Science Council of Canada
Report No. 24

December 1975

Technology Transfer Government Laboratories to Manufacturing Industry

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The Honourable Charles M. Drury, PC, MP,
Minister of State for Science and Technology,
House of Commons,
Ottawa, Ontario.

Dear Minister Drury:

In accordance with Sections 11 and 13 of the Science Council of Canada Act, I take pleasure in forwarding to you the Council's Report No. 24, *Technology Transfer: Government Laboratories to Manufacturing Industry*.

Yours sincerely,

Josef Kates,
Chairman,
Science Council of Canada.

Table of Contents

I. Introduction

It is a paradox that a major problem of Canada's economy results from our wealth of resources. The very strength of our resource industries has allowed us to neglect the need for a healthy secondary manufacturing sector. Yet, without one, our economic structure is unbalanced and our economic options are inflexible. In the medium and long term, this must prove to be a severe constraint.

New technology is one of the essential components of industrial innovation, and it has long been recognized that there is a need for much more innovation in Canadian industry.[1] The issue has now become an extremely urgent one. Manufacturing industry in Canada is disturbingly weak and dominated by foreign firms. So much so that other countries have come to think of "Canadianisation" as an industrial condition to be vigorously avoided. When so many other nations with resource-based economies are putting such new emphasis on strengthening their own manufacturing sectors, we cannot afford to be left behind. The time to act decisively is now, before our unfavourable technological situation deteriorates any further.

It is already obvious that we must re-orient our economy, while at the same time protecting our environment and conserving our resources. This will call for an almost unprecedented rate of innovation, and what is more, innovation deliberately designed to allow Canada to invent its own future. The exact requirements for new technologies will be dictated by our local circumstances; imported technology can, at best, meet only a part of the demand.

There are two separate policy problems affecting industrially-relevant R & D which are important in Canada. Making the best possible use of the government laboratories in support of industry is one; the distribution of R & D between government and industry is the other. It is the first of these problems which we address in this report, without prejudice to the continuing search for an optimal solution to the second. We are therefore concerned with the transfer of technology from the federal laboratories to secondary manufacturing industry, as a stimulus to innovation.

We must note, however, that technology transfer and the distribution of R & D are mutually coupled. One should remember, therefore, that an analysis of our national R & D effort in terms of its percentage distribution among the social sectors (government, industry,

1. For example, see Science Council of Canada Report No. 15, *Innovation in a Cold Climate: The Dilemma of Canadian Manufacturing*, and Background Studies Numbers 23 and 26. (All publications of the Science Council are listed at the end of this report.) Report No. 15 provides the following definition of innovation. "Applied to industrial activities, it usually means a conscious sequence of events, covering the whole process of creating and offering goods or services that are either new, or better or cheaper than those previously available. In this report 'innovation' means this whole process, from original conception to acceptance in use."

university) is meaningless if it does not take the total magnitude of the R & D effort into account as well. For example, the percentage of R & D being performed in government laboratories in Canada is unusually high among the industrialized countries, but it is well known that this is due to the unusually low absolute level of industrial R & D rather than to the unusually high level of R & D in government laboratories. A mere transfer of funds from one sector to another cannot by itself bring much improvement in this situation. The bulk of any new funding should occur in the industrial sector.

There are many, especially in industry, who still consider the federal R & D effort as a whole to be far too large. They would like to see this effort cut back sharply and the funds thus released made directly available to industry. (Some even go so far as to see much of the federal R & D involvement as a welfare program for government scientists.) It is emphatically not the object of this report to imply that industrial R & D should be done in government laboratories and the results then transferred to industry. The distribution of R & D between government and industry has received considerable attention already (with little effect). As early as its Fourth Report,[2] the Science Council stated that a major past Canadian failing had been "the performance of too much applied research far from the point of innovation". It was suggested there that a critical examination of every new R & D activity might well lead to industry performing a larger share of Canadian R & D than had occurred in the past.

The capability of Canadian industry in developing new technology is at present small and we depend very heavily on imported technology. Most of this comes in via the subsidiaries of foreign parent companies. It has always been well known that this was the case, but at the same time little has been done to improve the situation. Yet, if one looks beyond the immediate present, it becomes common sense and not chauvinism to argue that a greater proportion of industrially-exploited technology should in future be domestically-owned, even though it may more often be obtained by licensing and development than by direct invention.

The policy we advocate is consistent with the concept of international interdependence, which is one of the principal themes integrating many of the recommendations arising from the broad range of Science Council studies. In short, this concept sees Canada as a country which can, and should, contribute to all aspects of human endeavour at a level consistent with its means and the talents of its people.

With respect to science and technology, we cannot expect to make more than a small percentage of original discoveries or break-throughs ourselves. Even for the United States, technological self-sufficiency is

2. Science Council of Canada Report No. 4, *Towards a National Science Policy for Canada*, Information Canada, 1968.

increasingly seen as a counter-productive policy. But we can, as a nation, work to ensure that our participation in international technological transactions is based on a position of strength. Instead of a technological dependence arising out of weakness, we must carve out for ourselves a role of genuine technological interdependence.

For Canada, a technological sovereignty consistent with international interdependence must replace technological imbalance. We must develop an appropriate amount of original technology, "high" as well as "low" (i.e., complex and simple) and apply it vigorously. We need to stimulate innovation in secondary manufacturing industry. We must add shrewd international collaboration, careful licensing arrangements, and recognize also that public purchasing policies could be a powerful tool for promoting domestic technological development.[3] Only in this way can we successfully strengthen our technological standing, and in turn, our economic well-being and freedom of choice.

The federal government's laboratories have long been an important potential source of Canadian-owned technology, as well as of the requisite scientific support capacity. This potential has been utilized chiefly in laboratories working in the field of primary industries: agriculture, fisheries and forestry, in particular. However, technology transfer to secondary manufacturing industry has not been a principal concern even of those federal laboratories whose responsibilities bring them into contact with that industry. It is thus not surprising that the laboratories are frequently criticized for the low level of transfer which takes place.

It seemed vital that we examine the basis of these criticisms. However, we recognized at the outset – and we stress here – that successful technology transfer depends on the attitudes of private firms and on many aspects of government policies, as well as on the activities of government laboratories. In far too many instances private firms simply do not realize how valuable an asset the government laboratories can be to them. The smaller firms especially are all too often quite unnecessarily intimidated by the size and status of the laboratories. **Hence the dual objectives of this report:**

– to encourage the removal of all inhibitions faced by government laboratories in getting the technology they develop taken up and applied by Canadian manufacturing industry;

– to increase the interest of Canadian manufacturing industry in utilizing the laboratories as a source of technology.

Since an improvement in this process of technology transfer will depend in part on policy decisions outside the laboratories of either the government or industry, and will affect the state of the Canadian econ-

3. The important role of public purchasing policies has been repeatedly stressed by the Council, e.g., in Reports No. 4 (pp. 24 and 32), No. 15 (p. 40) and No. 21 (pp. 69–71).

omy in general, our report is directed to managers and policy makers as well as to engineers and scientists.

It was found that the objectives of this report could not be met without a major background study on the role and function of government laboratories. Such a study was carried out for the Council, concentrating specifically on the role of the laboratories in the transfer of technology to manufacturing industry. The results of this background study are being published separately.[4] A brief description of the data base provided by that study is included here as an Appendix.

The arguments presented in this report are mainly based on the background study, though we also draw to some extent on other relevant studies which we have published.[5]

To increase the likelihood that this report will lead to early and forthright action we have made its focus as sharp as possible, confining our remarks to technology transfer from government laboratories to manufacturing industry. We have done this in full awareness that there are in reality many related issues.

For example, technology transfer from government laboratories is only one of the factors affecting innovation in Canadian manufacturing but, having discussed in Report No. 15 the place of innovation in national industrial strategy, we have avoided going over the same ground again here. We would, nevertheless, point out that the general climate for innovation will itself substantially influence the demand from industry for technology originating in government laboratories.

As well, technology transfer is at most only one of the responsibilities of federal laboratories, as brief consideration of their various roles clearly shows. Broadly, a federal laboratory may have one or more of six primary roles.

- It may do R & D whose security implications are thought to make it unsuitable for a private organization.
- The R & D may be needed to assist a regulatory function, there being no private R & D institution available which is independent of the firms being regulated.
- The R & D required by a department may be felt to be otherwise inappropriate to private industry, or there may be no existing industrial capability and it is not judged worthwhile to create one.
- Certain R & D is necessary in connection with primary, secondary, and consumer standards, including their relationship to international standards.
- Some R & D is essential to permit intramural monitoring of the tech-

4. Science Council of Canada Background Study No. 35, *The Role and Function of Government Laboratories and the Transfer of Technology to the Manufacturing Sector,* by A. J. Cordell and J. M. Gilmour, forthcoming.

5. Science Council of Canada Report No. 15 and Background Studies Nos. 11, 19, 23, 26, 32.

nical state-of-the-art, without which the parent department may miss opportunities or mismanage its contract research.

– R & D may be undertaken in support of intramural capital facilities provided to meet the research and testing needs of Canadian industry.

As well as R & D performed in line with these six criteria, government laboratories may also engage in it for rather less clearcut reasons. In particular, contributions to the international pool of R & D knowledge facilitate in turn our drawing from it, an advantage of great benefit to Canada.[6] There is also a need for long-term, high risk research which may eventually prove extremely useful to this country, but which neither private firms nor the universities are in a position to undertake.

A third sense in which we have kept the focus of this report sharp is that technology transfer from federal laboratories to manufacturing industry is only one among the technology transfer processes in which these laboratories may take part. They may also, for example, transfer technology to the service and resource industries, or they may transfer it to a Provincial Research Council, to a municipality or to a foreign country – especially in the less developed world. On the other hand, a federal laboratory may also receive technology from, for example, a private firm, a university laboratory, the international pool, or another federal laboratory. Because we concentrate in this report on just one of these technology transfer routes, this should certainly not imply that we think the others unimportant.

One remaining proviso must be made: the particular responsibilities assigned to it make each federal laboratory virtually unique. This fact immediately limits the validity of general recommendations for the improvement of technology transfer from the laboratories to manufacturing industry. In effect, each recommendation which we make in this report should be regarded as a guideline that needs to be separately related to the circumstances of each laboratory at the earliest possible opportunity.

6. See also the discussion in the Council's Report No. 18, *Policy Objectives for Basic Research in Canada,* pages 23–25.

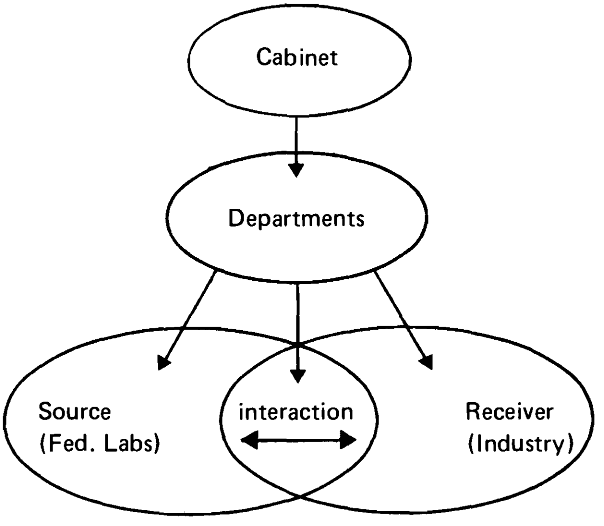
II. Nature of Technology Transfer

Technology transfer, in broad terms, takes place whenever technical knowledge, a technique or a device which emerges from, or is developed by, one group becomes taken up and used or applied by another. The first group we shall refer to as the technology source, the second as the technology receiver. This definition is in fact general enough to include the transmission and reception of 'scientific' information and 'know-how', as well as the transfer of 'technology' in the narrow sense.

Impediments to technology transfer can be divided into three categories, depending upon whether they arise mainly in the source, in the receiver, or in the interactive processes linking source and receiver, as shown in the diagram. There is bound to be some overlap between the three categories and assigning a problem to any particular one of them must therefore be rather arbitrary. We cannot, however, avoid some such classification if we want to understand the fundamentals of the mechanism.

We can at the outset identify the conditions in the source and receiver which will favour successful technology transfer. The basic requirement is that the source possess technical knowledge and/or a capability which could be useful to the receiver. In addition the source must understand the needs and limitations of the receiver. Source personnel must also be well disposed toward technology transfer, an atti-

Relations Affecting Technology Transfer



tude which will call for reinforcement through incentives. Finally, the source must want the particular transfer to take place and must throughout commit the means that successful transfer demands.

The conditions that should apply in the receiver are essentially complementary to these. Thus, the receiver should have complementary knowledge and capability; should understand the circumstances and potential contributions of the source; should demonstrate interest and support this with its own incentives; and should in turn assign the requisite means.

If these conditions exist in the source and receiver, and if there is mutual confidence, then the way will be open for successful technology transfer. It then becomes a matter of considering in what ways and to what extent source and receiver interact. The ways may range from publications and similar communications, through various forms of personnel movement and interaction, to joint planning, cross-contracting,[1] and joint projects. Various interface organizations, both government agencies and industrial associations, can play an important role here if one of their specific functions is the enhancement of technology transfer.

Source and receiver are thus dynamically linked. With the right conditions in each, with mutual confidence, and with appropriate methods of interaction, successful technology transfer is highly probable. In turn, successful transfer will tend to produce the right conditions and methods of interaction, and will also strengthen mutual confidence. Furthermore, feedback should ensure that there are continuing benefits to both sides. But if the conditions are wrong, or there is no mutual confidence, or the methods of interaction are ineffective, then the circle can become a vicious one, or the interaction may even break down completely. This is the situation we wish to prevent or – where it occurs – to remove.

1. "Cross-contracting" is used here to mean contracting-out and/or contracting-in of R & D from one sector (government or industry) to the other.

III. Role of the Source

Government laboratories are not presently structured to give high priority to technology transfer. The reasons for this are discussed in this chapter, but first, it is important to put industrial criticisms of the federal laboratories in perspective.

Industrial Criticism

The actual views which a firm holds about a laboratory are naturally influenced by its knowledge and expectation of that laboratory, by its past experience of interaction, and by the relationship between its products and the activities of the laboratory. The specific criticisms[1] which firms make are centred mostly on the laboratories' lack of market orientation, on their failure to understand some necessities of business goals, strategies and operations, and on their general lack of urgency. Critics also say that the laboratories do not inform industry adequately about those of their own capabilities which may be useful to industry, and that they are reluctant to share information, except through publications. These criticisms can all be summed up as difficulties in establishing good communication. There are opinions as well that the laboratories choose few projects leading to results with potential applications.

A small group of manufacturing firms seem to be wholly satisfied with government laboratories, another small group wholly dissatisfied, with the majority of firms falling somewhere between these extremes. Not surprisingly, satisfaction tends to depend on the amount of interaction a firm has experienced, and there is no real unanimity on any particular criticism of the laboratories.

The critical opinions are in general sincerely held but, on the evidence of our background study, many manufacturing firms are rather ill-informed about the roles of the laboratories, often even about the roles of laboratories working in fields relevant to them. In consequence, their criticisms of the laboratories are largely based on a failure to recognize that most of the work done in government laboratories is, by design, directed toward the kind of broad governmental goals we outlined in the first chapter. The purpose of many laboratory programs becomes apparent only when evaluated against those goals, but manufacturing firms do not normally make this evaluation.

Misconception naturally leads to disappointment. This disappointment has been deepened by feelings within manufacturing industry, especially in recent years, that industry has been promised substantially more assistance from government than it has received. Such attitudes give rise to further barriers to technology transfer.

1. A detailed discussion of these criticisms is provided in Chapter V of the Background Study.

Sense of Priorities

The background study showed that the core constraint on technology transfer by the federal laboratories to manufacturing industry is that transfer is not seen by most of these laboratories as one of their primary missions.[2] It follows that very few of the laboratories have their work oriented toward manufacturing industry. As most of the laboratories see it, with government as their main customer, manufacturing is at most only one among the industrial sectors to which they may need to pay attention.

A related limitation on the effectiveness of government laboratories in transferring technology to manufacturing industry is that manufacturing tends to be seen by the laboratories as the sector best able to do its own R & D.

Unless the limited attention that laboratories give to manufacturing industry is speedily and substantially increased, there is little hope of improved technology transfer, with all that this can mean for Canadian manufacturing industry. **It is therefore our strong recommendation that the federal laboratories intensify their efforts to transfer to manufacturing industry the technology suited to its needs.**

We further recommend that there be an early government policy directive to this effect. Such a directive is needed to clear up any doubts and uncertainties about the importance of technology transfer which may still persist at the laboratory level.

The precise effort which a given laboratory should devote to technology transfer cannot be specified exactly. But this is not necessary. What is necessary is a declaration of relative priorities, of relative emphases, and of the broad levels of effort to be devoted to technology transfer, together with indications as to how these levels are to be achieved, maintained and monitored. To this end **we recommend that in response to the government directive, each laboratory produce, as soon as possible, a detailed analysis of its performance and potential in technology transfer. The extent to which the technology transfer function can be up-graded should then be agreed between the laboratory and the parent department, in consultation with the Ministry of State for Science and Technology.**

Selective Cooperation with Industry

It is important to understand that technology transfer to manufacturing may require a laboratory to become highly selective, perhaps benefitting a specific firm rather than an industry at large. If a particular firm is to become a recipient, then as well as being kept informed of technical

2. These missions are sketched in Chapter I of this Report and are discussed at greater length in Chapter III of the Background Study.

possibilities arising in a laboratory, it may also need protection for its subsequent investment, such as is offered by an exclusive licence. We recognize that favouring a single firm in this way runs counter to the evenhanded approach which government laboratories usually like to adopt. They much prefer to create a broad knowledge base, or a knowledge base of use to all Canadian industry. In line with this, they normally transmit the information they generate or acquire to as large as possible an audience, as opposed to transferring it to selected firms (except in furtherance of a laboratory mission). This attitude on the part of government laboratories naturally acts as an important influence on their work programs.

It would not be easy to establish the exact correlation between the services provided by a given laboratory and the general needs of industry. Also, a real difficulty is that "industry", in contrast to a single firm, is often not able to say precisely what it wants of federal laboratories. Even an individual firm may not always fully realize the extent of its technical problems. Thus a government laboratory will quite often find itself trying to identify the group of "general industrial needs" that best corresponds with its capability, before it can try to meet those needs. It is also true that the difficulty frequently lies not in discriminating in favour of one firm at the expense of others, but in finding even one firm ready to risk the disclosure of its goals and strategies, which is the inevitable concomitant of cooperation with a government laboratory.

To the extent that the federal laboratories have contributed to the establishment of a broad knowledge base of use to Canadian industry at large, their efforts to date have certainly been worthwhile. Nevertheless, it is our conclusion that allowing a substantial proportion of laboratory work to become more closely linked with specific firms would be of general public benefit. Efforts of this sort, often referred to as the use of chosen instruments, are therefore to be welcomed, but they are more likely to be effective when appropriate firms are prepared to take the initiative. The same approach is sometimes called "the policy of maximum unfairness".[3] However, there is a wide range of cases when, properly applied, this policy proves to be the only practical one and no unfairness need be involved.

Selective cooperation between industrial firms and government laboratories is bound to raise problems of confidentiality in information exchange. Some of these problems are only superficial, some are more profound. Many of the superficial problems stem from the fact that government scientists are not aware of the significance, in the competitive commercial environment, of much of the information they

3. See W. C. Marshall, "Science and Industry: The Private Sector. Interaction between Government Laboratories and Industry: Lessons from Harwell's Experience", *Proc. Nat. Acad. Sci.* (USA), vol. 71, No. 6, pp. 2580–2583, June 1974.

acquire while interacting with industrial firms. The solution to these problems lies in an expansion rather than a restriction of interaction, since increased contact ought to lead to a better understanding of the situation, and hence to the taking of the necessary precautions. It would be very useful if guidelines on the subject of industrial security were prepared for government laboratories by the Ministry of State for Science and Technology (MOSST) and Industry, Trade and Commerce (ITC), with the aid of industrial associations.

The more profound problems of confidentiality are often related to the commerical need for exclusive information, which firms understandably seek before committing their own resources. We believe that the questions of what information developed within a government laboratory, through public funding alone, can be released selectively, and under what conditions, are ones that can be answered only on a case-by-case basis.

Timing

In their involvement with firms, government laboratories need to remember that business pressures normally make success in technology transfer critically dependent on timing. Imperfect timing may at best mean duplicated development effort, and at worst may lead to a lost technical opportunity or a marketing failure.

It is commonly argued that the earlier the involvement of the receiver with the source, the better the chances of success. On the other hand, the later the involvement, the more developed the technology and the greater the number of potential receivers. In practice, there should be little conflict between these two apparently opposite prescriptions, since it is likely that each case has its optimum arrangement. But in view of the criticism which many firms make, that government laboratories lack an understanding of the industrial sense of urgency, the whole question of timing is quite clearly one which the laboratories must take seriously.

Incentives to Personnel

Within a laboratory the way in which individual merit is recognized and rewarded can also frustrate technology transfer. Specifically, the activities associated with technology transfer may suffer in comparison with other activities that are believed to reflect better the perceived objectives of the mission department, or that are more easily measurable, or just more prestigious. (It is not only within universities that the "publish or perish" syndrome is believed to persist.) Laboratory personnel are, in fact, ordinarily assessed less mechanistically than is sometimes believed, but the average individual is bound to be influenced by what he or she understands to be the importance really attached to technology transfer by the laboratory management.

Removing this barrier to technology transfer is a matter of staff motivation, which might be fostered by applying and drawing their attention to more comprehensive reward systems. These systems would take appropriate account of the technology transfer function. **We therefore recommend that salary and promotion criteria in each laboratory be designed and applied to fully reflect all the functions of the laboratory, including technology transfer.**

One further hindrance to technology transfer for which the source can sometimes be blamed is that much which could be extremely useful to others is never formally recorded, mainly because there is little time and little incentive to record it. This is naturally a less significant problem when there is substantial contact between source and receiver personnel. It is also not a shortcoming of government scientists and engineers alone.

In view of what has been said here, it is scarcely surprising that manufacturing industry may regard the work of a government laboratory as being of a high calibre, while still complaining about the same laboratory's failure to be helpful to the industrial sector.

IV. Role of the Receiver

The background study confirmed what was widely sensed before: most of the 35 thousand firms in Canada which might possibly benefit from the transfer of technology have neither connections with, nor knowledge of, the government laboratories because they believe that they have no need for such contact. This needs to be changed.

Even when a government laboratory as source has a positive and continuing commitment to technology transfer, the attitude of potential receivers within manufacturing industry is still critical, although the actual demands on them for a successful outcome may be reduced. Technology transfer is a two-way process and transfer from federal laboratories to manufacturing industry can work effectively *only* if industrial firms are also fully committed to it. In cases where the source does not energetically promote technology transfer, receiver attitudes and capabilities become even more important.

Capabilities

In Canada the number of potential receivers is usually small. This is because successful technology transfer normally requires further applied research, development, or design work on the part of the receiver, rather than just application. The number of receivers in a position to benefit in any given case depends largely on the amount of additional work required before going into production.

There are some two hundred Canadian companies with five or more R & D staff (graduates in science or engineering).[1] By and large, only these companies could undertake research or development to complete an act of technology transfer. On the other hand, all 35 thousand manufacturing firms in Canada could theoretically benefit from technology transfer if only direct application were involved.

To improve the situation, it is imperative that there be a substantial change of attitude within much of manufacturing industry, just as there should be within government laboratories. Furthermore, a firm's criticisms of a government laboratory are valid only if it has sincerely tried, but failed, to establish a good working relationship with that laboratory. **We therefore recommend that managements in manufacturing industry insist upon frequent contacts with the laboratories at all levels.** Since the bulk of Canadian R & D is performed in a few narrow sectors of manufacturing industry, **we especially urge relevant industrial associations to press their members to increase communications with the federal laboratories.**

The receptivity of a firm to technology available from government laboratories often depends upon the size of the firm. Medium-sized firms have most to gain from government intramural R & D. Larger

1. F. Kelly, *Prospects for Scientists and Engineers in Canada,* Science Council of Canada Background Study No. 20, March 1971, Information Canada, Ottawa, pp. 21 and 23.

firms usually have their own R & D facilities and are well informed about relevant national and international technical developments. Small firms do not enjoy these advantages, nor do they normally have the spare resources to pick up and apply the results of government R & D. This is why, for small firms, the work of NRC's Technical Information Service is so important.[2]

Furthermore, although this report focusses on technology transfer from the federal laboratories to manufacturing industry, success requires that this external transfer be followed by another transfer internal to the firm.[3] The ultimate efficiency of the external transfer will be much influenced by that of the internal transfer: firms in which the drive to innovate runs right through all departments are far more likely to seize on promising ideas originating outside.

Commercial Interests

Canadian firms generally do not put a high premium on innovation. Some of their caution no doubt has its origins in circumstances which they feel to be beyond their control. In particular, the modest size of the Canadian domestic market is often said to call for international marketing, which many firms find so intimidating that they pass up innovative opportunities. There are certainly cases in which hesitation is justified, but acceptance of some impediments as insurmountable can easily become a way of thinking, preventing exploration of innovative possibilities even though such exploration would make sound business sense.

Other reasons sometimes given by firms unwilling to invest time and money in innovation include long distances and few large markets within the country; further market limitations arising from a firm's own regional orientation; relative satisfaction with their existing and projected levels of success. Much more vigorous attitudes are required, but it must be remembered that successful industrial innovation does not result from R & D alone: it also needs appropriate arrangements for manufacturing, marketing and financing.

Even when a firm is a comparatively frequent and successful innovator, it may still choose for good reasons of its own not to pursue a particular technical possibility offered by a government laboratory. The firm may instead decide that it has more promising projects already in hand. Alternatively, even if the new technical idea available from the government laboratory is in principle highly attractive, a firm may still conclude that to undertake it would mean putting an undesirable strain on its existing programs. The point is that firms have to survive even

2. See further discussion on p. 32.

3. See for example, Lionel A. Cox, "Transfer of Science and Technology in Successful Innovation", *Forest Products Journal*, Vol. 24, No. 9, September 1974, pp. 44–48.

without technology transfer to them from any one source. As a result, when an offer of some technology comes their way from a government laboratory, it may be untimely. This is bound to happen sometimes. The laboratories should recognize this fact and should avoid pushing upon industry technology for which there is no clear demand. Here again the chances of a laboratory investing effort in unwanted developments can be minimized by good communication with industry.

Another limitation in technology transfer results from the strong presence of subsidiaries of foreign firms in the research intensive sector of Canadian manufacturing. In general, these subsidiaries have less need for the output of government laboratories than do domestically-owned firms. We hope to see a substantial increase in the number and significance of Canadian-owned firms in this sector, and to facilitate this **we specifically recommend that government laboratories give the highest priority to the strengthening of domestically-owned manufacturing firms. This policy should be established by a directive from the Cabinet.** The domestically-owned firms should, none the less, remember that the natural inclination of the laboratories is bound to be toward firms which, whatever their origin, spontaneously take the initiative in interacting with the laboratories.

Matching of Technology to Markets

A mismatch can occur between the technology available from a government laboratory and the marketing opportunities open to the potential receiver as the latter perceives them. This poses a problem when receivers are unsure what their markets really want – otherwise they simply do not take what they do not need. In this situation, to make use of the technology available from a government laboratory, firms may have to substantially change their usual strategy. Normally, they try to meet a market demand with the technology they have previously used, or else they develop new technology to enable them to meet that demand better. But for some technologies available from government laboratories, they may have both to create a market for it and to develop it themselves to the point where it can meet that market.[4] The difficulties they anticipate with these two tasks combined can act as a powerful deterrent to their even attempting the transfer of such techniques. This is another problem whose magnitude can be reduced by early and close contacts between firms and government laboratories, since such contacts may provide the lead time for developing applications and markets for new technological possibilities.

4. The term "market" may give an oversimplified impression here, since technologies available from government laboratories are (in the case of manufacturing industries) more likely to affect industrial processes than material products. The "market" for a process may be internal to a firm, while affecting its competitive position with respect to other firms.

V. Basic Types of Interaction

An experienced practitioner has described technology transfer as "an exercise in human relations, patience and understanding".[1] Its successful practice demonstrably does depend on mutual interest, respect and confidence – especially technical confidence – between source and receiver. It is thus a mixture of art and science, well worth the serious attention of every government laboratory and private firm.

In Canada as elsewhere the research motivations of different laboratories vary greatly, the main differences naturally being between government, industry and university laboratories. Traditionally and currently government and university laboratories are considerably closer to each other than either is to industrial laboratories. This is one of the reasons why in its early stages the 'Make or Buy' policy has worked out as it has done, with the universities benefitting much more – and industry much less – than was originally intended.[2] It is very much in Canada's interest to maximize interaction and cooperation between the laboratories in all three sectors.

Problems of Attitudes

It follows that the attitudes which scientists and engineers in government and industry have toward each other are of critical significance. The way in which they understand each other's philosophies as well as problems is naturally shaped by the contrasting environments in which they work, and by their experience with technology transfer.

The government scientist tends to see his or her industrial counterpart as engaging in a less socially valuable activity, while to the industrial scientist the opposite number in government appears too protected. This difference of viewpoint should not be exaggerated nor considered peculiar to Canada. Equally it should not be ignored. There is no easy solution, but scientists and engineers ought to be encouraged as far as possible to acquire direct experience of both industry and government. Even this may not be a complete remedy since many of those who leave one sector for the other do so because they come to dislike the working environment of their previous employment.

The problem of attitudes becomes an especially serious barrier to technology transfer when personnel in government laboratories lack interest in the commercial exploitation of the results of their work, or when their industrial counterparts stop believing that there are practical possibilities in at least part of the work the laboratories do. These, of course, are polar positions, but the tendency is usually there – on both sides. Positive action on the part of managements is needed to counteract this tendency.

In a deeper sense, the problem of attitudes is a problem of values.

1. E. C. W. Perryman, "Technology Transfer", Atomic Energy of Canada Ltd., AECL-4769, 1974, p. 13.
2. See also p. 37.

There are undoubtedly those in government who are reluctant to put the knowledge and facilities created by *public* expenditure at the disposal of the *private* sector. Those who do not share this view should not dismiss its significance. The opponents of free technology transfer should realize that a stronger Canadian manufacturing industry is much more likely to be a socially responsible public asset than a weak industry too unsure of its future to care for anything much beyond corporate survival. In any case, the problem of social responsibility in industry should be resolved, where necessary, by appropriate public action – not by denying technology transfer and hindering industrial development.

Movement of Personnel

The probability of successful technology transfer is greatest when the original idea, with all its ramifications and the requisite background knowledge, is fully understood at the place of application. This need can be met by movement of personnel, who have this knowledge, from the place of origin to the place of application, for example, through secondment, transfer, or formal change of employment. There can often be complications with this, particularly when the secondment is from the public sector to the private. The Public Service Commission's "Interchange Canada" scheme is a useful small step in the right direction here, but its possibilities are far from being fully exploited.

Secondment of industrial staff to government laboratories also occurs. Both types of secondment are invaluable for communicating knowledge which cannot easily be written down or verbalized (such as the most appropriate support functions and organizational behaviour patterns) and for promoting mutual understanding. While secondment is a powerful technique, it must be administered sensitively to overcome possible problems of conflicts of interest and to protect the career prospects of those affected. It therefore deserves an early and explicit policy statement. **We recommend that secondment of industrial scientists to government laboratories, and of government scientists to industrial laboratories, be facilitated. The departments, the Public Service Commission, and the Treasury Board, in consultation with MOSST, should remove all impediments to this practice.** Each laboratory ought then to review its own secondment procedures in the light of the changed situation. Similarly, every effort should be made to remove impediments in the way of those wishing to change employment between government and industry.

Interpersonal Contacts

A second broad category of interaction to promote technology transfer consists of personal contacts between the originators of the technology and those responsible for product or process development in-from individuals, and so it is individuals that have to be encouraged by a suitable reward system. On the other hand, care should be taken to prevent development to a patentable stage of inventions that are of no industrial value.

In trying to get its licenses taken up by industry, CPDL has increasingly made use of the Program for the Advancement of Industrial Technology (PAIT), operated by the Department of Industry, Trade and Commerce (ITC). PAIT is not specifically focussed on technology transfer from government laboratories to manufacturing industry, but it is available to help in such transfer. The possibility of CPDL reporting in future to ITC instead of to NRC could therefore be a very promising development.

No examination of technology transfer to manufacturing industry in Canada would be complete that failed to consider the Technical Information Service of NRC.[3] TIS helps to keep industry aware of relevant technological developments, handles specific technical enquiries, and offers general assistance in the area of industrial engineering. Its services are confidential and are available at no charge.

The particular value of TIS lies in two facts. First, it is directed primarily toward firms with under 200 employees, firms which therefore tend to have few or no R & D staff. At present 90 per cent of Canadian manufacturing firms fall into this category. Second, it operates through field services – there are now 16 field offices – 6 of them managed by provincial agencies under contract. The field offices have been so located that there is one within 50 miles distance (80 km) for 80 per cent of potential users. The role of the individual TIS field officer is therefore vital.

The great strength of TIS is in the broad scope of the resources available to it. It has direct access to the internal collection of CISTI and to the NRC divisional libraries. In addition, it can draw on the expertise in NRC's own laboratories, in all Canadian public laboratories, in the larger Canadian companies (to some extent) and in the international pool. Backed by technical resources as extensive as this, it is essential that TIS should also be adequately funded to enable it to publicize and deploy its services as fully as is necessary to reach and help even the smallest and least well-informed of Canadian firms.

As well as TIS there are two other NRC services which can and do help to further technology transfer, the Industrial Research Assistance Program (IRAP) and the Project Research Applicable in Industry (PRAI) grant program. IRAP is not principally concerned with technology transfer as such, but it does encourage cooperation and interaction between technical personnel in industry, government and the universities. PRAI, and three related fellowship schemes, are more directly concerned with technology transfer, in this case with technology which has originated in the universities.

3. As of October 1974, TIS and the former National Science Library form NRC's Canada Institute for Scientific and Technical Information (CISTI).

In brief, it is not very helpful to present only research results if receivers need semi-developed designs, or to produce these if they are capable only of making direct applications. Similarly, receivers could also expect to benefit from periodic reappraisals of their methods for screening and evaluating technical material reaching them from outside.

Interface Organizations

We have emphasized in this report that technology transfer to manufacturing industry is only one of the functions of government laboratories. Other federal agencies also play an important part in technology transfer to this sector of industry by acting as interface organizations. Their coverage and impact must therefore be taken into account. Two such agencies stand out, Canadian Patents and Development Limited (CPDL) and the Technical Information Service (TIS) of the National Research Council (NRC).

CPDL is essentially an instrument for the transfer to private firms of commercially useful technology developed incidentally to the primary mission work of government laboratories. It can handle inventions arising in all Canadian government departments and agencies and, up to 1974, had done so for 33 of them. It also has agreements with 27 universities and 7 provincial research organizations.

A basic constraint on CPDL is that relatively few of the proposals made to it each year are suitable for immediate commercial development and exploitation. This constraint is reinforced by a second one, the limited interest shown by industry in the patents CPDL has on offer, which in turn must reflect a low industrial evaluation of their potential. In 1971-72 licenses were in force with only 140 companies and CPDL has estimated that in all there are less than 500 Canadian companies which might be interested in licensing and innovating its undeveloped inventions. One pleasing development which CPDL has been able to note in recent years is that several small Canadian companies have actually been formed from scratch to develop and sell an invention it has licensed.

There is no real evidence to suggest that much could be achieved simply by CPDL making more strenuous efforts to obtain a larger volume of proposals, or by its striving still harder to interest potential licensees. It must, however, be reiterated that what CPDL handles is primarily incidentally-arrived-at technology. It is also true that the patent process taken as a whole is an imperfect guide to the scope – potential and actual – for technology transfer.

Whether the incentives to the individual to use CPDL's services are adequate, and whether or not CPDL appears to the individual inventor as an attractive instrument for protecting his or her interests, are quite separate questions which we have not been able to consider in this report. These questions merit examination because ideas come from individuals, and so it is individuals that have to be encouraged by a suitable reward system. On the other hand, care should be taken to prevent development to a patentable stage of inventions that are of no industrial value.

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VI. Laboratory Organization for Interaction

The basic organization and management of government laboratories can have a decisive effect on the chances for successful technology transfer.[1] The structure and roles of an R & D establishment today is a composite of the original criteria that have survived since its inception, plus any additional criteria added later by external authority, together with the roles evolved incrementally within the laboratories, or assumed consciously or unconsciously by successive directing staffs.

The typical government R & D establishment is thus a complex, multifunctional organization. So great are the differences between these establishments, and between their constituent laboratories, that it is difficult to make comparative statements about them except at a high level of generality. For example, it is a well-known weakness of laboratories everywhere that some projects are continued beyond the point where commensurate returns can still reasonably be expected from them. As time goes on, even the broad mission attributed to an establishment may get somewhat out-of-step with contemporary needs.

What procedures can be instituted to ensure that the laboratories remain strategically relevant at all times? What parts can be played by laboratory advisory committees, and what should be the role of the research director? And where does contracting-out and contracting-in fit into the equation?

Strategic Review of the Mission of R & D Establishments

There are three factors above all which affect the continuing appropriateness of an R & D establishment's mission.

- There is the change over time in the departmental structure and missions in which the establishment is embedded. New departments are set up, old ones are re-organized, and their political and administrative goals are altered.
- When an R & D establishment has a clientele beyond its parent department, changes may occur in the circumstances of that clientele.
- The scientific and technical state-of-the-art will evolve, as will the associated facilities and equipment.

Changes of this sort call for an occasional strategic review of the mission of each R & D establishment. Even conceding that much change can be accommodated within the ordinary evolution of such an establishment, there is still value in a formal and detailed review to discover whether there are changes for which no adjustment has in fact been made. A review of this kind requires a highly competent external body capable of conducting a dialogue with each laboratory's scientific

1. Throughout the text the term "laboratory" is used both in its usual restricted sense and also, where no possibility of confusion could arise, as a shorthand term for an R & D institution. However, when we have wanted to refer specifically to an R & D complex consisting of a group of laboratories governed by a common policy, we have used the term "R & D establishment".

staff that is thorough enough to provide the latter with new insights into their potential role. Simultaneously, the review body could prepare the way for any changes which might appear desirable. The terms of reference for the strategic review body would need to include consideration of whether the laboratory were engaged in R & D that ought rather to be done in industry. **We therefore recommend that there be strategic reviews of the mission of each R & D establishment at about five-year intervals. The review body should have as members both distinguished scientists and engineers plus senior administrators or managers drawn, as appropriate, from government, industry and the universities. It should report directly to the parent department, or to the designated minister, in the case of Crown corporations.**

There was previously some intention that the Boards or Councils of Crown corporations concerned with R & D perform a review of this general sort, but this aspect of their functions did not develop into a thorough activity.

Laboratory Committees

The work programs of government R & D establishments and of the laboratories within them are formulated in many ways. The level at which a decision is taken can range from the bench scientist up through the section or the laboratory head to the establishment director, the latter two perhaps working with an internal and/or external advisory committee. The more resources a project requires, and the more mission-oriented the laboratory, the less the discretion likely to be allowed to the individual scientist.

There is no single ideal structure for making R & D decisions, the most effective arrangements depending on the circumstances, but one can isolate the key elements which ought to be included, whatever the structure. There are two major influences which should bear on proposed R & D programs: the opinions of those who will do the work (the performer) and the opinions of those for whom the work will be done (the beneficiary). The simplest case involving a government laboratory arises when the laboratory itself performs an R & D program for an exclusively departmental purpose. In a second common case the laboratory undertakes a program to benefit some particular industrial sector, the parent department then acting at most as a proxy.

When the beneficiary is paying directly for the work, he or she can insist on due weight being given to his views, provided only that the performer remains willing to undertake the work on the terms eventually agreed. Less clear-cut is the situation in which the beneficiary is not paying directly. In those cases the beneficiary may be a group or sector rather than an individual organization, so that it may not even be possible to identify an appropriate spokesperson. Worse still, the supposed beneficiary may not actually be aware of the work being done on his behalf. This can and does happen all too easily. A laboratory may, for example, feel that it has identified a beneficiary for a proposed program, but without any specific consultations having taken place. In such situations, the chances of success with technology transfer are severely diminished.

Not all laboratory projects should be determined by the needs of external beneficiaries. On the contrary, a laboratory will be at its most effective when its program contains a proper blend of this type of project – the essential raison d'être of the laboratory – together with other projects intended to develop and extend the laboratory's capability and productivity, train new staff, or establish a more basic scientific understanding on particular subjects. For this second group of projects the laboratory itself is, in effect, the immediate beneficiary.

The importance of an external advisory committee is now clear. Obviously, no end is served by having an advisory committee that is the captive of its laboratory either in membership or in responsibilities. But an advisory committee can be invaluable when it is independent and brings together representatives of a laboratory's existing and potential beneficiaries, with perhaps the further addition of appropriate external experts. The membership of such a committee would thus be drawn from the relevant department or departments, from other public bodies (for instance, provincial research laboratories) and from the private sector, including manufacturing industry where this was appropriate. All projects with external beneficiaries could then be made subject to review and recommendation by this committee, perhaps with specified exceptions (for example, work certified by its sponsor as being of high confidentiality on grounds of national or commercial security).

A properly functioning, external advisory committee would be responsible for assessing whether an R & D program was necessary, what priority it should have, what funds were allowable for it, and what ultimately should be its object, in terms of further development, direct application of results, or technology transfer. The committee would work through the laboratory's own senior management.

Many laboratories already provide for external members on advisory committees, including participation by representatives of manufacturing industry. What we have outlined above simply amounts to suggesting that further systematic consideration be given to the whole question of the influence of beneficiaries on laboratory programs. This would follow naturally from the redefinition of the place of technology transfer in laboratory missions which we called for earlier in this report. **We therefore recommend that each laboratory have an external advisory committee with representation and responsibilities along the lines we have indicated.**

Laboratory Directors

The heads of laboratories and establishments have, as a rule, a unique influence on both the specific programs and the general climate within their organizations. The general climate, no less than the conduct of individual programs, can have a substantial bearing on a laboratory's transfer achievements. Laboratories, and the R & D establishments of which they may be part, tend to have considerable inertia – like other organizations. They have a momentum which is a function of their existing staff and facilities and of their past commitments. The flexibility which still remains within them will depend on staff adaptability and on the foresight and resourcefulness of their heads, who must possess skills in personnel management as well as in science. In addition, if technology transfer to manufacturing is to be seen by the staff as a major influence on their approach to their work, then it is the laboratory and establishment heads in the first place who must point the way. For all the administrative calls on their time, they cannot afford to be remote from manufacturing industry if manufacturing firms are, or are meant to be, among their laboratories' beneficiaries. Ideally, they should in fact have had direct industrial experience themselves.

For its part, industry is likely to take a laboratory seriously only to the extent that the laboratory's senior staff, and above all its head, show a sustained and constructive interest in industry's problems.

The difficulty in discussing methods for improving the impact which heads have on their laboratories and establishments is that this is more a matter of personal style than of institutional circumstances. But it is in all cases imperative that the importance of the role be fully reflected both in the choosing of a head and in the terms of his or her appointment. In particular, a major problem results from the current pace of techno-economic development. It is, consequently, extremely difficult for a single individual, however competent, to sustain indefinitely the initial level of creative direction in face of the extremely heavy administrative demands on her or his time. **Our recommendation is that renewable term appointments be instituted for research heads, with single term appointments becoming normal practice.**

Contracting-Out

Strategic reviews, advisory committees and the attitude of the head can all help to make laboratories and R & D establishments outward looking, with corresponding benefit to technology transfer. The extent to which it contracts-out, and contracts-in, is a measure of how outward looking a laboratory really is. At the same time, if successful, cross-contracting can incline a laboratory to be still more outward looking.

Consider first contracting-out. The technology available for transfer to manufacturing industry is often only an indirect consequence of an intramural R & D program undertaken for governmental purposes. In such cases, even if the technology proves unsuitable for commercial exploitation, there is no cause for complaint. But the possibility of misallocated resources becomes a serious one when there is no very clear governmental justification for an R & D program and a laboratory looks instead to commercial development as a rationale for its effort.

Furthermore, when there has been a decision to 'make' rather than to 'buy', secondary technical possibilities which have emerged will not necessarily be transferred effectively, even though the main R & D objective may have been fully attained. If, however, the policy had been to 'buy', then such secondary possibilities ought really to have emerged already within the contracting organization. This, of course, assumes that the main R & D objective is equally competently attained, and it still does not completely guarantee that the secondary technical products will be any more efficiently exploited. But the probability of successful exploitation should certainly be higher in such a case.

Several other points must also be made about contracting-out. In the first place, the way in which the 'Make or Buy' policy has so far worked out in practice has given rise to much surprise and a good deal of disappointment. In part, this has happened because too optimistic expectations were encouraged initially. But, in addition, the existing orientation and emphasis of the laboratories has meant, as was mentioned above, that universities have benefitted much more, and manufacturing industry much less, than was originally projected.[2] Manufacturing has also suffered, for the same reason, in comparison with other industrial sectors. The limited early success of the 'Make or Buy' policy should nevertheless be seen in long-term perspective. This policy, imaginatively and determinedly applied, and in conjunction with technology transfer, continues to provide one of the major opportunities for strengthening Canadian manufacturing industry.

However, unless responsibility for contracting-out is placed at a senior enough level in a department, there will be an inevitable tendency for contracts to be small, of restricted conception and short duration, and for them to be used mainly to plug gaps in intramural programs. They will tend as well to be among the first to be squeezed when there is budget pressure. It should also be recognized that private companies will not usually accept contracts unless they can be convinced that they will end up either with some useful new technology or with a reasonable direct profit. They cannot normally afford to settle for just the cost of labour plus overheads. Indeed, if we really want to strengthen the technical capability of Canadian industry we

2. This is a relative statement. In absolute terms industry received contracts worth nearly four times as much as those issued to universities in 1974–75 ($23 million and $6 million respectively).

must be prepared, in spite of the risks and difficulties, to contract-out major programs at the systems level and in the first conceptual stages. It is only by this early and significant involvement that our domestic industry can be helped to establish the developmental capabilities necessary for international marketing footholds.

In this context, the attractiveness of the contracting-out policy, as seen from within government, is much reduced when it can be carried through only at the expense of an existing in-house capacity. Here again the extensive secondment of both facilities and personnel should be given much more constructive consideration than happens at present.[3]

The thrust of this report is that we must have more of the kind of policy innovation that would permit such secondment. Government departments should understand that by ending forthwith their reluctance to take reasonable risks for the sake of building up Canadian manufacturing industry, they could have a dramatic effect on morale, quite apart from the direct opportunities which they would also then be opening up.

Contracting-out to manufacturing companies must therefore be implemented and government laboratories should aim at developing concentrations of technical competence in Canadian industry.

Laboratories should place contracts early enough to include systems design and project management and should be substantial enough and sufficiently long-term to encourage the build-up of industrial capability. They should also in appropriate cases stipulate the use of designated government laboratory support.

We recognize the supportive role that has to be played in the implementation of this policy by the Department of Industry, Trade and Commerce (stimulation of industry), by the Department of Supply and Services (purchasing policies), and by the Treasury Board (budgetary allowances for the costs of such actions to the laboratories).

The present situation is well exemplified in Environment Canada, which deploys a large component of the federal R & D budget, but contracts-out mostly through small, consultant-type research contracts designed to increase its own systems knowledge and capability. To illustrate the degree of vision and willingness to take risks that is required, one might suggest the contracting-out of complete national environment-monitoring networks relative to air and/or water. This would demand a scale of capability and a magnitude of expenditure which only large, collaborative and integrated industrial teams could satisfy. Such teams could utilize not only their own capacities, but also, on a subcontracted basis, the talent within the universities and the federal laboratories. Industry for its part would be faced with the immediate

3. A more extensive statement on the subject of contracting-out may be found in the Science Council's 7th Annual Report, 1972–73, Information Canada, Ottawa, 1973, pp. 28–32.

challenge of responding imaginatively to such requirements, and would do so in the light of the obvious international opportunities which now exist for environmental systems.

Action of this kind, designed to meet major requirements, but at the same time calculated to catalyse the emergence of a critical industrial mass capable of competing internationally, should lie at the heart of the contracting-out policy. Only when it does will it be possible to feel that this policy is being taken seriously.

Contracting-In

Contracting-out can clearly make a major contribution to successful technology transfer. It is important to understand why it is also desirable that some of the work of government laboratories be done under contract to non-government sponsors, specifically for manufacturing industry. To a small extent 'contracting-in' of this sort already happens, for several good reasons. Of particular importance is the fact that when a government laboratory undertakes work meant to be useful to specific industrial firms, only those firms can really know in detail what they actually need. External contracts also provide a discipline which differs from that of internal funding. For their part, industrial customers may decide to place a contract with a government laboratory to avoid developing an in-house capacity for something needed only once. In addition, the contracts can frequently obtain a wide access to a particular government laboratory's current technology and ideas.

In accepting contracts from outside parties there is however one difficulty which government laboratories have to avoid: they must be careful not to get into competition with private firms. This proviso includes the need to avoid undertaking R & D which might pre-empt the development of a capability that could more appropriately be located in industry.

Joint Projects

The policy of cross-contracting (i.e., contracting-out and contracting-in) has the development of technical cooperation between the two parties as one of its objectives. The amount of such cooperation will nevertheless not always be high, since contacts may often, and with some justification, occur only through procurement officers or contract administrators. "Joint projects" refer here only to those ventures in which full technical cooperation actually does take place, at least at the planning and management levels, and more often than not at the bench level as well.

The number of possible variants of a joint project is very large. In a simple typical case, a firm developing a new project may cooperate with a government testing laboratory to evolve a design that has characteristics important to the public interest – for example, low noise or low energy consumption – without a penalty in production costs or reliability. It is a type of cooperation of special importance in the development of realistic standards of performance.

Joint projects may be based on contracting-in or -out if one of the partners pays for the work done by the other as well as for his or her own. Joint projects may also be based on agreements not involving transfer of funds, but instead provision for mutual technical and scientific services. In the latter case a solid foundation for technology transfer is built into the agreement. The fact that joint projects must simultaneously involve both government and industry has the further advantage that exchange of personnel between the two parties is thereby facilitated. The potential benefits of joint projects are thus great and it is our firm hope that this arrangement will become increasingly practised by both government laboratories and manufacturing industry.

There are few precedents for joint projects in Canada and there is the problem of administrative resistance to experimenting with something unusual. The importance of overcoming this syndrome should be obvious. When trying to stimulate innovation in industry, government should be prepared to innovate itself.

VII. Other Influences

The focus of this report has been kept as sharp as possible. It is worth re-stating, however, that technology transfer from government laboratories to manufacturing industry is affected by several other factors, more general than those on which we have dwelt in this report.

For example, tariff and taxation policies play a major part in shaping the general climate. Similarly, it is obviously important that there be adequate venture capital available to potential entrepreneurs. On the evidence at hand there is no room for complacency on this latter score, at least where high-risk capital is concerned.

One other such general influence, or set of influences, affecting the prospects for technology transfer are public purchasing policies. We have throughout this report stressed the importance of the federal laboratories as a source of domestically-owned technology. To provide necessary incentives to industrial use of this resource **we urge that government procurement planning give full recognition to the long-range opportunities which now exist for developing domestic technology, that the federal laboratories be actively included in procurement planning to facilitate this development, and that Canadian industry be given the maximum possible notice of emerging procurement possibilities.** The last part of this recommendation is particularly important. Again and again, contracts have had to be placed abroad simply because the delivery dates specified at the times of formal bidding have not allowed domestic industry to mobilize the requisite capacity. In many of these instances advance notice of the intended procurement would have permitted our industry to bid competitively. In particular, in the absence of exceptional reasons to the contrary, the government should buy what it has paid to have developed.

The harnessing of government procurement policy to create and develop industrial strength is now a recognized strategy in other industrial countries. It is essential that Canada too use federal procurement policies to the same end.[1] There are signs that this is beginning to happen, for example, through the 'Make or Buy' policy. One area in which there is immediate and major scope for better application of federal procurement policies to develop national industrial strength is the rapidly evolving Canadian space program. Here the systems and prime-contractor responsibilities have been mainly carried out by foreign contractors. The basis for a Canadian industrial capability to manage this strategically important program has long been available, but has not been exploited. If it were to be exploited, the resulting domestic business could then be used actively to support Canadian firms in this field in the international market place.

1. Provincial governments have, of course, just as important a role to play with respect to this strategy.

VIII. Principal Recommendations

The efficient transfer of technology from its point of origin to a place where it can be effectively applied is a critical requirement of modern industrial societies. The closer the point of origin to the point of application, the higher the chances of success, which is another way of saying that industrial research is best done in industry. Nevertheless, other sources of technology should not be ignored, when available. Thus federal laboratories clearly have a definitive role to play in the development of Canadian-owned technologies. To strengthen the links between these laboratories and manufacturing industry we have in this report made the following recommendations:

1. The federal laboratories should intensify their efforts to transfer to manufacturing industry technology suited to its needs. (p. 19)
Responsibility – Heads of federal laboratories and establishments plus External Advisory Committees.

2. There should be an early government policy directive to this effect. (p. 19)
Responsibility – MOSST and the Cabinet

3. Each laboratory should produce, in response to this directive, a detailed analysis of its performance and potential in technology transfer. The extent to which the technology transfer function can be up-graded should then be agreed between the laboratory and the parent department in consultation with MOSST. (p. 19)
Responsibility – Laboratory Directors, Parent Departments and Agencies plus MOSST.

4. In the relevant laboratories, efforts to further technology transfer should be specifically recognized as one of the criteria bearing on salary and promotion. (p. 22)
Responsibility – Laboratory and Establishment Heads, External Advisory Committees and the Public Service Commission.

5. Secondment of industrial scientists to government laboratories and of government scientists to industrial laboratories should be facilitated. The departments, the Public Service Commission (PSC) and the Treasury Board (TB) should remove all government impediments to this practice, in consultation with MOSST. (p. 29)
Responsibility – Federal Departments and Agencies, especially PSC, TB and ITC, plus MOSST.

6. Technology transfer is a two-way process. Canadian manufacturing industry will benefit if managements insist on securing frequent contact with the government laboratories at all levels. (p. 24)
Responsibility – Industrial Associations and Industrial Managements.

7. Most industrial R & D in Canada is performed in narrow sectors of industry. The relevant industrial associations must press their members to increase communication with federal laboratories. (p. 24)
Responsibility – Industrial Associations.

8. Government laboratories must give the highest priority to the strengthening of domestically-owned manufacturing companies. This policy should be established by a directive from the Cabinet. (p. 26)
Responsibility – MOSST and the Cabinet, then Laboratories, Parent Departments and Agencies.

9. There should be strategic reviews of the mission of each R & D establishment at about five-year intervals. The review body should have as members both distinguished scientists and engineers and senior administrators or managers. There should, as appropriate, be representatives from government, industry and the universities. The report should be addressed to the parent department, or to the designated minister, in the case of Crown corporations. (p. 35)
Responsibility – Parent Departments and Agencies in consultation with MOSST and ITC.

10. Each laboratory should have an external advisory committee, with representatives both from within and from without the public service, and especially from industry. This committee should review and make recommendations concerning all work undertaken by a laboratory. (p. 36)
Responsibility – Parent Departments and Agencies.

11. Renewable term appointments should be instituted for laboratory and establishment heads, with single term appointments becoming normal practice. (p. 37)
Responsibility – Parent Departments and Agencies.

12. Contracting-out to manufacturing companies must be implemented and government laboratories should assist in developing industrial centres of excellence. (p. 39)
Responsibility – Federal Laboratories, DSS, ITC in consultation with MOSST.

13. Laboratories should place contracts early enough to include in them systems design and project management. Such contracts should be substantial and sufficiently long-term to encourage the build-up of industrial capability. They should also, in appropriate cases, stipulate the use of designated government laboratory support. (p. 39)
Responsibility – Laboratory and Establishment Heads, DSS, ITC, in consultation with MOSST.

14. Government procurement planning should recognize the long-range opportunities which now exist for developing domestic technology, the federal laboratories should be actively included in procurement planning to facilitate this development, and Canadian industry should be given the maximum possible notice of emerging procurement possibilities. (p. 44)
Responsibility – DSS and Customer Departments in consultation with MOSST and ITC.

Those familiar with earlier reports of the Science Council will realize that we have made some of these recommendations before. It should also be realized that with every year that goes by it becomes harder to get this country onto a properly balanced industrial footing. Some things will not wait. This is one of them.

Appendix

Background Study on the Role and Function of Government Laboratories and the Transfer of Technology to Manufacturing Industry.

This study consisted in the first place of detailed interviews with the heads of some thirty research establishments attached to the most science-based federal departments and Crown corporations; with the heads of some of the laboratories within these establishments; and with the officials within the corresponding departments responsible for the establishments. Detailed opinions were also solicited from two samples of manufacturing firms through a mailed questionnaire. The first industrial sample gave depth to the study, the second gave breadth.

The first sample contained 70 firms and produced 51 usable responses. Interviews were then conducted with 63 of these firms. The 70 firms ranged from one with three employees to a multinational corporation with 27 000. They were intended to be a representative sample of firms which had interacted with government laboratories, though some of them turned out in fact to have had no interaction. The sample was also meant to reflect the geographical distribution of manufacturing firms in Canada, broadly but not exactly. About 30 per cent of the sample consisted of foreign-owned firms, just under two-thirds of these being American. Proportional representation of the various types of manufacturing firms was not aimed for and medium to high technology firms were somewhat over-represented. All the firms had one thing in common: unlike most Canadian companies they each had an R & D unit, the largest of these units having a professional staff of over 300, the smallest having just one individual.

The second industrial sample consisted of 213 firms and produced 179 usable responses. About a third of all Canadian manufacturing R & D units were included in this sample, which was a stratified random one drawn from the MOSST Directory of Industrial Research and Development, after the elimination of the firms chosen for the smaller sample.

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Index

24