Original sub-agreement in N.S. was for $35 million, of which only $20 million is currently approved (to FY 1988/89); the need for the balance ($15 million) will be reassessed in year two by provincial and federal governments and will depend on the availability of unds at that time.

c Projections only; discussions are in progress and funds/PYs have not yet been allocated.

d Indicates original allocations and does not reflect requested reprofiling. In 1984/85, a total of $24.1 million was unexpected; of this amount, $12 million is being requested for reprofiling into 1985/86, 1986/87 and 1987/88.

e Program funds exclude salary dollars.

III Resources

Fisheries Development Program ($000s) continued

Resources	Ontario 84-85	West	Pacific
O & M	74.5	205.8	273.2
Capital	0	37.6	3.5
PYs	.4	1	1

IV- Cost Recovery

Costs are not recovered from the client group for technological diffusion activities. Cost sharing on specific projects may take place with other levels of government.

Note: No separation is currently made between resources devoted to technology diffusion and resources devoted to other activities.