PRINCIPLES AND PRACTICES ADOPTED BY CANADIAN SCIENCE-BASED GOVERNMENT DEPARTMENTS AND AGENCIES TO FACILITATE TECHNOLOGY TRANSFER TO THE PRIVATE SECTOR

[Pilot Study]

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TO FACILITATE TECHNOLOGY TRANSFER TO THE PRIVATE SECTOR

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BACKGROUND

Canadian government research laboratories are under increasing pressure to demonstrate that they are contributing to the wealth and physical well-being of Canadians. Reviews of the relevance of the government's research agenda have taken place over the past few years and have given rise to numerous reports.

The most recent series of reports, under the general title, "Science and Technology for the New Century", outlines the government's plan to "allow Canada to take advantage of the worldwide economic shift to knowledge-based industries" (Government of Canada, 1996, p. 1) Among other things, the plan calls for improved management of science and technology (S&T) activities within the federal government. One aspect of this call for improvement is to encourage better management and commercial exploitation of intellectual property developed within government departments and agencies.

The section of the Summary entitled, "Annex: Commitments to Action", states, among other things:

> 5. The transfer of knowledge and technology is an explicit objective of federal S&T, and departments and agencies will be closely evaluated on their efforts in meeting it.
>
> 6. All science-based departments and agencies will develop strategies for promoting partnerships and collaborative S&T arrangements with industry, the provinces, universities, and other stake holders.
>
> 9. Federal departments and agencies will take measures to improve access to their facilities and encourage an open-door approach to others engaged in scientific research.

15. The federal government will start immediately to review its intellectual property policy in order to determine what improvements can be made to increase opportunities for commercialization and partnerships with the private sector.

16. The transfer of knowledge and the sharing of scientific information and data with Canadian researchers, schools, universities, libraries and industry will be a key function of all federal departments and agencies.

17. Federal departments and agencies will develop information services for dissemination via the Information Highway aimed at encouraging innovation, particularly at the community level.

These "commitments to action" fall under the general heading of technology/knowledge transfer from government laboratories to industry or academia. They do not mention a requirement that the laboratories charge for technology/knowledge transfer.

This pilot study is part of an on-going examination by Industry Canada into the relationship between government laboratories and industry, with special emphasis on intellectual property management. It supports the "commitments to action", as they apply to the transfer of technology or scientific knowledge to Canadian industry and the management of intellectual property.

PILOT STUDY OBJECTIVES

To identify and, where possible, document principles and best practices in cases of successful commercialization of intellectual property (IP) arising from either the straight transfer of government developed technology or scientific knowledge to the private sector, or the transfer of technology or knowledge that resulted from an R&D contract or collaborative R&D activities between government laboratories and the private sector. For the purposes of this study, software development was classed as a technology.

This pilot study did not evaluate or determine the commercial impact of adopting government-developed technology or know-how.

METHODOLOGY

Phase One of this study was an extensive review of the R&D management literature on technology transfer from government laboratories to industry to identify effective practices or factors associated with successful transfer of government technology or knowledge to the private sector.

In addition to the literature review, a limited number of interviews were held with members of the American Federal Laboratory Consortium both before and during their annual conference in Seattle in June of 1996. Subscribers to the web-site of the Innovation Research Centre of McMaster University were also asked to contribute their opinions on best technology transfer practices.

Phase One resulted in an updated report entitled, "Review of R&D Management Literature Concerned with Technology Transfer Between Government Laboratories and Industry" (Clarke, 1996).

Phase Two consisted of the identification of successful cases of technology transfer from Canadian government departments and agencies. Subsequently, interviews were held with the principals involved in both government and industry to identify factors or actions associated with the successful transfer.

Members of the Federal Partners in Technology Transfer Committee (FPTT), a group of public servants responsible for facilitating technology transfer from their respective departments, were invited, by letter, to assist in the pilot study. They were asked to provide information on two or three recent (within the past 5-6 years) examples of what they considered to be successful transfer of technology or scientific knowledge from their departments to the private sector.

The following members were invited to participate:

Agriculture and Agri-Foods Canada (AAFC)

Atomic Energy of Canada Limited (AECL)

Canadian Space Agency (CSA)

Communications Research Centre (CRC)

Department of National Defence (CRAD) *

Environment Canada (EC)

Fisheries and Oceans Canada (F&O)

National Research Council of Canada (NRC)

Natural Resources Canada (NRCan)

* Chief Research and Development, the R&D arm of D.N.D.

A four page summary of the factors and practices associated with successful government-to-industry technology transfer identified in the literature search was included with the letter (Appendix A).

Agriculture and Agri-Foods Canada, and Environment Canada declined to take part in the study.

After successful technology transfer cases had been identified, structured interviews were held with both the departmental technology transfer officer or a scientist closely associated with the transfer, and an official of the recipient company to identify the factors that the parties felt had contributed to the successful transfer. In most cases, personal interviews were conducted with government personnel. Some of the industry interviews were conducted by telephone.

Interviews were also held with personnel in Public Works and Government Services Canada.

Web-sites maintained by the science-based government departments were visited to see the types of information they provide and to determine whether they "advertised" technologies available for licensing.

Industry respondents were contacted initially by telephone to elicit their cooperation. They were then faxed a letter which outlined the questions to be covered during the interview, and the four page summary of factors and practices described above. All industry personnel contacted provided information for the study.

PHASE ONE - SUMMARY OF THE LITERATURE REVIEW

The complete report, "Review of R&D Management Literature Concerned with Technology Transfer Between Government Laboratories and Industry", is available from Industry Canada. The following is a summary of information contained in the technology transfer literature.

Unrealistic Expected Payoff from Technology Transfer

There is a general expectation that government laboratories are a repository of a large amount of commercializable technology and one only needs to uncover it to start the money rolling in.

Experience, however, teaches that "cash cows" are not lurking in government laboratories. In the U.S., the various Acts of Congress to promote technology transfer have not resulted in a significantly large percentage return on the U.S. government's investment in internal R&D. In the U.K, efforts to commercialize technology from their defence department were unable to even cover the costs of the commercialization effort.

Papadakis (1995), in a major review of the U.S. federal laboratory system, observes that, "the vast majority of the [U.S. federal laboratory] system (about 80% of the labs) has no meaningful role in American competitiveness, while the remaining labs are characterized by powerfully entrenched agency missions with circumscribed economic roles". She notes that much of the R&D of the federal laboratories flows directly to the government or to regulated organizations for achieving government-imposed performance standards in health, safety, environmental quality, etc. She concludes that "there is no reason to believe that the federal laboratory system can directly enhance U.S. international competitiveness". She further concludes that, "in order for federal laboratories to contribute to competitiveness, they must have explicit missions to do so". She states that "spinoff transfers" are the best that can be hoped for from those laboratories that have some commercial orientation.

There is no reason to believe that the situation in Canada is any different from that in the U.S. or the U.K.

Fit With Departmental Mandate

Government technology transfer programs can be divided into two categories depending on the mission of the laboratory: "Technology Spin-off Programs", and "Technology Utilization Programs" (Table 1, from Mock, et al, 1993).

Technology Utilization Program

In a technology utilization technology transfer program, the mission of the government laboratory is to improve or create technology specifically for use in the private or non-government

sector. The principal mission of the laboratory can only be achieved if successful technology transfer occurs.

In Canada, government laboratories falling into this category include Atomic Energy of Canada Limited (AECL), sections of Agriculture and Agri-Foods Canada, the CANMET unit of Natural Resources Canada and the National Research Council.

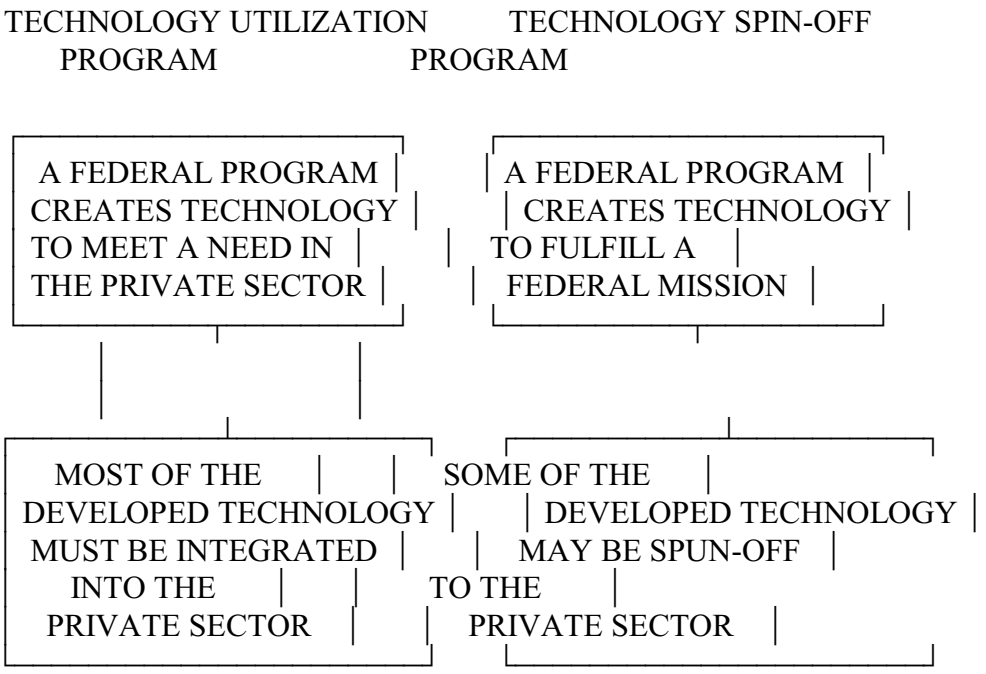

Figure 1. Types of Technology Transfer Programs

Technology Spin-Off Program

A technology spin-off technology transfer program tends to be associated with government laboratories involved in environmental, health or defence research where the primary results of the research are targeted at meeting the department or agency's policy or regulatory mandate, or the needs of an internal client (e.g., DND where the primary client is the Canadian Armed Forces). Only some of the technology developed in the laboratory is appropriate for transfer to the private sector and it may be used for purposes other than those for which it was originally created. In this case, the primary mission of the department or agency can be fulfilled even if technology transfer efforts to the private sector are ineffective.

Technology Transfer Strategy

The strategy used by the department or agency to transfer technology to the private or non-government sectors is dependent on the mandate or mission of the laboratory. In technology utilization programs, the non-government end-user's needs should be pre-eminent in planning the research program and therefore should involve considerable consultation with the end-user. In spin-off programs, the main thrust is to identify "dual use" technology or research results that will benefit industry as well as the internal departmental client. The focus is on having a quick response time so that potential industrial partners or adopters can be involved as soon as possible in the research or development phase of a project.

Technology Transfer Mechanisms

Technology transfer can take place in a number of ways, and government organizations may use several different mechanisms or channels to move technology or knowhow to the private sector. Roessner and Bean (1994) identify the following mechanisms:

- Publications produced by the government laboratory (e.g technology awareness reports, media announcements) and other publications containing articles reporting on laboratory results (e.g., trade and learned journals, conference proceedings);

- Workshops/seminars conducted by federal laboratory scientists or engineers to disseminate information on new or emerging technologies with possible applications to industry;

- Laboratory visits by industrial technical personnel to share information and discuss technical problems with government personnel;

- Technical consultation with industry by technical and scientific laboratory personnel with unique expertise;

- Industrial use of government facilities where unique government facilities exist (e.g., wind tunnels, particle accelerators);

- Personnel transfers where government personnel involved in the technology development temporarily go to the receiving organization, or industrial personnel who will be involved in the adoption of the new technology work in the government laboratory before the transfer;

- Cooperative R&D where government and industry researchers work together to develop the technology;

- Sponsored R&D where industry contracts with the government laboratory for

work on a specific project (i.e., contracting-in);

- Contract R&D where the government laboratory contracts with a private sector firm or consortia to conduct research (i.e., contracting-out); and

- Licensing where the government department or agency licenses the technology to a firm on either a exclusive or non-exclusive basis.

Other transfer mechanisms include:

- Pilot testing of government developed technology by the private sector to demonstrate the technology;

- Data banks containing information about federal government research (e.g., U.S. Federal Government Research In Progress (FEDRIP) data bank, Canadian National Technology Index);

- Information dissemination centers designed to answer requests from industry about research or to put requesters in contact with expert personnel within the organization;
- Industrial shows, exhibits and trade fairs to provide a broad spectrum of potential industrial adopters with information about the technology;

- Industrial visits by government scientists and engineers to learn about industrial technical problems and opportunities for the application of government developed technologies or technical information;

- Third party organizations, such as the U.S. Federal Laboratory Consortium, the U.S. National Technology Transfer Center, and Canada's National Technology Index, that are set up or given the mandate to facilitate the transfer of government technology to the private sector; and

- Internet Web-Sites established and maintained by the individual government laboratories that list technologies, expertise and facilities available to the private sector.

As can be seen from the above list, many of the mechanisms are quite formal, requiring some kind of contractual agreement (e.g., licensing, contract R&D, and sponsored R&D) and others are, or can be very informal (e.g., publications, consultations, trade shows, and laboratory visits). Thus in any exhaustive study of technology transfer from government laboratories to industry, the broad range of mechanisms should be addressed. Although important, licenses are only one of the many channels by which government developed technology and knowledge finds its way to industry.

Use of Technology Transfer Mechanisms

In a review of the Canadian laboratory system in 1990, Niosi and Manseau (1994) reported that government respondents found the following technology transfer mechanisms to be "very successful" (% of labs that found mechanism very successful):

- Person-to-person contact - (87%);
- Cooperative R&D - (67%);
- Contractual relations for direct R&D funding - (46%);
- Memberships in R&D consortia - (41%);
- Encouraging informal visits - (36%);
- Permitting outsiders to access labs - (36%);
- On-site seminars and conferences - (33%); and
- Sales of patents, licenses, etc. - (33%).

Presentations at scientific meetings, fliers, newsletters, personnel exchanges, and a centralized technology transfer office were considered successful mechanism by less than 28% of the government respondents. Quality of effort would affect the success rate of these mechanisms but this was not discussed. Both the industrial and academic respondents ranked person-to-person contact first as a successful mechanism for technology transfer. Potworowski and Caloz (1994) identified what they felt to be the best practices in technology transfer when the mechanism for transfer was an R&D consortium. Among the best practices they reported were:

- receptor companies carry out a parallel in-house project to that in the consortium to draw out all relevant information;
- member companies have a liaison representative on the project team; and
- consortium signs specific contracts to ensure that the technology is not only transferred, but adapted, implemented and commissioned in a member's company plant.

The authors noted that these practices all involve close links between the technology developer or consortium and the receptor or member company.

Why Firms Interact with Government Laboratories

Published studies identify several major reasons why companies approach federal laboratories for assistance.

In a study of collaborative interactions between federal government laboratories and industrial partners, Bozeman and Papadakis (1995) found that the major commercial reasons for, or objectives of companies that interact with the federal laboratories were (in order of priority):

- engaging in strategic pre-commercial research;
- interest in accessing unique resources of the lab;
- desire to develop new products and services;
- improving products; and
- solving a technical problem.

The authors noted that "obtaining technology" was mentioned in only 24% of the cases of technology transfer examined, leading them to suggest that, "a narrow focus on licensing and tangible technology transfer can underestimate the commercial role of the federal laboratories".

Bozeman and Papadakis found that, in deciding whether to work with the U.S. federal laboratories on a specific project, U.S. companies valued:

- gaining access to the skills and knowledge of the federal laboratory scientists and engineers;
- gaining access to the unique expertise of the laboratory;
- previous personal contacts with the lab personnel; and
- access to equipment and facilities.

"Having been contacted by the federal laboratory" was ranked at the bottom of the list.

The types of commercially relevant interactions used by their industrial sample, ranging from Cooperative Research and Development Agreements (CRADA) to government scientists working at the firm, are shown in Figure 2.

Figure 2: Types of U.S. Company-Laboratory Interactions

The category "Coop R&D (not CRADA)" covers informal or casual co-operative or collaborative R&D activities between a government and industrial laboratory that are not covered by a formal CRADA agreement.

Measuring the Impact on Industry of Technology Transfer

A major concern noted in the literature, is the tendency of people to look only at licenses or patents as the measure of success of commercial government laboratory-industry interaction. As noted above, licensing is only one of many mechanisms for transferring technology or know-how to a potential adopter.

The low ranking of licenses, as shown in Figure 2, makes the number of licenses issued by a laboratory to industry a poor indicator of a laboratory's interaction with the private sector.

Carr (1992) states that while measuring market impact through measures such as royalty

income is an attractive approach, he believes that "it is not a very useful tool for technology transfer managers in the short term" as revenues usually lag licensing by many years and vary dramatically from license to license. He points out that half of Stanford University's royalty stream comes from just one "home-run" license. He suggests surveying the industrial recipients of government technical knowledge, technologies, etc., to learn about the complete impact of a laboratory on the commercial competitiveness of a firm.

Roessner (1993) states that measuring the effectiveness of industry-government laboratory interaction only in terms of technology transfer (e.g., licenses and royalties) is too limiting and will substantially underestimate the full value of the government laboratories to industry. He further states that more appropriate measures of interaction are the intermediate ones of:

- number of technical papers authored jointly with industry;

- company patents and invention disclosures directly attributable to collaborative work;

- new development projects undertaken by companies as a result of interaction with a federal laboratory; and

- technical problems solved, or dead-ends avoided as a result of information obtained from the government laboratories.

Bozeman and Papadakis (1995) argue that "much of the activities of laboratories involve processes that are quite fluid and informal, and the entity transferred is not a finished technology, but a prototype, a process, or practical knowledge or know-how, e.g., technical assistance".

Factors and Practices Associated with Successful Transfer

Common threads or themes associated with successful technology transfer can be identified. Some of these are organizational factors; others are practices or actions taken by the government laboratory to enhance transfer. (See Appendix A for the complete list.)

Neil Smith (1995), Manager of Intellectual Property of AECL, in a presentation to the Licensing Executives Society Annual Meeting in 1995, outlined what he believes to be the more important and obvious success factors in licensing technology to existing or newly spun-out companies:

- the key technical staff must be committed to the success of the technology transfer, and be directly involved;

- ideally, the transfer should involve the key technical people moving out (either permanently or on temporary loan) with the technology to the licensee;

- the licensee must have people in place who can understand and implement the technology effectively, and should also have strong managers;
- on-going collaboration between the licensor and the licensee during the product development activities to maintain the interest of the original inventors; and

- the existence of a clearly defined and understood agreement on the expectations of both parties is essential.

Smith also believes that the geographical proximity of the licensee and licensor is an important success factor that should not be underestimated. Studies of communication patterns in R&D organizations confirms that the closer two scientists are to each other geographically, the greater the probability that they will communicate on a daily basis, especially if they share a common scientific interest.

Smith noted that technology transfer failures are more likely to occur with the more traditional form of technology transfer, i.e., a license with no ongoing involvement of the developers in the technology. "In an arms-length license, the people cease to be involved once the agreement is consummated".

The following provides additional support for, and elaboration of many of the factors mentioned by Smith.

Prime Requirement - Good Interpersonal Interactions

A major factor reported in most, if not all, of the articles reviewed is the importance of person-to-person contact in technology transfer, that is, contact between the inventor(s) and the technical staff adopting the technology or acquiring technical knowhow/information (Souder, Nashar, and Padmanabhan, 1990; Wood and EerNisse, 1992; and Roessner and Bean, 1991, 1994).

Close interaction can occur in several ways: through partnerships where the scientific personnel in the adopting firm are collaborating with the government scientists to develop the technology; by having the inventor(s) move temporarily along with the technology or knowledge to the adopting firm, or having personnel from the adopting firm spend time in the government laboratory while learning about the technology. Involvement of the government inventor(s) in some capacity in the downstream development of the technology or use of the technical knowledge is an essential element of successful technology transfer.

Roessner (1993) recommends that, to maximize idea transfer, federal laboratories and public policies should encourage close personal interaction among scientists and engineers in government laboratories and their counterparts in industry. The most effective mechanisms for this are professional meetings and conferences, laboratory visits, seminars, workshops, and cooperative research. He states that public funds should be spent to support travel to conferences by federal laboratory and industrial researchers, industry visits to federal laboratories, and sabbaticals or temporary assignments of federal laboratory scientists to industry and vice versa.

Martin et al (1978), in a study of the transfer of Canadian government developed technology to small and newly established firms, found that a key factor in the successful transfer via license was a continuing close working relationship between the originating laboratory and the recipient company. He found that interpersonal contact among government and company scientists was very important.

Organizational Factors

The literature notes that management support at all levels in both the originating government laboratory and in the adopting private sector firm for the transfer process is a necessary factor and ensures that adequate resources are provided. Bhaneja et al (1982), in a review of eight cases of technology transfer from the Department of Communications to Canadian industry, found that support of senior management at the Director General and Assistant Deputy Minister level was one of the critical factors in determining the success of the transfer process.

Technology transfer champions who assist in clearing away bureaucratic obstacles and maintaining the enthusiasm for the transfer are also considered to be essential. The transfer process is also enhanced when government "red-tape" is at a minimum and there is an effective royalty-based incentive system in place to encourage the government employees to think about commercialization of their work.

Organizational Practices

Government departments concerned with improving their technology transfer process usually implement certain organizational practices that assist the transfer process. Among the practices identified in the literature are instituting an inventor-friendly invention disclosure and patenting system so that government scientists do not become tangled up in a lot of internal paperwork, that might make them reluctant to bring inventions to the attention of their superiors.

The literature also notes that senior government management should convey to their scientific staff that technology transfer is a legitimate and valued activity. One method of doing this is to have a suitable reward and incentive system that encourages the scientists and engineers to become involved with the commercialization of their work. Bhaneje et al (1982) believe that including technology transfer activities in the performance evaluation of scientific personnel is a critical factor for success. Involvement in the commercialization process is enhanced if the government employees have received management training so that they understand the new product development process and the challenges facing potential adopting firms.

Marketing Practices

The marketing practices of government laboratories are as important in technology transfer as their technology development activities. If the marketing fails, the technology or knowledge "stays on the shelf", unexploited. Marketing practices include "customer" identification, determination of the "selling" price and terms associated with the intellectual property and general advertising of the laboratory's "wares".

A major theme of the literature is that government laboratories should be pro-active in letting the private sector know what they have, and about their interest in working with the private sector in collaborative research activities. Another benefit of pro-active marketing is identification of potential industrial partners or adopters as early in the research and development process as possible. Studies show that the earlier the involvement of the potential adopter, the higher the probability of successful transfer and commercialization.

Among the key marketing practices recommended in the literature is identification of the technological needs or challenges facing potential partners or adopter organizations. This can be done by formal marketing studies or, informally, by having scientific staff meet with their industrial counterparts through visits to companies or during conference attendance to learn about common areas of research interest. Where commonalities of research interest occur, there is potential for collaboration or exchange. A good understanding of the industry and the companies in it, also enables a laboratory to make more efficient use of its technology transfer budget through targeted marketing approaches, i.e., contacting only those companies with similar research interests.

A flexible approach to managing intellectual property is also identified in the literature as an important marketing tool. Assignment of sole rights to intellectual property encourages adopting companies to make the additional investment needed for technology development. In a review of commercialization resulting from Canadian government contracts, Supapol (1990) refers to an earlier 1968 study that found that commercial utilization of inventions that arise from research performed under government contract was greater when the contractor had the rights to the invention. His own study found the same results. He stated that, "Contractor retention of property rights is therefore stimulative to private commercial exploitation".

Deferring up-front license fees and royalty fees is especially attractive to smaller firms that need all their financial resources for further development and marketing. Another effective marketing practice noted was advising potential adopters clearly of the government's intentions regarding ownership/licensing of intellectual property rights.

Inviting industry personnel to visit a government laboratory, either at an "open-house" or as individual visits, is a key tool in making industry aware of the laboratory's interest in working with industry in some capacity.

Although they are a more passive approach to marketing, trade magazine articles, fact sheets, displays at trade shows, and the Internet are methods by which outsiders learn about the research and development activities and capabilities of government laboratories.

PHASE TWO - GOVERNMENT AND INDUSTRY SURVEY OF FACTORS AND PRACTICES THAT FACILITATE TECHNOLOGY TRANSFER

This section identifies areas of agreement among government and industrial respondents on both the positive and negative factors and practices associated with the transfer of technology or know-how from Canadian government laboratories. Although this is a pilot study that examined a very limited number of cases, and only a small number of industrial and government officials were interviewed, the findings, in general, agree with those outlined in the extensive literature review.

Interviews were held with twenty-three government personnel, comprising technology transfer officials and bench scientists or engineers associated with a specific case of technology transfer, and officers from thirteen companies across Canada from Dartmouth, Nova Scotia to Victoria, B.C. Company size ranged from new start-ups to well-established mid-sized firms. Although only ten technology cases were selected, respondents commented on other examples.

This pilot study did not cover all forms of technology transfer. Only cases that involved some form of contractual arrangement were reviewed. The many other informal mechanisms that the literature review showed to be as commercially important as the more easily identified formal arrangements were not examined.

Intellectual Property Management

Intellectual Property Management Software

Several departments and agencies such as NRC, CRC and DND use sophisticated software to keep track of licenses and agreements with the private sector.

IP as a Source of Income for Government Laboratories

> "I am constantly convinced we make too much of IP" - Senior Public Servant

None of the government personnel interviewed said that revenue from licensing was a major source of funds. Most stated that "contracting-in" was a much larger source of funds, by several orders of magnitude. One departmental respondent said that the department receives approximately $100,000 annually in royalties and earns $10 million from R&D contracts.

One respondent noted that for all the government technology the former Canadian Patents and Development Limited (the organization that used to commercialize Crown-owned intellectual property) controlled, revenues were about $2 million per year, which did not cover operating costs.

AECL claims to have about 30 active licenses that generate a royalty stream of about $400,000 which "sort of covers" the costs of managing their intellectual property. AECL's business plan estimates envisage a growth in royalty revenue to only $1 million by the year 2000 (Smith, 1995).

Only one government respondent stated that his department was covering the costs of its technology transfer activities from license and royalty fees. Another said that his department had 61 royalty bearing licenses out of a portfolio of over 230 patents.

Identification of Intellectual Property

Several government respondents said that their departments had set up business development or technology transfer offices to assist in the identification of commercializable intellectual property.

Two cases were cited where industrial personnel had been invited to review technologies in the government laboratory to determine whether any on them had commercial potential. The British have nicknamed such industrial reviewers as "technological ferrets".

Government respondents believed that an "inventor-friendly" disclosure system and provision of assistance to government employees in filling out disclosure forms were important elements in encouraging government scientists to disclose potentially patentable work.

Licensing Government Developed Technology or Know-how

" We negotiated a painless licensing agreement"

"Make sure the technical person (inventor) has no say in determining the commercial value of the technology"

These quotes from two industrial respondents illustrate both praise and complaints about the way departments handle the issue of licensing intellectual property.

In all of the cases of technology transfer examined during this pilot study, the technology or know-how was developed by government personnel and the resulting intellectual property was owned by the Crown. Thus the concerns mentioned by the industrial respondents were in connection with the way the federal government departments managed the licensing of their intellectual property.

Several small or newly established firms were pleased that the departments they were dealing with did not ask for large up-front license fees but were willing to wait until a royalty stream was generated.

One firm's respondent (first quote) was very happy with the flexibility shown by the government department in managing its intellectual property; the government department provided

a six month money back guarantee that the technology being licensed would work as promised. In addition, the department provided a blanket, non-disclosure agreement so that communications between scientists in the company and the government laboratory on future technologies for transfer would be speeded up.

The same department, when faced with patents that they could not market on their own, was willing and able to enter into an agreement with a private sector firm that held complementary patents to combine their patents to produce a more complete licensable package. This package was successfully licensed to a Canadian firm.

Another industrial interviewee stated that the willingness of the government department to grant him a sole license was vital to his decision to start a new company around the technology.

A common complaint by several industrial interviewees and at least one regional government technology transfer officer was the time it took to obtain a license. The problem appeared to be the many layers of departmental approval before a license is issued. One respondent said that because of the many approval layers in the department they dealt with, they had to make their case for a license at each level. In this particular department, the unit responsible for licensing is both geographically and organizationally separated from the R&D units. Industry is also concerned that the "window of opportunity", a concept that several respondents felt some government personnel did not understand, can be lost if license negotiations drag on too long.

One respondent also stated that there should be a commitment by a department that a firm is going to receive a license, especially if the firm is sharing in the development costs in a collaborative R&D project. This would allow the firm to start working on commercial opportunities while still in the R&D stage.

Concerns were also raised about some departments' policy of taking ownership of any IP developed in their laboratories when they do contract work for a company (contracting-in). This concern was noted in an earlier study conducted for Industry Canada (Clarke and Reavley, 1995). Because of this "we do it, we own it" stance, some firms no longer contract with the government laboratories for R&D work in their core technology areas.

The government's reluctance to issue sole licenses for an area of application also causes concern. One company representative said they were taking a risk by accepting a non-exclusive license with only a promise from the department not to license to others. Another commented that technology transfer officers do not understand the need for exclusivity. His company has investors standing by <u>if</u> it can obtain a sole license to some technology in a specific area of application from a government department.

Some respondents believe that the demand by some departments for up-front fees and a minimum annual royalty biases the licensing system in favour of larger and possibly foreign owned firms. They felt that payments should only be required from small companies when the technology actually produces a cash flow.

One company questioned the ethics of one government department in asking for a royalty statement as part of a bid on a request for proposal for an R&D contract.

Several respondents complained about valuation problems associated with determining the license and royalty rates. One said that one department routinely starts its licensing negotiations in the 20-30% range, which he felt was unreasonably high.

As noted in the second quote above, some government inventors have unrealistic expectations about the value of their inventions. This can lead to unrealistic demands for fees unless, as happened in one case, the business development officer ignored pressures from the inventor to charge a high rate.

Several government interviewees acknowledged that valuation of technology was a difficult task. They were actively looking for ways to improve the process to make it more equitable for both the developer and the adopter.

Royalty rates and license fees charged by government should reflect the level of investment that will be required by the company to commercialize the product or service. In general, the higher the corporate investment, the lower should be the royalty rate or license fee. One respondent complained about a technology transfer officer who did not understand the need for additional costly development of a technology, and therefore tried to get, in the industrialist's view, an unrealistically high license fee and royalty rate. Another noted that government personnel lack marketing knowledge and therefore do not understand the many additional expenses needed to commercialize a product.

Technology valuation problems with government departments prompted one respondent to state, "It is always preferable to obtain technology from a private sector source rather than from a government lab; both [private sector developer and adopter] know the value of the technology in the market place".

Guidelines for Prospective Adopting Firms

Many of the government respondents said that they provided prospective licensees with a written guide to assist them in preparing a case for acquiring a license from the government laboratory. For example, the Defence and Civil Institute of Environmental Medicine in Downsview, Ontario, provides prospective licensees with a "Guideline for Preparing a Commercial Outline". (See Appendix B) The NRC guideline is entitled, "Guidelines for Developing a Business Proposition".

Technology Transfer Mechanisms

Promoting R&D Partnerships or Collaboration

One senior government respondent argued quite strongly that the best examples of technology transfer occur when the government does not have to transfer technology in the first place, i.e., where the technology was developed by the private sector under some financial arrangement with a government lab. "You not only have the technology in place right away but you have established an innovative capability in the industry that has the experience, know-how, and credibility to not only 'push' the technology but also to adapt it to other applications".

He stated that, "the best role for government is to provide the need [for the technology], the funds, and the showcase". The government can incorporate its in-house developed technology into the final product as work progresses. Use of the end product by the government provides feedback on its operation as well as credibility to the manufacturing firm when it markets the technology elsewhere. Several other departments, including NRCan and NRC, said that early involvement of industry in partnerships or collaborative R&D was their technology transfer mechanism of choice.

Another government respondent believed that the use of the Unsolicited Proposals Brokerage Service (UPBS) to promote consortia of government departments to provide financial support for industry-proposed R&D projects was a "best practice". The respondent felt that the UPBS, "breaks down old cultural and often parochial barriers between government departments, and promotes the efficiency of alliances and teamwork with government".

In private correspondence, Carl Krasnor of Brock University's industrial liaison office, shared his view of technology transfer. "The most desirable situation for technology transfer and especially commercialization is that the research which produces the technology be carried out as a dynamic partnership between the industry and the [government] laboratory. It is very rare that a technology produced in isolation in a laboratory by non-business scientists will effectively meet a commercial need".

Development R&D Contracts

The use of R&D contracts to facilitate the movement of technology and know-how from government departments to the private sector and on to the market place is clearly an important tool. In the cases reviewed in this study, several government departments provided not only technical and scientific support but also financial support in the form of an R&D contract to assist in the further development of the technology. As noted earlier in the literature review, Niosi and Manseu (1994) found that 46% of their respondents said that contractual relations for direct R&D funding was a very successful technology transfer mechanism.

Without on-going assistance in the form of financial support through a development contract, many firms, especially smaller high technology firms, would not have a chance to develop new products or services. As noted above, development contracts also ensure that there is a link between the technological needs and interests of the government laboratory that issues an R&D contract and the firm that is seeking to commercialize the resulting technology or know-how. This can promote a longer-term relationship beyond the time period of the contract. The two major sources of financial support mentioned were the Industrial Research Assistance Program managed

by NRC and the now defunct Defence Industry Productivity Program that was managed by DND.

Factors and Practices That Facilitate Technology Transfer

The following factors and practices were identified by the interviewees as being important in assisting the transfer of technology or knowhow from a Canadian government laboratory to the industrial adopter.

Working Relationship Between Government and Industry Engineers and Scientists

> "The effectiveness of the transfer is determined to a great extent by the level of involvement of the government scientists in the development phase of the project" - F&O Respondent

All the government and industry interviewees emphasized that the technology transfer process is greatly facilitated when there is a good working relationship among the government scientists or engineers who invented or developed the technology or know-how, and the adopting company's scientists and engineers who have to develop it into a marketable product or service. This results in a team working relationship that can bridge geographical distances and foster the transfer of timely advice and technical assistance.

Several respondents pointed out that this type of close relationship is fostered when the government laboratory and the industrial laboratory share common technological interests, i.e., when there are areas where their R&D strategies overlap. One department reviewed IRAP proposals as a method of identifying such areas of overlap.

In several of the cases examined, the scientific personnel knew each other before the transfer took place through working together on earlier R&D contracts.

The literature review on technology transfer identifies face-to-face contact between developers and adopters as the most important mechanism of technology transfer. Respondents to this study confirmed that view.

Mobility of the Government Inventor and Industrial Personnel

The ability of the government inventor/developer to move with the technology on either a permanent (spin-out) or temporary basis was identified in the literature as a key practice in encouraging efficient technology transfer. This practice is followed by the government departments contacted. In two cases, the government inventor moved out to start a new firm; in one, a government employee spent a year on sabbatical leave in the adopting firm.

The flip side of government personnel mobility is the temporary transfer of industrial personnel into the government laboratories to use their facilities. This was also identified as an

important practice by government departments but it does not appear to be used often.

Champions

Technology transfer champions in both the government department and the adopting firm were considered to be an essential factor for success. The champions did not allow obstacles to get in the way of successful transfer. In many of the cases examined, the head of the laboratory was named as the government technology transfer champion; in one case the champion was the department's chief technology transfer officer.

This agrees with the literature which clearly identified the presence of technology transfer champions as being an essential element in successful technology transfer.

Encouragement to be Involved in Technology Transfer

Although there was support at the local laboratory management level in the cases examined, some departments did not have organizational rewards, recognition or encouragement for government scientists and engineers to be involved in technology transfer.

One government interviewee did not believe that senior management in headquarters were sending a clear message to the laboratories that technology transfer was a valued activity. As a result, the present thrust for technology transfer was viewed by many of their scientists, as the "fad of the week".

Two government respondents complained about user-unfriendly licensing systems in their respective departments.

The failure to return some of the revenue from license and royalty fees to the originating laboratory was seen as a serious lack of encouragement for technology transfer activities.

Government Laboratory Culture

"If technology transfer is in the culture of the laboratory, then experiments can be designed with technology transfer in mind" - NRC Laboratory Manager

Although technology transfer has been informally encouraged in the past, the March, 1996 publication of the Canadian government's report series, "Science and Technology for the New Century", increases its priority in the operations of government laboratories. This should reinforce a culture change that is taking place in government laboratories to promote closer relationships among government and industrial laboratories and personnel.

Both government and industry interviewees agreed that the active support of laboratory management, in both the developer and adopter organizations, was a key element in the successful transfer of the technologies studied.

Several industrial interviewees mentioned that a positive factor in successful transfer was that they were dealing with government scientists and engineers who were enthusiastic about seeing their inventions/developments commercialized and applied.

Two industrial respondents also noted that there were people on the government side who had some knowledge of their industry and their business. One said that the departmental representative had taken the trouble to learn something about their business.

Government Scientists'/Engineers' Knowledge of the Technology Transfer Process and New Product Development

> "[Bench level scientists and engineers] need real world training [so that they can understand the concerns and actions of business in developing a new product or process] from the private sector and not just a government bureaucrat's lecture" - Government Scientist.

Both government and industrial respondents commented on the lack of knowledge of government scientists and engineers about technology transfer, management of intellectual property and the new product development process. This affects relationships between the government laboratories and industry. Several business development officers admitted that they had not had any training in technology transfer or new product development.

Industrial interviewees were asked if there was any kind of training and development that could be provided to government personnel to help them be more successful with technology transfer activities.

In general the replies had the common theme that the bench scientists or engineers need to understand that development can stop when the product or service meets the needs of the end-customer. Respondents felt that government scientists were reluctant to "let their baby go" and to stop trying to improve the technology by adding bells and whistles the end user did not want. They also noted a fear among some scientists of losing control of their projects to the private sector.

One respondent thought that it would be advantageous if government laboratory personnel had some industrial experience and vice versa. This would give them a better understanding about technology transfer and the costs of developing new products or services.

Knowledge about the new product development process might reduce the incidences of scientists trying to pressure companies into adopting their technologically elegant, but unmarketable technical ideas. As one industrial respondent said, "We don't do R&D just because

it is fascinating".

Some departments have provided their scientific staff with some limited training or information booklets to assist them in technology transfer and intellectual property management.

In 1996, the Department of National Defence (DND) published, "A Guide to the Technology Exploitation Process for CRAD Scientists and Managers". The main chapters cover topics such as:

- Creation of New Intellectual Property
- Identifying and Evaluating New Intellectual Property
- Protection of Intellectual Property
- Commercialization of Intellectual Property

In addition, the guide contains sample forms: a Business Opportunity Document, and a Invention Disclosure form.

Respondents at one of the CRAD/DND laboratories also said that their staff had attended in-house seminars on technology transfer and IP management. One of the objectives of the seminar was to encourage laboratory personnel to think about dual applications of the work they were doing for their primary military client.

An NRCan respondent said some of their scientific staff had taken some university marketing courses to assist them in marketing their expertise and technologies.

CRC has published some information pamphlets to assist their employees in dealing with technology transfer issues.

No department mentioned sending their scientific staff on technology commercialization or new product development courses that deal with high technology. The need for this training has been identified by the Treasury Board Working Group looking into R&D management training for government scientific personnel (Varette, 1996).

Both groups of respondents recommended that suitable training and information be provided to government bench level scientists and engineers, and anyone else whose job it is to transfer technology to the private sector.

Characteristics of an Effective Government Technology Transfer Officer

One government respondent felt that important factors in technology transfer were the skills

and knowledge that the government technology transfer officer brings to the job. Specifically mentioned were:

- good interpersonal skills that enable the officer to build a trusting professional relationship with both the government inventor/developer and officials in the adopting firm;

- an understanding of the technology being transferred;
- an understanding of the prospective company/industry to which the technology is being transferred;

- a good understanding of intellectual property management; and

- an educational and work experience background that includes both science and business.

Several of the technology transfer/business development officers interviewed had legal backgrounds but no technical background and some had no management training in technology transfer or new product development.

Company Perspective

Company Commitment

Industrial and government interviewees pointed out that company commitment to the transfer and future development of the technology is essential. When the technology or know-how is viewed by the company as a key part of their technological strategy, and their own financial resources are used, there is a higher probability that the transfer and commercialization will succeed. Thus the active support of senior and middle management in companies is an important element supporting the transfer process.

Having the financial resources to hang in through "thin financial periods" or between development contracts was considered by both industry and government respondents as a positive factor.

Company commitment also encourages the company to work to develop and maintain an on-going, good relationship with government personnel (e.g., helping government scientific personnel out when possible, at no charge).

As noted earlier, a technology transfer champion in the firm was also mentioned as an important factor in successful transfer.

How Companies Learned About the Technology

The most common methods by which companies learned about the availability of a technology or know-how were monitoring the activities of specific government laboratories and/or through good personal contacts in a laboratory.

No one mentioned learning about licensing opportunities from non-personal sources, such as fact sheets or computer listings, although one respondent said that one of his sales representatives on a visit to a government laboratory came across a research report and recognized its commercial potential.

In one case an entrepreneur went to a government laboratory and asked the manager to show him what he had available for licensing. This resulted in the start-up of a new company. In a few cases, government laboratory personnel "spun-out" to start or join a firm.

Regardless of the exact mechanism, interpersonal contact played a key role in learning about the technologies for license.

Stage of Involvement of the Firm

In most cases examined, the government laboratory had fully developed the technology to the stage where the adopting company could make immediate use of it. In only a few cases was the technology at the stage of proven scientific or engineering feasibility. The companies then either merged the government technology with some of their own, or developed it further for a new application.

In two cases, testing the new product or process to finalize its design and proving its performance to potential customers took many years.

Impact of Technology Adoption on the Company

Industrial respondents were asked whether the technology or knowhow adopted had an immediate impact on the firm, or whether the effects were downstream.

Most of the respondents said the impact was relatively immediate. In some cases, a company was created around the technology. It should be noted, however, that in many cases examined, commercial success is still to be achieved.

In two cases, the respondents said that the government technology allowed them to move ahead faster and save time and resources as their products incorporating the government technology/knowhow were marketed much more quickly.

In only one case, associated with a medium sized firm, was the impact longer term as it took about eight years to fully develop the technology. During this time, there was a close working relationship between the government laboratory and the company.

Other Forms of On-going Assistance

In addition to technical advice and assistance, government and industrial respondents mentioned other forms of assistance.

Several industrial respondents said that the departments they dealt with assisted them in marketing the finished product to foreign governments.

In addition, many respondents pointed out that working with government laboratories provides smaller firms with a level of credibility that they can use in approaching prospective investors or foreign buyers.

Marketing Government Laboratories To Industry

> "To the extent that government laboratories are still inventing something, completing it, and then looking for an adopter, probably means the laboratory is severely mismanaged" - NRC Respondent

The marketing of government laboratories to industry involves not only formal patents and licenses but also the many informal methods by which government and industry personnel get to know each other and their respective capabilities and technological needs.

Both sides agreed that government efforts to learn about the nature of the business their prospective technology adopters are in, and learning about their needs is a "best practice". To facilitate this, most government departments have established a "business development office" in their laboratories.

Government laboratory "open-houses" were also regarded by both sides as an effective practice. In most of the cases examined, industry found out about technologies available for license either through personal contacts, or visits to the laboratory.

One government department has found conference attendance a valuable method of identifying companies that might be interested in licensing their technologies. However budget constraints and Treasury Board restrictions on conference attendance are limiting use of this marketing approach.

The same department also makes use of the Industrial Technology Advisors of NRC's Industrial Research Assistance Program (IRAP) as a "dealer network", to advertise its technologies and expertise across Canada.

Respondents in industry and government questioned whether government personnel were traveling out to firms frequently enough to be kept up-to-date on problems or needs.

At least two industrial respondents thought that the departments they deal with needed to

strengthen their marketing activities.

One departmental official said that they no longer had the financial resources to hold "open-houses" for industry, or to travel to out-of-the-way places to visit prospective clients.

Web-sites

As part of this study of technology transfer practices, the web-sites of the various government departments were visited to determine what use they were making of the Internet to advertise expertise or technologies for license. (See Appendix C)

Most departments use their web-sites simply to tell the world about their areas of research.

The site operated by DND's Ottawa research laboratory (DREO) mentions their interest in establishing collaborative R&D ventures with the private sector.

Only CRC, NRCan, NRC and the National Water Research Institute of Environment Canada were explicitly advertising technologies available for license at the time their web-sites were visited.

One industrial respondent who monitors the Internet said that departments should put more information on their web-sites "to whet his appetite". To do this and avoid unnecessary disclosure, it might be possible to have a second level of access to more detailed information for people who have signed "blanket non-disclosure" forms with the department.

Special Programs to Encourage Technology Transfer

Several departments have special programs to facilitate the transfer of technology or know-how to the private sector.

Agriculture and Agri-Foods Canada (AAFC)

To facilitate collaborative research activities, which have been identified as an effective technology transfer mechanism, AAFC has established the Agri-Food R&D Matching Investment Initiative. Under this program, the department will match one-for-one industry R&D contributions to collaborative research projects.

One of the program's objectives is to speed up the process of transferring new technology to the private sector by involving industry research investors directly.

Canadian Space Agency

The Canadian Space Agency (CSA) established a Technology Diffusion Program, to "promote the exploitation of space technologies, particularly for non-space products and services".

They provide advice, assistance and information on an "in-kind" basis to support marketing, development and licensing activities. Funds of up to $50,000 per project are available, on a contractual basis, for further technological development to bring the prospective product or service closer to the market.

Information on technologies available for licensing is available on a 3.5" computer disk, which includes not only CSA technologies but also technologies available for licensing from the European Space Agency.

CSA does not, at the moment, have their technologies for license listed on their web-site, but they plan to do so in the near future.

National Research Council of Canada

The best method for technology transfer, identified in the literature, is having the person(s) who developed the technology or knowhow move to the organization that is commercializing it. The National Research Council of Canada is presently developing a policy designed to facilitate the transfer of technology developed in their laboratories to industry via the movement of NRC personnel.

The proposed policy calls for the granting of "Entrepreneurship Leave" to NRC employees who wish to either establish a new company based on technology they have developed while employees of NRC (a "Spin-Off"), or to join an existing company and take technology they have developed while in the employ of NRC with them. The leave can be with or without pay.

A person on leave status, can return to NRC on two months notice, thus reducing the personal risk to the individual.

Another part of the proposed policy deals with "Entrepreneurship Secondments" to facilitate the temporary secondment of key NRC personnel who have been involved in the technology development to the adopting company. **SUMMARY AND RECOMMENDATIONS**

The practices summarized in this section were mentioned by at least one interviewee as being useful in facilitating technology transfer. It should not be assumed that all government departments and agencies follow the practices, or that even within a department, the practices are followed in every case.

Technology transfer practices which were identified by both industrial and government interviewees as needing improvement are also listed in this section. A more detailed list of

problems mentioned by government respondents is contained in Appendix D.

Management of Intellectual Property

Both government and industrial respondents said that the issues of ownership of intellectual property, assignment of sole licenses, the valuation of technology and determination of royalty and licensing rates are areas that affect the technology transfer process.

Government personnel interviewed agreed that revenues from intellectual property are not significant relative to the revenues obtained from conducting contract R&D work for industry.

Intellectual property management practices that facilitated the transfer process were:

- an inventor-friendly disclosure process;
- minimal license fees for small firms;
- willingness to wait for a royalty stream to be generated;
- provision of a "money back guarantee" if the technology did not perform as promised;
- willingness to combine government and industry patents to produce a more complete patent portfolio;
- assignment of a sole license for a niche technology;
- use of blanket non-disclosure agreements to speed up discussions; and
- provision of guidelines to assist firms in acquiring a license.

The major problems identified by respondents were:

- slowness and some uncertainty associated with issuing licenses;
- department's reluctance to issue sole licenses; and
- the difficulty in valuating technology.

Industrial respondents were concerned about missing the "window of opportunity" if license negotiations took too long. As noted in the literature review, the issue of identifying the government's position on licensing/ownership as early as possible in negotiations with the private

sector is considered a best practice and would contribute to speeding up the licensing process.

In an earlier study of Canadian government technology transfer (Clarke and Reavley, 1995), it was found that most adopters are reluctant to make the necessary investments required to develop and commercialize a technology unless they have at least a sole license allowing for exploitation of a particular market. Their real preference is to own the technology.

Valuation of the worth of a patent depends on the evaluator's view of the future, and hence is somewhat subjective. Both industry and government interviewees said that valuation was a difficult task.

To assist in overcoming the difficulties with the management of intellectual property, it would be advantageous to bring representatives of government and industry together so that these problems can be addressed.

Recommendation

It is recommended that either the former Intellectual Property Advisory Committee subgroup, comprising industry and government officials be resurrected, or that the interdepartmental Federal Partners in Technology Transfer committee membership be expanded to include representatives from industrial associations, especially from industrial sectors involved in software and computer science.

Encouraging Involvement of Government Engineers and Scientists in the Development Phase

One observation that should be highlighted is that the culture in the government laboratories has changed significantly. Most industrial interviewees were impressed with the enthusiasm shown by government scientists and engineers for working with them to commercialize their "babies".

Both government and industrial respondents recognized the positive impact of having the government inventor(s) involved in the downstream development of the technology or utilization of the technical knowhow. A close working relationship between the government and company scientists and engineers was considered to be very important by all respondents.

Among the practices used to facilitate the interaction between the inventor(s) and the adopters were:

- strong support for the technology transfer activity by senior and middle management, and champions;

- the use of collaborative teams made up of personnel from both organizations;

- the awarding of R&D development contracts that involved the originating government inventor(s) in an ongoing relationship with the adopters;

- the identification of industrial partners who shared common technological interests with the laboratory;

- allowing government scientists to spend time working in the adopter's laboratory;

- special programs to encourage the spin-off of government technology, along with the inventor(s);

- providing the bench scientists with courses explaining the technology transfer process;

- allowing adopters to use government laboratory facilities; and

- making technology transfer a recognized and rewarded activity.

Several respondents believe that the geographic proximity of the two groups to each other as important in maintaining good working relationships.

The major mechanisms that all departments are using to promote personal contact is collaborative research or "partnerships". These enable the potential adopter to be involved early in the "production" of the new knowledge or technology.

The degree of involvement of government scientists or engineers in the development and commercialization phases is to a great extent dependent on the assistance, rewards, recognition and incentives that the department has in place to encourage such involvement.

There is no consistency across government departments in providing assistance, rewards or recognition for technology transfer activities. For example, several departments do not assess technology transfer activities during performance appraisals. Some departments provide for the payment of monies from a royalty/license stream to scientific staff involved in the development process; many do not. Most departments arrange for any excess funds to be returned to the originating government laboratory, but at least two departments do not.

The only problem that some of the industrial and government respondents identified was that many government bench scientists are not very familiar with the technology transfer and commercialization process. This can strain relationships if the government scientist or engineer tries to push for the commercialization of a technology that has little market potential. Only a few government departments have provided any training or advice to their employees on how technologies are commercialized.

Several respondents suggested that this difficulty could be easily overcome with adequate management training in the areas of technology transfer and new product development.

Recommendations

It is recommended that government departments examine their practices to ensure that they support the on-going interaction between government scientists/engineers and their counterparts in industry, and that such interaction is suitably recognized and rewarded.

It is also recommended that courses on technology transfer and new product development be provided to bench scientists and engineers so that they can work more effectively with the departmental business development officer, or directly with industry.

Marketing Government Technology/Knowhow

Government departments are using a variety of methods to market their expertise and technology.

Among the practices mentioned by the respondents were:

- conference attendance;
- holding industrial "open-houses";
- sensitizing scientific staff to look for commercialization opportunities in their work;
- visiting potential and existing industrial clients;
- creation of business development or technology transfer offices to coordinate interaction with the private sector;
- preparation and targeted mailing of "fact" sheets;
- advertisements in local magazines;
- using IRAP's Industrial Technology Advisors as a "dealer network";
- inviting prospective adopters to visit the laboratory to see what they have; and
- advertising expertise and technologies on the department's web-site.

One method that stands out, is the use of the NRC's Industrial Research Assistance Program's Industrial Technology Advisors, as a "dealer network". While many government laboratories make use of their local Technology Advisor, one department was attempting to make use of the advisor network across Canada.

Most of the transfers studied in this pilot study resulted from pro-active searching by the private sector adopters. Although based on an extremely small number of cases, this finding agrees with U.S. studies which show that technology transfer is more likely to be successful when initiated by the private sector.

This does not mean, however, that government laboratories should take a passive stance and let the "customers" discover them. It does mean that all methods should be used to make information about the laboratory's expertise and capabilities as accessible as possible. By knowing what industry wants and needs, government technology transfer officers are in a better position to advise industry about what their laboratory can do for them. Several industrial respondents were favourably impressed by government people with whom they were dealing who had taken the time to learn something about their businesses.

Both government and industrial respondents felt that there was a need for greater face-to-face interaction between the government technology transfer officers and their prospective industrial clients. As one industrial respondent stated, "they need to get out more". Budgetary and policy constraints seem to be at the heart of this problem.

Inadequate interaction may also contribute to government personnel's' lack of knowledge about the new product development process in industry and the costs involved. Several business development officers had no training in technology transfer, or new product development and this impeded their ability to be effective marketeers.

The scientific/engineering staff can be an excellent source of information about potential overlaps of R&D agendas of industry and government. As noted in the literature, the first tentative steps towards a collaborative research project can start during a conversation at a scientific conference or workshop. Several departments have provided some marketing training to assist their scientists in identifying commercial opportunities.

A senior U.S. government laboratory manager said that he makes sure that his scientists "are not glued to their laboratory chairs". He ensures that they go out and visit their scientific counterparts in the industrial sector to whom they provide assistance.

Recommendations

It is recommended that departments and agencies examine their marketing activities to ensure that sufficient funds are available for travel to identify potential collaborators or adopters, and to learn about how business is conducted in their areas of interest.

Treasury Board should remove all restrictions on conference attendance that inhibit interaction among government and industry scientists and engineers.

It is also recommended that business development officers be provided with appropriate training to enable them to be more effective in their positions.

Internet Web Sites

Companies and institutions are making increasing use of web-sites as an advertising medium. Government departments should also exploit this medium. Several industrial respondents complained about the lack of detailed information on many department web-sites. This may result from fears about disclosing too much about a technology prior to patenting.

Recommendation

It is recommended that departments explore the feasibility of having two levels of access to their web-sites: a first level to which everyone can access, and a second level that is only accessible by password to those who have previously signed a blanket non-disclosure agreement. The first level should contain sufficient information for a visitor to decide if they want more information about a technology. The second level should provide access to more detailed information that would be covered by the previously arranged non-disclosure agreement. Accessing the second level would automatically bind the visitor to the non-disclosure agreement.

Company Support for Technology Transfer

Technology transfer will only take place when the government has what a company wants, be it technology, knowledge, facilities or expertise.

The best company practices to facilitate technology transfer were:

- active monitoring of government personnel's work;
- maintaining personal contacts with individual government scientists;
- senior management support;
- willingness to put own resources into the development process; and
- acceptance of government personnel as competent colleagues.

The most long-term relationship noted during this pilot study occurred when the area of

scientific interest of the government laboratory coincided with the scientific interests of the company. In this particular case, the fact that they were thousands of miles apart did not affect the relationship.

CONCLUSIONS

The culture in the government laboratories has changed to the point where most government scientists and engineers are open to working with the private sector, to mutual advantage.

Canadian government departments are doing many of the things that the literature on technology transfer recommends to improve the probability of successful transfer of government developed technology or knowhow. The key practice of allowing and encouraging government scientists/engineers to be involved in the downstream further development and application of the technology or know-how appears to be followed by all of the departments examined. These departments also allow the adopting organization's scientific personnel to work in the government laboratory prior to, or during the transfer process. Focussing on collaboration and partnerships that involve the industrial adopter in the technological development at an early stage is an important practice being followed by most departments.

The extent to which the individual departments follow many of the other "best practices" that have been identified in the literature and this pilot study varies considerably. For example, in several departments, the internal reward system is not in line with the position of their headquarters in the promotion of technology transfer.

Technology transfer/business development officers in some of the government departments and agencies have made and are making considerable efforts to overcome barriers through education and training, novel marketing approaches, red-tape reduction, and flexibility in licensing.

The management of intellectual property, including issues such as licensing and ownership of IP, is a major bone of contention with the private sector and must be addressed to the satisfaction of both parties.

The future good relationship between government laboratories and industry is threatened primarily by three issues; lack of funds for government scientists and business development officers to meet with their industrial counterparts face-to-face to learn about their needs and their strategic directions (also Treasury Board restrictions in the case of conference attendance); disagreements over the government's handling of intellectual property; and the lack of knowledge of government personnel, including some business development officers, of the technology transfer and new product development processes.

The science-based departments, in cooperation with Industry Canada and Treasury Board, must work with Canadian industry to eliminate the human and systemic barriers that inhibit the efficient and effective transfer of technology, know-how and advice to Canadian industry. This will be a major step in meeting the "Committments to Action" that are outlined in the government' strategy document, "Science and Technology for the New Century".

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APPENDIX A

FACTORS AND PRACTICES ASSOCIATED WITH SUCCESSFUL GOVERNMENT TO INDUSTRY TECHNOLOGY TRANSFER

This summary is based on an extensive review of the R&D management literature dealing with government to industry technology transfer. Common threads or themes associated with successful technology transfer were identified. Some of these are organizational factors, and others are practices or actions taken by the government laboratory to enhance transfer.

This is an attempt to pull these threads together in some coherent fashion. The different factors or practices identified may be more critical at different stages of the technology transfer process, and are not mutually exclusive.

The studies further indicate that firms are looking for longer term assistance rather than immediate commercial benefits. Most of these studies are American and the firms studied were relatively large. Small firms would most likely be more interested in near-term commercial benefits from their interaction with government laboratories.

Factors Associated with Successful Technology Transfer

The single most critical factor reported in most if not all of the articles reviewed is the importance of person-to-person contact in technology transfer, i.e., between the inventor(s) and the technical staff adopting the technology or technical information. Personal contact is considered to be the most efficient mechanism of technology transfer.

The following factors were reported as having been associated with the more successful technology transfer activities:

- high level of support for technology transfer activities in both the originating and adopting organization;
- middle management support in both organizations;
- the government laboratory is multi-missioned;
- strong intrapreneurial attitudes among the federal government personnel;

- existence of technology transfer champions in both organizations;

- technology to be transferred could be adopted/utilized incrementally, did not cause great disruption to the adopting firm;

- technology had the potential for diverse market applications;

- low level of government "red-tape" and bureaucratic rules; and

- existence of a royalty-based incentive system within the government laboratory.

Practices or Actions Associated with Successful Technology Transfer

The following practices have been categorized in terms of general organizational practices, prospecting/marketing practices, and developing/adopting practices.

Organizational Practices

- organization of the technology transfer activity is contained within a senior level organizational unit;

- adequate level of resources have been assigned to support the technology transfer activity (people, money and time);

- each technology transfer activity is managed as a discrete project with objectives, deadlines, cost-estimates and evaluation of success being clearly described;

- inventor-friendly disclosure and patent systems are established;

- technology transfer within the government department is recognized as a legitimate, valued activity;

- networks of bench level scientists/engineers are set up to assist their colleagues in the technology transfer activity and to advise the central technology transfer unit of commercial opportunities as they arise;

- a suitable reward and incentive system is in place to motivate and encourage the involvement of the technical staff, and other key contributors to the commercialization and transfer process;

- technology transfer operating practices are consistent across all government departments; and

- bench level scientists and engineers in the government laboratories have received training so that they understand the concerns and actions of business in developing a new product/process.

Prospecting/Marketing Practices

- a strategic plan for technology transfer is prepared that clearly identifies the products/services to transfer and the potential markets;

- only firms with the technical capability to further develop the technology for the market are considered for transfer;

- technology transfer champions in both the originating and adopter organizations are identified and supported;
- industrial personnel are involved in the shaping of the government laboratory's research agenda (especially important in departments with mandates to transfer technology to the private sector);

- targeted or highly focussed marketing procedures are used to identify and approach prospective adopters;

- marketing studies are conducted to identify technical problems in or technological needs of potential client industries, or individual firms;

- the key decision makers in the prospective adopting firm are identified; marketing efforts are focussed on them;

- adequate funding is made available to support government personnel traveling to industrial sites and conferences, and for sabbatical leaves in industry;

- checklists are used to ensure that all the important questions concerning the technology and the transfer process have been considered;

- general communications mechanisms are used to make prospective customers of the government laboratories technologies, expertise, etc. aware of their existence and willingness to work with companies, e.g. trade journal articles, newsletters, internet web-sites, etc.;

- potential adopters are advised clearly of the government's intentions regarding ownership/licensing of intellectual property rights;

- adopters are assigned exclusive proprietary rights to the intellectual property

in order to encourage additional investment in the technology development;

- bench level scientists and engineers are trained so that they can identify potentially valuable intellectual property;

- industrial experts are invited to the laboratory to identify possible areas of technology/knowledge transfer;

- major stake holders are involved in the patenting decision; it is not left to lawyers to decide; and

- up-front fees or royalties are deferred, especially for small adopting firms.

Developing/Adopting the Technology

- the technology/knowledge originator is directly involved with the technical staff of the adopting organization;

- the industrial adopter of the technology is involved very early in the development of the technology, ideally in a collaborative arrangement;

- multi-functional teams made up of members of the originating laboratory and the adopting company are established to facilitate the technology transfer;
- technical staff are permitted to move on a temporary or permanent basis to the adopting organization;

- on-going technical assistance is provided to the adopting firm after the transfer, as necessary;

- the originating government laboratory is willing to develop the technology to the prototype stage, or in the case of a process, to demonstrate its merits in a field trial; and

- private sector firms are allowed access to government facilities and equipment.

APPENDIX B

SAMPLE OF DEPARTMENTAL GUIDELINES

FOR INDUSTRY

APPENDIX C

EXAMPLES OF PAGES TAKEN FROM

DEPARTMENTAL WEBSITES

APPENDIX D

BARRIERS TO EFFECTIVE AND EFFICIENT TECHNOLOGY TRANSFER

While the focus of this study was to identify factors or practices that facilitate the technology transfer process, government respondents were more than willing to identify those factors or practices that made the transfer process unnecessarily difficult or complicated.

As noted earlier, these responses reflect the sum total of problems indicated by the respondents. Some the problems may not exist in specific departments. For example, in some departments, the invention disclosure procedures are considered "user-friendly" while in others they are a barrier to disclosure that must be overcome.

The difficulties to technology transfer given by the government respondents are grouped under general categories:

Budget Restraints

- no longer able to hold industrial "open-houses" to show industry what they are doing, or about learn of industry-wide problems;

- no longer able to travel to out-of-the way locations to learn about specific industry problems;

- engineers rarely allowed to attend conferences to learn about industrial needs (i.e., lower than scientists in the conference attendance pecking order);

- have to focus on marketing their technologies to local firms only because of a lack of travel funds;

- department does not provide an adequate level of resources to support the technology transfer activity;

- lack of a specific marketing budget that would allow marketing people to accompany scientists to conferences;

- budget cuts have reduced the ability to develop technology that will be needed by industry;

- few firms can now afford to come to the lab for assistance.

Lack of Training/Knowledge

- scientists do not actively market their know-how or expertise to the world;

- scientists not provided with technology transfer or intellectual property management training;

- the ability to determine whether the technology is worth moving forward from the bench is a major weakness; - government personnel in the laboratories do not always accept the need to expend resources (time and money) on marketing activities;

- scientists need to gain a greater appreciation of life in the commercial world;

- younger scientists do not understand that technology transfer requires an on-going commitment to assist the adopting company, it is not just handing someone a patent;

Lack of Organizational Support/Rewards

- little or no direction or support for technology transfer activities from headquarters;

- technology transfer system is not inventor-friendly;

- licensing procedures are not user-friendly;

- there are no rewards for technology transfer activities;

- Treasury Board policy restricts the number of people a department can send to a conference;

- technology transfer is viewed by many of the scientists as a fad; its recognition as a valued activity "waxes and wanes in [our department] depending on the flavour of the week";

- we do not have the tools necessary to successfully transfer technology or know-how to the private sector;

- central administration has a regulatory mentality, primary concern is to follow all the bureaucratic rules, not to facilitate partnerships with the private sector;

- too much red-tape;

- bureaucratic rules that inhibit the setting up and maintenance of a web-site;

- having to send licensing agreements to Ottawa for approval slows down the process because of the various levels of headquarter's review;

- originating laboratories not sharing in the royalty/license revenues;

Miscellaneous

- adopting firms wanting an "exclusive" license;

- suspicions about the quality of work produced by government scientists and engineers;

- concern over the fragmentation of complex technologies through multiple ownership of intellectual property; and

- web-site pages quite old.