THE DOC RESEARCH PROGRAM - APPROACHES TO REALIGNMENT

December, 1985

(1) Canada. Dept. of Communications

(2) THE DOC RESEARCH PROGRAM - APPROACHES TO REALIGNMENT

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It was in response to genuine and clearly-defined needs that Canada's federal laboratories established their world-wide reputation for excellence. We believe that closer relationships with end users of the research is the best prescription for their continued vitality. There may be many administrative approaches to achieving this, and it is not our role to choose one model over another. But a serious attempt must be made to make the federal laboratories more "business-like", more demand-driven. And in this case, we believe the direction is as important as the destination.

<u>Task Force on Federal Policies and Programs for Technology Development: A Report to the Minister of State for Science and Technology</u>

July 1984

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EXECUTIVE SUMMARY

The role of government labs has been increasingly debated, both in Canada and in other countries, for the past several years. In 1984, in a report which questioned both the relevance and effectiveness of research conducted in government labs, the Wright Task Force on Federal Policies and Programs for Technology Development recommended that "a review of all federal laboratories be carried out, with each laboratory being required to demonstrate to a designated central agency its relevance and usefulness." The May 1985 Budget of the Minister of Finance called for "changes to improve the effectiveness and client responsiveness of its grant, research, and technology-transfer programs," as well as inviting "provinces and users to join in a plan for consolidating and rationalizing existing centres." Reviews of government labs, focussing on issues such as role, relevance, effectiveness, duplication, rationalization and possible privatization have been proliferating for several years now both in Canada and around the world.

The Department of Communications (DOC) initiated an exhaustive process of review for its own program in 1983. This review has proceeded in two phases.

The first phase focussed on whether most of the research program could be privatized in the form of a not-for-profit corporation (CCIS, or the Canadian Communications, Informatics and Space R & D Institute) jointly sponsored by the public and private sectors. This phase of the review was carried out by a government-industry task force supported by a consortium of consultants led by Price Waterhouse. This CCIS Feasibility Study concluded that privatization was not feasible at the present time, although it endorsed privatization as a longer-term objective.

The second phase of the review was a direct response to one of the recommendations made in the CCIS Feasibility Study and was carried out with advice from the government-industry task force responsible for the CCIS exercise. This second phase involved a fundamental strategic review of the entire research program, with a view to establishing what role -- if any -- the federal government should have in the conduct of R & D in the areas of communications, space, informatics and workplace automation. This report contains the findings and conclusions of that review.

THE NEED FOR PUBLIC SECTOR INVOLVEMENT

The strategic review concludes that there is a need for a government R & D program in the areas of communications, space, informatics and workplace automation. This conclusion is based on the following analyses:

1. The technologies are strategic for the larger economy and demand an ongoing commitment to R & D

It is generally agreed both in Canada and around the world that the information technologies -- upon which the DOC research program focuses -- are crucial to the long-term health of the larger economy. The industries developing and deploying these technologies constitute the fastest growing sectors in every economy within the developed world. The technologies and their applications are fundamental to long-term gains in productivity. However, these technologies are evolving very rapidly, and any country wishing to keep up must commit substantial resources over the long term to R & D.

As the U.S. Congress Office of Technology Assessment pointed out in a substantial report published in February 1985, "The information technology industry (those who make and sell or provide access to communications media) and the information industry (those who use the new technologies to produce and sell new information services and products) are a growing part of the U.S. economy. Their economic importance is felt both domestically and internationally. These industries also have an important indirect effect, in that the technologies and services they produce contribute materially to the economy in such forms as productivity growth, better quality of products and improved managerial decision-making. The health of the information industries depends in part on their ability to bring forth new products to develop new applications; this ability, in turn, depends on R & D." The same is also true for Canadian information industries.

2. The Canadian R & D effort is significantly smaller and more fragmented than that of most of its major trading partners

There can be little doubt that the Canadian R & D effort is dwarfed by many of its major trading partners. In 1981, Canada's R & D expenditures were about $4 billion; the United States spent around $90 billion and Japan more than $30 billion. Even in relative terms, the Canadian commitment is small: in 1981, Canada spent only 1.25 per cent of its gross domestic product on R & D, while the comparable figure for the U.S., Japan, the U.K. and France was well over two per cent. Despite the existence of Bell-Northern Research (BNR) and Northern Telecom, the level of Canadian R & D in high technology areas lags behind most major industrialized countries. In a 1984 report, the OECD ranked Canada 10th in terms of the proportion of Net Domestic Product devoted to R & D on electrical machinery, communications equipment and electronic components -- behind all our major trading partners.

Our national R & D effort is also significantly more fragmented than that of Japan or most Western European countries, all of which have adopted comprehensive industrial strategies which permit them to focus their R & D efforts in a co-ordinated manner on strategic technological areas such as information technology. Government labs often play a crucial role in these strategies. No such strategic consensus exists in Canada, and, once one passes beyond the large facilities of Bell Northern and a few others, most of our national R & D effort is scattered helter-skelter among a wide range of small companies and under-financed university labs.

3. The DOC research program is an important national resource

The DOC research program represents in Canada the second largest laboratory complex working in the broad communications area. Only BNR is larger, but its work is mostly developmental, as is the work of most other industry labs, which cannot afford the risks or the remoteness from pay-off of longer-range work. University labs are much smaller, and generally their work is aimed more at the advancement of knowledge than any application. In fact, the DOC research program, which carries out mission-oriented research, is the largest in the country devoting itself to longer-range research as opposed to development.

Given the increasing recognition by the governments of other industrialized countries that a serious commitment to longer-range research is vital to continuing competitiveness in the information technology area, the DOC research program represents an important national resource which only government can sustain. If the laboratories were wound up, there would effectively be no centre of any size left in the country pursuing longer-term work in the area of information technology.

4. The DOC research program serves government needs

The Department of Communications has a crucial need for R & D support, as well as technical advice and information, to carry out its responsibilities with respect to the development of policies, regulations, standards, procurement and industrial support for a communications area characterized by a very high rate of technological advance and innovation. For example, research on potential uses of the spectrum is very important to spectrum management and regulation and DOC researchers add a vital technical expertise to DOC delegations at national and international standard-setting bodies. It is also central to DOC industrial development, and this report identifies important new opportunities for industrial development in the conduct of applied research and long-range development related to procurement for government telecommunications systems, as shall be seen below. In addition, the program carries out work -- usually long-range research as a basis for technical advice and the preparation of technical specifications for procurement -- to a number of other federal departments and agencies.

Much of this work involves longer-range research to meet government needs not always generalizable to the commercial marketplace -- work which, because of its long-range character, industry is often uninterested in carrying out and frequently lacks the capability to do. While it might be desirable to have industry carry out more of this research over the longer term, there is at present no other set of laboratories in the country -- except perhaps those of BNR -- with the size and sophistication necessary to undertake this work.

THE STRATEGIC ASSESSMENT

Given that there is no alternative to the maintenance -- at least in the medium term -- of the existing research laboratories, the question arises as to what they should do and how they should be run. To this end, the report distilled seven principles from the best R&D practices and procedures in public and private labs, as described in interviews and the literature. These principles illuminate both how labs should be operated and managed, and the respective roles of university, government and industry in the R & D area. They also provide the basis for the strategic assessment of the DOC research program. These seven principles, and the assessments flowing from them, are as follows:

1. The primary focus of government labs should be applied research or long-range development to meet government needs

The primary focus of government labs should be applied research or long-range development to meet government needs. Such applied research is usually from two to eight years from any actual service or product and, while practical in its focus on government needs, addresses a technological area which is still uncertain. As already noted, such work is generally uninteresting to industry -- especially small and medium-sized companies -- because of its long-range character.

Such a focus for government labs is completely consistent with the report of the Wright Task Force, which expressed scepticism about their capability to conduct industrial R & D because of their insulation from the market. However, as creatures of government, government labs can be very effective in responding to government needs. These needs can flow from internal government requirements or over-riding public policy priorities. Clearly, however, for such work to be both effective and relevant, the process of identifying government needs must be formal, rigorous and capable of taking a long-term perspective, as the Wright Task Force emphasized.

After carrying out considerable development work to meet industry needs in the late 1970s and early 1980s, the DOC research program has reached a watershed and there is considerable uncertainty about its future direction. But within this context -- and, as we noted above -- DOC has continuing needs for research support and technical expertise to carry out its responsibilities for spectrum management, standard-setting and policy development and implementation. The second largest government client of the program is currently the Department of National Defence (DND), although the uneasiness of that relationship -- combined with the fact that the inter-Ministerial agreement at its basis is 15 years old -- argues strongly for its comprehensive review. A number of other federal departments and agencies -- including Energy, Mines and Resources, the National Research Council and the Department of Transport -- also call on DOC expertise.

As far as the future is concerned, one of the most important unexploited opportunities for the program lies in the area of procurement-related applied research and long-range development. The reason for this is that the work of government labs is most effective and relevant when the government is itself is the "user-demander" of the technology. Information technology (the term used to describe the broad range of technologies in the computer and communications areas) is generally acknowledged as a potentially major source of productivity in the service sector -- an important consideration in an era of deficit reduction and concern about government efficiency. For this reason, the potential synergy between the research program and the Government Telecommunications Agency (GTA) -- also part of DOC -- must be much more fully exploited, as must similar synergies between the research program and other procurement centres within government, especially in the space area.

More generally, however, it is important to undertake a fundamental reassessment of the relationship between the labs and its clients. In particular, it would be useful to put all of these arrangements -- including those with DOC, the dominant client -- on a strict contractual footing so that the labs can operate on a full cost-recovery basis. This would not only impose significant cost discipline; it would also create a useful vehicle for establishing a stronger client orientation.

2. Role vis à vis industry

As the Wright Task Force pointed out, government labs should only carry out work on behalf of industry if it is in the national interest, if the industry is fragmented and if the work itself is too high-risk, expensive or remote from pay-off for industry to do the necessary R & D. Within this context, the most effective focus for government-sponsored R & D will be on projects intended to meet government needs, but with potential commercial implications. If the work of government labs is to have commercial potential, industry must exercise influence over the direction of their research program.

There are a few large companies in the information technology industry, but by far the greatest number of Canadian companies are small and medium-sized. Their commitment to R & D is generally much larger than in other industries, but most lack the resources to carry out the longer-range research which is generally acknowledged as vital to international competitiveness over the long haul in this research-intensive and highly competitive field. For this reason, there may be a role for government labs in the conduct of longer-range research which would complement the near-term development work of these companies.

As the previous section argued, the work of government labs is only effective when it is driven by government needs concretely defined. As Richard R. Nelson and Richard N. Langlois suggested in a recent *Science* article, "In cases of government procurement for defense, space, or similar clearly defined public projects, the government is itself the user-demander. It thus has knowledge of its own needs and, usually, at least a modicum of expertise in the technology it proposes to use. Motivation and knowledge line up fairly well in such circumstances, and the government is frequently able to sponsor effective R & D on the relevant technology. To the extent that the technology can be easily transferred to commercial application, the result is the well-known 'spillover' into civilian technology."

Our concern must be to maximize the commercial "spillover" from longer-range work intended to meet government needs.

One obvious means is to ensure that all near-term development is carried out by industry, preferably on contract, which is generally recognized as the most effective means of technology transfer. Indeed, we would propose an examination of the research program to make sure that it is not performing any near-term development -- work which is less than three to two years from a final product or service. Industry is very capable at such work and very interested in doing it.

A second means is to concentrate on those kinds of government needs whose fulfillment would have commercial implications. In virtually every major industrialized country, the meeting of government procurement needs has become an important instrument of industrial development. In Canada, procurement has been less effective in this sense, essentially because a perfectly legitimate concern with cost-effectiveness has inclined government procurement officers to buy "off-the-shelf" products from large multinational concerns (who will remain around to provide service) rather than from small and medium-sized Canadian companies (who may not survive in an increasingly competitive environment). As the Wright Task Force pointed out, a lack of long-term procurement planning has meant that smaller Canadian companies have not had sufficient advance notice to develop products which would meet government requirements.

Government research programs such as that at DOC have a dual role in encouraging procurement from Canadian industry. First, they must prepare the technical specifications for any procurement-related R & D carried out by industry; clearly, the preparation of such specifications by industry would place it in a conflict of interest situation. Second, by identifying long-term government procurement needs and carrying out high-risk longer-range research related to those needs, they can reduce the risks both to industry and to government procurement officers (who must justify their expenditures in terms of cost-effectiveness). Indeed, in our view, government procurement can only become an effective instrument of industrial development if government labs assume this dual role.

A third means of maximizing the commercial "spillover" from government research is to ensure that the research strategies chosen to meet government needs have commercial potential and that recipients of technology transfers can in fact commercially exploit the technology. To this end, two significant changes are suggested in present procedures.

First, there must be formal, ongoing links between the research program and the DOC Technology and Industry Sector, which will permit the latter to exercise a genuine influence on the program. The Technology and Industry Sector is responsible through GTA for a major centre of government procurement in the telecommunications area. The sector has developed, or is now developing, important capabilities with respect to technology promotion the assessment of technologies and the financial and marketing capabilities of Canadian firms. These responsibilities provide a vital complement to the activities of the research program in areas such as the identification of government needs, the estimation of commercial potential and technology transfer.

Second, if the long-range research strategies of the program are to have commercial potential, industry must have an influence on the direction of the program. In other words, there must be formal mechanisms which ensure that industry's market awareness and market discipline are brought directly to bear on the program. In addition to assuring the commercial relevance of the long-range research strategies within the program, these mechanisms -- by providing for industry oversight of the program -- would also enhance the accountability and transparency of the program to senior management and the Minister.

3. Optimal university links require commitment to fundamental research

Close links between universities and government-sponsored research programs are central to the effective mobilization of a country's research resources, especially in a relatively small country such as Canada. For such links to be optimized, government sponsored research programs must have some commitment to fundamental research and such a program should be developed and updated in conjunction with the universities.

As the Wright Task Force emphasized, universities now play "a central and strategic role in Canada's overall research effort" and represent a crucial link in the innovation chain. In virtually every industrialized country, there has been a proliferation of co-operative research projects involving universities, government and industry. Indeed, in most Western European countries, the effective marshalling of a national R & D effort in information technology focusses on the co-ordination of university, government and industry R & D efforts. Canada tends to lag behind in this respect.

In light of these realities, the Wright Task Force and the U.S. Federal Laboratory Review (Packard) Panel -- whose report on government labs to the White House Science Council was published in 1983 -- strongly recommended dynamic interaction between government labs and university researchers. However, there is considerable evidence of a belief within universities that such collaboration will commit universities to even more applied research at the expense of what must lie at the heart of the university enterprise -- fundamental research and the teaching of students. Consequently, for such collaboration to be as meaningful as possible, government labs must undertake some fundamental research. In fact, the Packard Panel argued that government labs should conduct basic research, but this should be subject to formal peer reviews by university researchers.

The DOC research program now conducts virtually no fundamental research, though it did in the past; and, while it has extensive informal contacts with the university community, university researchers exercise no influence on the direction of the program. In our view, the DOC research program should expend from 10 to 15 per cent of its resources in the conduct of directed fundamental research -- that is, fundamental research which falls within the broad mission of the program -- and such research should be carried out in the context of formal mechanisms to assure university input and review of such a program.

Such an arrangement would have important benefits for the research program and perhaps for the national R & D effort. The greater commitment to fundamental research by the research program in the past lay the basis for its many important contributions in the 1970s, and a renewed commitment now will lay the basis for future contributions in the late 1980s and 1990s. As many industry labs have discovered, more intimate collaboration with universities would make recruitment much more effective -- an important consideration for a research program with a cadre whose average age is older than industrial labs. Such collaboration would also raise the prestige of the research program, given that the universities are often the arbiters of reputation in this area. Finally, increased co-operation might well generate greater synergies between the research program and university research efforts, therefore increasing the critical mass within Canada of resources in strategic technological areas.

4. Fundamental vs. applied

Organizationally and in relation to the environment in which they are conducted, fundamental research and applied R & D are different activities, drawing on different sources of information, driven by different concerns and priorities, and possessing quite different clients. The former involves basic science and is essentially aimed at the advancement of knowledge. The latter focuses on technology and has as its ultimate objective the creation of saleable and feasible or manufacturable services or products. A blurring of the boundary between the two can undermine the respective integrity of each. For this reason, they should be separated to the degree possible.

If the DOC research program undertakes directed fundamental research, this activity should be separate in budgetary terms from its applied research and long-range development. The small size of the research program renders difficult the achievement of an organizational separation without sacrificing research effectiveness in certain subject areas. However, a real effort should be made to achieve such organizational separation where possible.

5. An international monitoring and domestic dissemination role

Government labs have an important role in monitoring technological developments in other countries and disseminating the resulting information to public policy-makers, to industry and to university researchers. This role is particularly important for a country such as Canada, which conducts only two per cent of global R & D in the broad communications area.

The Economic Council and the Science Council have pointed out that foreign technology diffuses more slowly into Canada than into our major trading partners, and recommend that government take action to assure the rapid adaptation of foreign technologies by Canadian firms. Large firms, such as Northern Telecom, of course, have the resources to keep up with technological developments abroad. However, smaller and medium-sized information technology companies have to struggle to keep abreast.

To some degree, this information can be gleaned from scientific publications. However, there is as a general rule a lag of anywhere from 18 to 30 months between publication and the first mention of technological development at a scientific conference. Such a delay is unacceptable in a technological area evolving as rapidly as information technology.

The researchers in the DOC research program are uniquely equipped to carry out the role of gathering this information. They have the technical expertise and a developing awareness of Canadian government, industry and university needs. More important, since much of this data is gathered informally on an information exchange basis at international scientific conferences, only researchers are in a position to gather such information.

6. R & D is a unique endeavour requiring unique managerial practices

Effective R & D demands creativity, intellectual agility, a willingness to take risks and work which proceeds over relatively long time-frames. As a consequence, effective R & D management must combine firm accountability with sufficient flexibility to encourage intelligent risk-taking, personal initiative and high morale among staff.

Both the Wright Task Force and the U.S. Federal Laboratory Review Panel were highly critical of the many financial and administrative controls to which government research programs are subjected. They characterized these as "micro-management" and argued that these create rigidities which hamper the effectiveness of the research by undermining risk-taking, creativity, personal initiative and morale among research staff. The Packard Panel went on to argue that these controls -- whose basic rationale is to ensure the accountability of the research program -- only provide a narrow financial and administrative accountability while leaving the program opaque to both senior management and all but the most aggressive user.

The DOC research program is subject to the full gamut of Treasury Board and Public Service Commission rules, guidelines and regulations. It is tightly controlled with respect to budgets, person/years, contracts, purchases, travel, hiring, firing, promotion and personnel classification. In addition, in the case of CRC, vital technical services are provided by the Department's Personnel and Administration sector. In our view, these constraints significantly limit the flexibility which is fundamental to an effective research program.

There can be little doubt that these controls do assure a narrow financial and administrative accountability on the part of the program. However, they in no way provide the basis for its accountability in meaningful terms either to senior management, the Minister or its clients. There was little understanding of program activities within other DOC sectors, while the CCIS feasibility study provided evidence of a similar ignorance on the part of industry and the university community.

The report proposes a number of avenues for reducing the burden of micro-management upon the program.

7. The quality of vision and the notion of critical mass

Research and development is most successful when it is driven by a clear, realistic and compelling vision of its ultimate importance to its users -- a vision which to the degree possible is shared by those users. For the vision to be credible, however, sufficient resources -- enough critical mass -- must be available to make the vision at least appear achievable. The vision itself may help in this respect -- by focussing a research program so that there are enough resources concentrated in critical areas.

After being driven by the strong visions associated with space and Telidon during the 1970s, the DOC research program is now seeking a new focus or frame of reference. There is a growing sense now that it is too diffuse

-- in other words, is engaged in too many small projects which lack over-all significance and do not form a coherent whole.

This report provides the conceptual basis, though not the substance, of a new vision. It argues that the research program must focus on applied research and long-range development at the strategic intersection of government needs (defined in terms of internal government requirements and public policy priorities), commercial potential and Canadian industrial capability. As illustrated in Figure 1, this formulation would significantly reduce the range of projects which the research program would undertake and thus the critical mass for projects at this strategic nexus.

However, for the vision to be effective, its focus must be more precise than this conceptual framework. In order to flesh out this strategic nexus, the research program must consult extensively with government clients in the context of developing a new scientific plan reflecting the scientific and technological priorities of the 1980s and 1990s. More important, there must be extensive consultations with both industry and the university research community, with a view to creating a strategic consenus on the direction and vision for the program. Indeed, consultations should be viewed as a means, not just of sharpening the focus of the program, but of harmonizing the national R & D effort in information technology to assure that sufficient critical mass is present in strategic technological areas.

ORGANIZATIONAL OPTIONS

The review of the DOC research program, based on these seven principles, concluded that there was a need for a major restructuring of the labs and their activities. To this end, the report laid out a number of organizational options which incorporated the organizational implications of these principles. Altogether, 26 options were considered, if all the permutations of each combination of options are included.

Among the options proposed were a number which would have the effect of treating the Canadian Workplace Automation Centre (CWARC) quite differently from the Communications Research Centre. These options were examined because the CCIS Feasibility Study proposed as an alternative for consideration the establishment of an informatics research institute using CWARC as its nucleus. In our view, it would be inappropriate to implement any of these options at present for two reasons. First, CWARC already represents an interesting experiment upon which a promising beginning has been made, and it would be unwise -- perhaps even perverse -- to embark on a new regime before there is any meaningful basis for evaluation of the present experiment. Second, different organizational frameworks for the CRC and CWARC would result in an undesirable complexity with respect to both the organization and accountability of the DOC research program.

The elimination of these mixed organizational models significantly reduces the range of options available. Indeed, at the most basic level, there are only two -- keeping the research program within the Department, or putting it outside, though there are, of course, important variations within each category. In our view, the fundamental decision now facing the government is whether the research program should stay within the Department or be moved outside. But no matter which option is chosen, it must conform to the seven principles

1. Remain within Department

If the research program remains as a sector of DOC, the restructuring should involve:

- the introduction of formal mechanisms for joint planning with other DOC sectors and the sharing of significant proportion of goods and service budgets with other sectors, in order to enhance the responsiveness of the program to their needs and its over-all accountability within government;

- initiation of a personnel management demonstration project and assumption of responsibility by the Sector for the provision of vital technical services, in order to reduce micro-management; and

- increased personnel exchanges with industry and universities, as well as increased oversight of the program by industry and university representatives, in order to enhance the responsiveness of the program to their needs and its over-all accountability.

It should be noted, however, that, insofar as the realization of the seven principles is concerned, there are both advantages and disadvantages to keeping the research program within the Department.

For example, the real strength of such an approach is that it would assure a genuine responsiveness on the part of the program to the needs of the rest of the Department and probably to the government as a whole. Such responsiveness is vital, given that -- as already noted -- the primary emphasis of the program should be upon applied research and long-range development to meet government needs.

However, as long as the research program remains part of the Department, there are distinct limits to how far it is possible to go in reducing micro-management. For example, as part of the Department, the research program would continue to be subject to the full gamut of Treasury Board and Public Service Commission regulations, rules and guidelines, though a special dispensation might be sought with respect to personnel classification and performance assessment in the context of a personnel management demonstration project.

In addition, though it would possible to increase the degree to which industry and the university research community could exercise an influence upon the program, there are definite limits to such influence as long as the research program remains within the Department. Put most simply, industry and university representatives would have to be limited to an advisory role and thus the responsiveness of the program to their needs would be more limited.

2. Quasi-autonomous status

The CCIS Feasibility Study made a persuasive case against privatization of the program, emphasizing -- among other things -- the high improbability of the program's being able to achieve financial self-suffiency or even a significant reliance on the marketplace for revenues. In other words, the program would remain primarily dependent upon the federal government for its financial support. This fact limits to two the range of options available to give the program some form of independent status. It could be established either as a Departmental Corporation or a branch designated as a department under the Financial Administration Act; in either case, it would report to the Minister of Communications.

Under both of these institutional arrangements, the DOC research program would become a new independent agency and be run by a board appointed by the Governor in Council and representative of industry, the university research community and major government clients. However, in order to assure the new agency's responsiveness to government needs, the legislation establishing it would provide that the Minister could assign R & D tasks to the new agency. In addition, the new agency would operate on a cost-recovery basis, with all of its research activity funded through contracts with clients. This broad approach would have three important virtues.

First, it would result in a much greater reduction in micro-management than would be possible if the program remained within the Department. Through legislation and designation as a separate employer under the Public Service Staff Relations Act, the agency would be freed from Public Service Commission regulations, rules and guidelines with respect to hiring and promotions. In addition, Treasury Board rules and guidelines with respect to personnel classification would also not have to apply. Indeed, if the new agency were entirely funded through contracts, it may well be that no Treasury Board rules would apply.

Second, this option would give industry and university representatives -- as members of the board running the new agency -- clear decision-making responsibilities with respect to the program, as opposed to the limited advisory role they would have to play if the program remained within DOC. Clearly, in such circumstances, the research program would be significantly more responsive to industry and universities than if the program remained within the Department.

Third, under such an arrangement, the labs could be moved to a cost-recovery basis, with their funding provided not through Parliamentary appropriations but through contracts with DOC and perhaps other federal departments and agencies. The contractual mechanism would impose both cost and results discipline on the labs, as well as giving them a clear client orientation. In addition, the creation of a semi-autonomous research agency with such a funding regime would be a necessary first step towards their ultimate privatization, if that proved feasible in the long run.

AN ACTION PLAN FOR REALIGNMENT

Whatever organizational option is selected for the research program, there would seem to be a need for a major realignment. The present lack of a clear-cut strategic vision and the absence of formal and effective links with industry, universities and government users -- all point to a need for a realignment. One consequence of these weaknesses is a general lack of knowledge about the direction of the research program among industry, university researchers and even managers in other DOC sectors. In many instances, lack of understanding has precipitated a negative perception of the research program on the part of those who should be its strongest supporters.

These factors have contributed to a crisis of legitimacy for the program. Reorganization of the program will remove some of these factors, but they will not solve the problem. Indeed, the only means of responding to such a situation is to undertake a major realignment of the program in a manner which fully involves industry, the university research community and government users.In order to set in motion this process of realignment, the report puts forward a three-stage action plan for the coming year:

1. Organizational realignment

The first stage will focus on establishing a new organizational framework for the research program. It involves:

(a) Internal discussion of organizational options: The senior management of the Department has already held preliminary discussions on the organizational options available for the research program.

(b) Consultation with CCIS Steering Committee: The CCIS Steering Committee was the government-industry task force charged with the responsibility for exploring the notion of privatizing the Communications Research Centre. After receiving a negative verdict on privatization, the committee agreed that the Department should undertake this fundamental strategic review of the labs. In June 1985, the Committee met to consider this report. The vast majority of the members were positive about the quality and direction of the report, and all stated that the best organizational option was some form of semi-autonomous status. The industry representatives were particularly positive about the report. These included: Don Chisholm, Chairman, Bell-Northern Research; John MacNaughton, Senior Vice-President, Spar Aerospace; and Laurent Nadeau, President, Comterm. Doug Parkhill, the former Assistant Deputy Minister for Research at DOC, is also a member. The government representatives included officials of DOC, the Ministry of State for Science and Technology (MOSST) and the Department of National Defence (DND). Only the DND official disagreed with the report because it is his department's view that all defence-related research carried out at DOC, along with the corresponding personnel and facilities, should come under DND's jurisdiction.

(c) Cabinet approval: With this input from the CCIS Steering Committee, the Minister is seeking Cabinet approval for the broad role and organizational option selected for the research program.

2. Consultations to develop new scientific plan

Whatever organizational option is selected, it is vital that the research activities conducted within the program be fully responsive to the needs of its principal clients. To this end, the program will develop a new scientific plan in conjunction with actual and potential government clients, as well as industry and the university research community. This stage in the realignment of research program would involve:

(a) Preparation of draft scientific plan: In conjunction with DOC senior management or the board of the new independent research agency, a committee of experts from the research program will develop a scientific plan in light of the best possible picture of present and future developments in the broad communications area. While existing technological expertise and people available at CRC should be a consideration in the development of such a plan, this cannot be a decisive consideration. Much more important should be the imperative of focussing resources in fewer areas in order to create critical mass in key technological areas at the strategic nexus of present and future government need, commercial potential and Canadian industrial capability.

(b) Intensive domestic consultations: In order to validate the scientific plan, intensive consultations will be held with industry, the university research community, government users of research results and government officials dependent upon the research program for its contribution to the fulfillment of public policy objectives. The consultations could involve symposiums, meetings with key associations and interviews with selected individuals and institutions. The object of these consultations would be to achieve a refinement and re-elaboration of the scientific plan reflecting a realistic assessment of clients' present and future R & D needs.

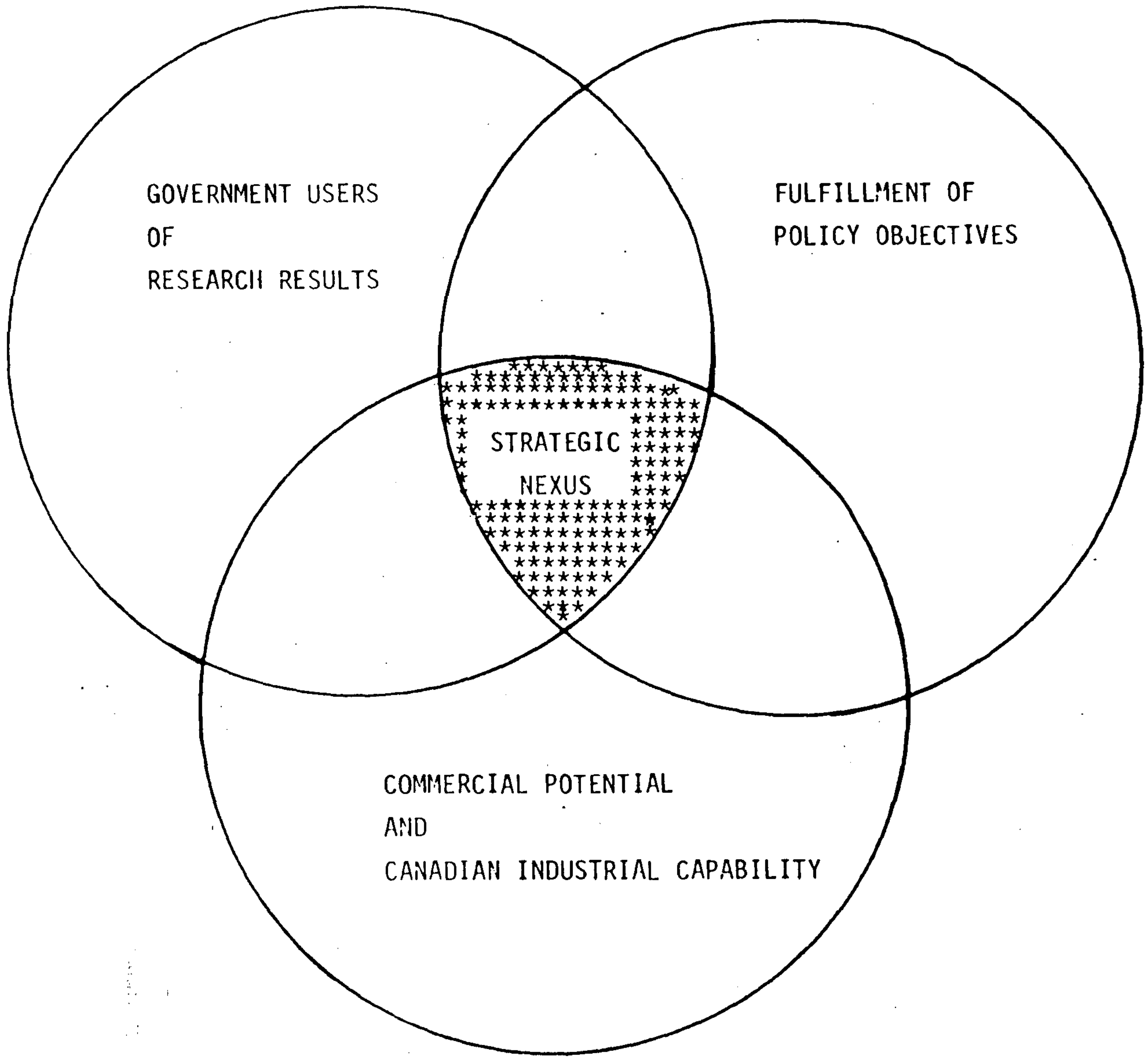
(c) International consultations: With a view to validating the re-elaborated scientific plan which results from the consultations, future discussions would also be undertaken with world-class experts in the relevant technological areas in order to seek their comments on the revised plan and their views on how these technological areas will be evolving over the next 15 years.

3. Implementation

The implementation phase would focus on all the steps required to effect the realignment. Some of this activity could be taking place while consultations on a new scientific plan are proceeding. For example, implementation plans for the reorganization could be under preparation, as could any required changes in legislation or regulations.

FIGURE

THE STRATEGIC NEXUS



PREFATORY NOTE

The purpose of this prefatory note is to provide some of the immediate background to the strategic review of the Research Sector embodied in this report. It is also intended to give readers a sense of the direction and structure of the report as a whole.

BACKGROUND -- CCIS TASK FORCE AND VIABILITY STUDY

In March 1983, it was decided that the Minister of Communications should establish a Task Force (including private sector and federal government representatives) to:

- assess the potential viability of establishing a world-class not-for-profit corporation -- a Canadian Communications, Informatics and Space R & D Institute (CCIS) -- which would be jointly funded by the public and private sectors and utilize the Department's Communications Research Centre (CRC) as its nucleus; and

- prepare detailed business and implementation plans for CCIS.

The CCIS proposal was intended both to raise to world-class level the resources available in Canada for R & D in these strategic technological areas and to address the long-standing problems associated with the conduct of R & D in a government environment.

In July 1983, funding for a study of the proposal was approved, and the membership of the Task Force (to be called the CCIS Steering Committee) was announced in November 1983. Its membership was intended to be representative of the industry and of major government clients of CRC. Its members were: (their titles and affiliations at the time of the last meeting of the Steering Committee are given in parenthesis)

Alain Gourd (Chairman)
Senior Assistant Deputy Minister
Department of Communications

Donald Chisholm, President
Innovation and Development
Northern Telecom

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The work program of the Steering Committee was carried out under contract by consultants from Price Waterhouse Ltd., in co-operation with Nordicity Group Ltd. and Philip A. Lapp Ltd. Their work was to be conducted in two phases:

1) assessment of the viability of CCIS, and
2) preparation of business and implementation plans.

The final Phase 1 report was formally presented to the Department and the Steering Committee in June 1984. The report concluded that a CCIS,

John MacNaughton, Senior Vice-President
Spar Aerospace

Laurent Nadeau, President
Comterm

John Killick, Assistant Deputy Minister (Material)
Department of National Defence

Arthur Collin, Associate Deputy-Minister,
Energy, Mines and Resources
(Secretary, MOSST)

David Low, Deputy Secretary
Ministry of State for Science and Technology

Doug Parkhill, Assistant Deputy Minister, Research
Department of Communications
(retired)

K. Hepburn, Assistant Deputy Minister, Technology and Industry
Department of Communications

D. Maclean, Director General, (Secretary)
Technology and Policy Assessment
Department of Communications

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- lacks the support, either financial or moral, of industry;
- puts continuing funding by government at some risk;
- would involve serious problems of implementation; and
- does not respond effectively to widely varying needs in different fields.

This conclusion was formally accepted by both the Department and the CCIS Steering Committee in June 1984.

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ESTABLISHMENT OF THE STRATEGIC REVIEW

The CCIS feasibility study was clearly useful in that it prevented the Department from embarking in a direction which would not be viable at the present time. However, it left the Department with no firm option with respect to the future of its research programs in an environment which had changed considerably in the 15 years since their inception.

Among the alternatives to CCIS put forward in the Phase 1 study was the conduct of a strategic review of DOC research activities. The Department decided to act on this proposed alternative.

A Departmental Working Group, which reported to the Senior Assistant Deputy Minister, was established. Its members included:

Richard Stursberg (chairman)
Director General
Strategy and Plans

Bert Blevis
Acting Assistant Deputy Minister -- Research

Ron Barrington
Director General
Radar and Communications Technology Research and Development

Jacques Lyrette
Director General
Canadian Workplace Automation Research Centre

Donald MacLean
Director General
Technology and Policy Assessment

James Taylor
Special Research Adviser
Canadian Workplace Automation Research Centre

John Sifton (secretary)
Strategy and Plans

It was decided that the review should attempt to answer in broad and practical terms the question, "What should be the role of government communications, informatics and space R & D in the 1980s and 1990s?" The question was fundamental and the review was therefore a far-ranging one. However, it was focussed by a concern to ensure that the DOC research program acquired a clearer results orientation and stronger and more effective links with the ultimate users of its research, whether in government or the private sector. Its focus was less on the subject-matter of the research program than on the means and organizational realignments which would help the program to achieve these objectives.

Terms of reference and a workplan for the review were prepared for presentation to the CCIS Steering Committee at its June 1984 meeting on the final version of the CCIS feasibility study. The Committee accepted the proposal for the review, with some comments and suggestions for revision. These have been incorporated into the review.

The review was also intended to examine some of the other alternatives put forward for consideration by Price Waterhouse — including one which dealt with the privatization in some degree of the Canadian Workplace Automation Research Centre.

KEY TO REPORT

This report, embodying the findings and conclusions of the review, contains six chapters which examine the issues facing the Department's research program as follows:

Chapter 1 - delineates some key factors in the broader national and international environment which are pertinent to the role of government labs in Canada.

Chapter 2 - defines and discusses seven theoretical principles -- based on the best practices and procedures in private and public sector labs — which suggest how to manage and define the role of a government lab.

Chapter 3 - provides a useful historical perspective on the evolution of the DOC research program.

Chapter 4 - provides a strategic assessment of the DOC research program in light of the seven theoretical principles enunciated in Chapter 2.

Chapter 5 - puts forward a number of organizational options for the research program in light of the strategic assessment in the previous chapter.

Chapter 6 - suggests a broad strategic focus for the research program and a strategy for carrying out its realignment.

CONTENTS OF CHAPTER 1.0

Chapter 1.0

INTRODUCTION -- THE NEW ENVIRONMENT

Since a significant R & D program became part of the new Department of Communications in 1969, the technology which is its focus has changed profoundly in its nature and its significance. Both in Canada and around the world, R & D expenditures -- especially by industry, but also by government -- have grown considerably. Many countries have set in motion large and co-ordinated national R & D efforts, and the respective roles of government, industry and university labs have become the subject of increasingly intense debate. Also at issue has been the degree to which R & D efforts should focus on different stages of the R & D cycle -- that is, on fundamental research or product development, applied research or long-range development. This debate has taken on increasing urgency in Canada, with the publication in mid-1984 of reports on this subject by the Wright Task Force on Federal Policies and Programs for Technology Development and the Standing Senate Committee on National Finance.

This debate, and the trends in the larger environment which have given birth to it, provide both the reason and much of the substance for a reconsideration of the role of DOC's research program.

1.1 MAJOR TECHNICAL ADVANCES

It is now a commonplace to note that the technology on which the research program works has undergone a revolution. As early as 1973, the Science Council of Canada characterized this technology as "transformative"[1] and, since then, there have been major technical advances. These have been viewed as so important in this country and around the world that Science Council chairman Stuart Smith now argues: "...we must reduce our present dependency upon raw materials and we must diversify our economy into some knowledge-intensive and higher value-added products. To maintain our national wealth, we have to change our industrial mixture. To do that means we have to change the institutions which have carried us to the point where we are today."[2]

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1 Science Council of Canada, Strategies of Development for the Canadian Computer Industry (Background Report No. 21, 1973), p. 4.

2 Dr. Stuart Smith, Chairman, Science Council of Canada, Learning to Take Advantage of the New Technology, Address to the Canadian Association of Physicists Corporate Members, Ottawa, April 25, 1984.

1.1.1 Changing transmission technologies

One important example of this transformation has been the changes in transmission technologies over the last 15 years. In 1969, satellites were mainly used in Canada and the United States for military and experimental purposes; now Canada has a commercial satellite communications system, the U.S. has several, and the major issues are crowded orbits and frequency bands. Meanwhile, on the ground, copper cable is beginning to give way to optical fibre, which promises radically increased bandwidths and which will complement and in some cases pose a stiff challenge to satellite communications for two-way voice communication and for distances under 1,000 kilometres.

More significant is the way these transmission media are being used. In 1969, transmission was in analog form; now it is increasingly digital, the language of computers. Computers, which in 1969 occupied a entire room, now fit on a desktop or in a briefcase as a result of advances in micro-electronics.

1.1.2 The convergence of communications and computing

As a result of these developments, computer and communications technologies are converging to the point where it is becoming ever more difficult to tell where the communications system ends and the terminal or computer begins. This fact represents one of the fundamental differences between the world of the late 1960s and the world of the 1980s. As Charles D. Farris, chairman of the U.S. Federal Communications Commission, put it, "In that world (1966) a line between communications and data processing was defensible. The advent of distributed data processing made these rules obsolete. The new 'smart terminals' are both data processors and communications devices.... The realities of the marketplace and the likely evolution of technology simply do not support such a distinction."[1]

The merger of these two fields is creating a distinctively new information technology that most observers agree is already beginning to have a fundamental impact on both homes and the workplace, as well as having important implications for future economic growth and development. This trend is dramatically illustrated by the rise in sales of personal computers which are pervading offices, appearing in a growing number of homes and increasingly linked by communications systems.

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[1] Charles D. Farris, Chairman, Federal Communications Commission (FCC), the FCC's Second Computer Inquiry, 1982.

1.1.3 New industrial alignments

Traditionally, the largest Canadian market for equipment in this area was for telecommunications equipment. As Figure 1-1 illustrates, this is all changing and the new computer-communications hybrids are becoming increasingly important. The market for home terminals has grown rapidly while that for office equipment has finally outstripped that for telecommunications equipment. According to projections based on Statistics Canada data, if present trends continue, the Canadian market for office equipment will be worth $10.5 billion by 1986, while the telecommunications equipment market will be worth about $6.0 billion and that for home terminal equipment $3.5 billion.[1] These markets in themselves are sizeable, and it is important that Canada retain or gain a foothold in them.

The importance of this hybrid market is increasingly recognized by industries around the world, and is stimulating new industrial alignments. Indeed, it was the growing significance of this market that was a factor in precipitating the deregulation of A T & T in the U.S. As a result, telecommunications companies have been pushing agressively into the businesses of computer equipment and software. A T & T itself has bought Olivetti and established technology agreements with Zilog, Intel and Motorola. Similarly, Northern Telecom has established new arrangements with Sperry and Digital Equipment Corporation (DEC). These moves on the part of the telecommunications companies are being paralleled by the big computer manufacturers. IBM has moved into switching technology by buying ROLM, and has developed a joint venture with Aetna Insurance to create its own long distance digital carrier (Satellite Business Systems). The same general approach is also being pursued by other major computer manufacturers in the United States.

1.1.4 The advent of the software era

It is software which, of course, makes all of this equipment usable, and software sales are projected to grow at a rate of 30 per cent a year over the next five years. Indeed, with the clear emergence of artificial intelligence onto the strategic and research agendas of major industries, it is now being argued that "the 1970s were the years of great hardware ideas. The 1980s would be transitional years. The 1990s would be years of great software ideas, and most important, those great software ideas would completely transform the concept of 'computing'."[2]

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[1] Dr. James Taylor, "Briefing notes for meeting with Bruce Macdonald, November 15, 1984," (Unreleased), p. 9.

[2] Edward A. Feigenbaum and Pamela McCorduck, The Fifth Generation: Artificial Intelligence and Japan's Computer Challenge to the World (New American Library, 1984), p. 25.

1.1.5 Strategic technologies of fundamental importance

The industries which manufacture and traditionally have made direct use of these technologies represent the most rapidly growing sector of the Canadian economy. Collectively, our software, computing, office equipment, telecommunications, media and cultural industries account for about six per cent of GDP and and it is expected that their growth will continue over the next two decades.

According to John A. Young, president of Hewlett-Packard and chairman of the recent U.S. President's Commission on Industrial Competitiveness, "It is estimated that, by 1990, the electronics industry on a global basis will have jumped from the tenth largest to the fourth largest industry in the world. By the year 2,000 it will be second only to energy."[1]

In a recent report, the U.S. Congress Office of Technology Assessment argued that the indirect influence of information technology industries on the economy was also very significant: "These industries also have an important indirect effect, in that the technologies and services they produce contribute materially to the economy in such forms as productivity growth, better quality of products and improved managerial decisionmaking."[2]

It can be seen, then, that the technology, which has been the focus of the research program, has profoundly altered and grown in economic importance over the last 15 years. It is expected that this process of technological change will continue and even intensify, as will the growth in importance of this strategic technological area.

1.2 THE GLOBAL CONTEXT -- THE R & D DEBATE

It is now almost redundant to point out that, within the developed world, the revolution in computer and communications technologies is a universal phenomenon, which is being taken very seriously by governments everywhere. Indeed, the markets for the technology are global in scope, and no country can seal itself off from foreign competition.

This fact has important implications for national R & D efforts. As a recent joint study by the University of Ottawa and the Department of Communications pointed out, "The internationalization of markets leads to very intensified efforts in R & D, a result of the strategic behaviour of the firms and of industrial choices of nations in the context of international

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1 John A. Young, President, Hewlett-Packard Company, "An Agenda for the Electronics Industry," Global Stakes: The Future of High Technology America, James Botkin, Dan Dimancescu and Ray Stata (Cambridge, Mass.: Ballinger, 1982), p. 172.

2 U.S. Congress, Office of Technology Assessment (OTA), Information Technology R&D: Critical Trends and Issues (Washington: February 1985), p. 4.

competition."[1] They go on to argue: "Not only is R & D the essential condition for success in fields where the rate of technical progress is extremely rapid; it also helps make full use of innovative strategies as a lever against competition and enables specialization in large-scale products and advanced technologies. These are necessary conditions for penetrating international markets where increasing competition from the 'newly industrialized countries' may readily be observed."[2]

The approach of other countries to employing the resources they commit to R & D -- as well as the very size of those commitments -- in these strategic technological areas may contain some useful lessons for Canada, though no one would suggest that rote imitation of foreign models would provide an appropriate response to Canada's particular needs. Japan and the United States take very different approaches, and they are the world leaders in these technological areas. For a small country such as Canada, the response of other countries -- for example, Britain and France -- to this dual challenge may be especially relevant. However, it should not be forgotten that the outcome of the competition between the U.S. and Japan in these areas may well determine the direction of the world economy in the coming decades.

1.2.1 Japan

Government has played a key role in the astonishing rise of Japan to its present pre-eminence in a number of key industrial sectors. The government agency most responsible for this rise has, of course, been the Ministry of International Trade and Industry (MITI), though the Ministry of Post and Telecommunications (MPT) has also played an important role in the communications area.

Broad Context: MITI's impact and aspirations are considerable. As Ezra Vogel puts it, "They boldly try to restructure industry, concentrating resources in areas where they think Japan will be competitive internationally in the future. As wages rose to Western levels in the late 1960s, MITI bureaucrats tried to reconcentrate resources in industries that were capital-intensive rather than labour-intensive. After the 1973 oil shock they greatly accelerated plans to push Japan into service- and knowledge-intensive industries rather than energy-intensive ones."[3]

The Japanese government very effectively employs a wide range of traditional mechanisms to encourage the development of strategic industries -- direct and indirect subsidies through, for example, tax breaks and closed

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[1] G. Ara, A. Albert, M.A. Crener and J.-P. Sallenave, The World Telecommunications Market: Characteristics, Structures and Trends, Occasional Papers, Vol. I (Ottawa: University of Ottawa and Department of Communications, 1983), p. 9.

[2] Ibid., p. 11.

[3] Ezra Vogel, Japan as Number One (New York: Harper Colophon Books, 1980), p. 71.

market policies, loans and the conduct of R & D in government labs.[1] Indeed, government labs such as MPT's Radio Research Laboratories, MITI's Electrotechnical Laboratories and the National Aeronautics and Space Development Agency carry out work, though on a larger scale, in many of the areas addressed by the DOC research program.

However, it should be noted that these instruments are not deployed in such a fashion as to favour a few large companies or inhibit competition among Japanese firms. In fact, new companies are emerging more quickly in Japan than even the United States, and even the death rates of firms are the same as in the U.S. There is, in short, considerable flux in the Japanese economy, and this -- the continuing emergence of small innovative firms -- may be an important factor in explaining the rate of innovation in Japan.[2] Government policy encourages this flux by trying to equalize the competitive forces at play in particular technological areas[3] and favouring the emergence of many firms in most areas.[4]

In addition, government policy has traditionally not tried to ensure that R & D is carried out exclusively in government labs, though the Japanese government does play an important role by establishing joint government-industry research institutes to focus on research in strategic technological areas. As Charles McMillan points out, "...unlike the United States or Britain, Japan's primary research emphasis is not in government or the universities...."[5] Roughly, 72 per cent of Japanese research support comes from the private sector; the comparable figures for the U.S., West Germany, France and the United Kingdom are 49.6, 48.3, 58.7 and 47.3 per cent, respectively.[6]

As a proportion of GNP, Japan's expenditures on R & D are well below those of the United States, West Germany and the United Kingdom, though far above that of Canada. In absolute terms, its R & D expenditures are also well below those of the United States. However, "in terms of the number of researchers per 100,000 population, Japan is second to the U.S. with 240 versus 280, compared to 150 in Sweden and West Germany, 140 in Britain, 130 in France and 90 in Canada."[7]

The role of government -- creating a strategic consensus: Given that Japanese R & D expenditures are not high in comparison to those of other industrialized countries and the Japanese government provides a relatively

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1 Interesearch, State-Business Interaction (Unpublished study prepared by by University of Ottawa and Department of Communications, September 1983), p. 37.

2 "Europe's Technology Gap," The Economist (November, 24, 1984), p. 95.

3 Charles J. McMillan, The Japanese Industrial System (New York: Walter de Gruyter, 1984), p. 117.

4 Ibid., p. 105.

5 Ibid., p. 102.

6 Ibid., p. 96.

7 Loc. cit.

low level of direct financial support to R & D and industrial development, why has Japan moved ahead so dramatically in so many heavy industries and high technology industries? The reason, paradoxically, is the role government has assumed.

To a large degree, this industry-support role is carried out by MITI. It involves essentially two elements: the formulation of long-term strategic plans for Japanese industry, and a formidable capacity for creating an industry consensus around that plan.

MITI's capacity to create such a consensus may derive in part from cultural factors such as the value placed on co-operation in Japanese society. McMillan views as a key factor the predisposition to take the longer view on the part of Japanese industry: "The emphasis is on the long term, not the short term. The emphasis is on learning and know-how, or process, rather than end product. The rationale is to develop sunrise sectors."[1]

However, MITI works very hard to create its strategic consensus in the full knowledge that "Consensus building is the glue that makes Japanese decisions stick."[2] Indeed, "MITI and private industry are interconnected in a network of influence relationships leading to a consensual process of decision making about industry policy. MITI acts as a coordinator and an orchestrator of this process."[3] In short, MITI and company officials are constantly exchanging views and developing mutual understanding.[4]

Technology policies have been a key component in these industrial strategies, though by no means the only component. Certainly, "Japan's technological emphasis has been a central factor in catching up to the West."[5] However, in this context, it should be noted that "While the government has played a leading role, the success of individual entrepreneurs, various research institutes, and the universities should not be underestimated."[6] At the same time, it should not be forgotten that all of these achievements occurred in the context of the over-all Japanese strategic consensus.

A new emphasis on research: In the 1950s, 1960s and early 1970s, the MITI-industry strategic consensus emphasized the development of heavy industries (steel, automobiles) and consumer industries (consumer electronics). The national research effort was very responsive to this emphasis. "Even though Japan has historically spent less on R & D, in over

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1 Ibid., pp. 94, 95.

2 Botkin, et al., op. cit., p. 34.

3 Everett M. Rogers and Judith K. Larsen, Silicon Valley Fever: Growth of High-Technology Culture (New York: Basic Books, 1984), p. 215.

4 Feigenbaum and McCorduck, op. cit., p. 114.

5 McMillan, op. cit., p. 96.

6 Loc. cit.

all terms, research in specific sectors such as electronic and mechanical engineering, chemicals and automobiles, to cite specific examples, has been notably greater and more successful."[1] In short, Japanese R & D by both government and industry has tended to respond fully and coherently to the imperatives of the over-all MITI-industry consensus on industrial strategy. As part of this thrust, MITI supported, and continues to support, a range of large-scale research projects in strategic technological areas inside government and industry labs through its Agency of Industrial Science and Technology.[2]

In keeping with the emphasis on getting the initial technology from abroad, Japan tended to emphasize product development rather than fundamental research.

This is changing, however. One of the key elements in the MITI-industry strategic consensus for the 1980s is the development of knowledge-intensive industries. Fundamental to this strategy is a much greater emphasis on R & D as a whole, with up to 20 per cent of Japan's GNP to be directed towards new high technology industries.[3] In December 1984, the Japanese Cabinet approved a plan to raise Japan's commitment to R & D immediately from 2.78 to 3.0 per cent of GNP, with a further increase to 3.5 per cent over the next 10 years.[4] In comparison, Canada's target for 1985 is 1.50 per cent and we likely will not achieve that by 1990 without a doubling of research expenditures in current dollars.[5]

In order to mobilize R & D resources for R & D in strategic technological areas, MITI has initiated long-term national projects in areas such as Very Large Scale Integration (VLSI), fibre optics, space technology, robotics, supercomputers and fifth-generation computers.[6] All of these involve intimate industry-government co-operation both in their conception and their implementation. In addition, "This research work, which at first was primarily directed towards mastering and improving foreign technologies, is increasingly turning towards basic and applied research."[7]

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1 Ibid., p. 98.

2 Ministry of International Trade and Industry (MITI), AIST (Agency of Industrial Science and Technology), 1984 (Tokyo, 1984), p. 2.

3 McMillan, op. cit., p. 106.

4 Bert Blevis, "Canada/Japan S&T Consultations and Visits," (Memorandum to Distribution, December 19, 1984), p. 1.

5 Natural Sciences and Engineering Research Council, Completing the Bridge to the 90's: NSERC's Second Five-Year Plan (Discussion Draft, December 1984), p. 3.

6 Research Sector, Department of Communications, The Sectoral Environment for Research and Development in Telecommunications, Space and Informatics (Unpublished compendium prepared in context of Strategic Plan, 1984).

7 Interesearch, op. cit., p. 38.

The VLSI project has already made it possible for Japanese manufacturers to take a decisive lead over their American competitors, especially in the area of 64K memory chips, and they are now posing a stiff challenge with respect to chips of larger capacity.[1]

The December 1984 decision by the Japanese Cabinet called for an increased emphasis on both basic and applied research in four areas of optical electronics and information science. Funding support was to come from both the public and private sectors.[2]

The Fifth Generation: The Fifth Generation project, because of its ambition, has been more controversial and may well have strained the strategic consensus of Japan Inc. However, **the Fifth Generation project, which operates out of the MITI owned and operated Institute for New Generation Computer Technology (ICOT), is typical in the emphasis it places on intimate industry-government co-operation. Indeed, it is structured so as to build up the research infrastructure of Japanese industry.** As Feigenbaum and McCorduck note, "this new structure seems to have been developed to implement a goal of major importance to MITI: to apply pressure upon Japanese industrial computer scientists to innovate, not merely to evolve existing Western technologies.[3]

A number of American observers regard the carefully thought out strategy and ambitious basic research thrust of the Japanese Fifth Generation Project as ominous because of the intimate involvement of industry in both its inception and implementation. In their view, "The Fifth Generation project, in its short life, has emplaced the technology transfer mechanisms necessary for Japanese industry to move effectively to bring its developments to market. Right now, the United States has a substantial lead over the Japanese in virtually every area of Fifth Generation work. But Fortune's article on the Fifth Generation concludes with this observation: 'Even if the U.S. retains its lead in AI (artificial intelligence), there is no guarantee that the laboratory work will end up in products. Computer research tends to seep into the American marketplace slowly except when companies perceive a competitive threat. Assuming that ICOT can do even a fraction of what it intends, the results will show up quickly in Japanese computer products. So the U.S. computer industry could be outmanoeuvered unless it takes the Fifth Generation seriously.'"[4]

1.2.2 The United States

There are significant differences between the U.S. and Japan in their approaches to R & D and industrial development. Perhaps the most notable of these is the absence in the United States of any strategic consensus between industry and government on technology and industrial development in these areas. **There is no over-arching strategy on how industry or the national R & D effort should be restructured to meet the challenge of the 1980s.**

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1 Loc. cit.

2 Blevis, "Canada/Japan S&T Consultations and Visits," p. 1.

3 Feigenbaum and McCorduck, op. cit., p. 117.

4 Ibid., p. 138.

This is not surprising, given the U.S. emphasis on private sector initiative to meet new technological challenges. In this context, it is worth noting that many of the important innovations which had such a wide-ranging impact in the computer and communications areas took place in Silicon Valley, where more than two thirds of the electronics manufacturing firms employ fewer than 10 workers.[1] Partly because of this fact, many now regard the birth of small, aggressively entrepreneurial firms as crucial to a high rate of technological innovation, and note that the birth rate of new firms in the United States lags only a little behind that in Japan.[2]

The role of government: This is not to say that government resources are not used to support the national R & D effort. Indeed, as Figure 1-2 shows, throughout the 1970s U.S governments contributed almost twice as high a proportion of total national R & D expenditures as did the Japanese government; the Canadian government commitment was comparable in proportional terms to the American.[3] The over-all size of the U.S. R & D effort is also much greater in absolute terms -- almost triple that of Japan and more than 20 times that of Canada's.[4]

In the broad communications and computer area, the involvement of the U.S. government is considerable. For example, in 1981, the government put forward close to $3.66 billion to support R & D in the telecommunications area; the private sector put up about $2.4 billion. For the most part, this federal support was not provided in the context of any national industrial strategy, but as a contribution towards the fulfillment of departmental missions. Indeed, $3.6 billion of the total $3.66 billion federal commitment to R & D on telecommunications technology was sponsored for military reasons. In addition, "90 per cent of the private R & D spending financed by telecommunications equipment manufacturers themselves was deemed 'worthy of interest' by the Defence Department and up to one-third of these expenditures were reimbursed to them under specific conditions."[5] The massive funding for Mr. Reagan's Strategic Defense Initiative likely ensures a significant future growth in the importance of defence-related research.

The U.S. government tries to make sure that a proportion of its support goes to the small, innovative firms which are the engines of innovation. As The Economist points out, "Government contracts can be a lifeline for small firms and new industries. The United States uses various devices to encourage government purchases of products from small firms. A

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1 Everett M. Rogers and Judith K. Larsen, Silicon Valley Fever: Growth of High-Technology Culture (New York: Basic Books, 1984), p. 59.

2 "Europe's Technology Gap," The Economist, p. 95.

3 Organization for Economic Co-operation and Development (OECD), OECD Science and technology Indicators: Resources devoted to R & D (Paris: OECD, 1984), p. 326.

4 Ibid.

5 Interesearch, op. cit., p. 47.

recent study found that almost half the first-year sales of small firms in its sample were made to the federal government."[1]

In addition, in contrast to Canada, "much of the U.S. public research effort...is contracted from the military/space complex to private organizations -- like Mitre Corporation."[2] In other words, **there is considerable interpenetration of the private and public sectors in the R & D area, though this occurs in a decentralized, program-specific basis and not in the context of any over-arching national industrial strategy.**

A more focussed and involved role for government labs: Despite this interpenetration, the Federal Laboratory Review Panel, chaired by David Packard of Hewlitt-Packard and reporting to the White House Science Council, was highly critical of the quality of interaction by U.S. government labs with both industry and universities: "Federal laboratories have felt traditionally that they are part of the government, committed to its highest service and totally dependent on it for support. Although the degree of interaction with universities and industry varied among the laboratories visited, the Panel feels that this interaction could be increased at all Federal laboratories."[3]

The Packard panel saw such interaction as vital: "**The United States can no longer afford the luxury of isolating its government laboratories from university and industry laboratories.** Although endowed with the best research institutions in the world, this country is increasingly challenged in its military and economic competitiveness. The national interest demands that the Federal laboratories collaborate with universities and industry to ensure continued advances in scientific knowledge and its translation into useful technology."[4]

In other words, **the Panel saw U.S. government labs as playing an essential role in developing and strengthening the research infrastructure of the entire country.** It also saw close interaction with users as one of the two key factors in determining the effectiveness of a government lab. The other factor was a clearly defined mission: "The Panel believes that clearly defined missions...are important to the vitality of any laboratory. Of the laboratories visited, those with well defined missions clearly were better performers than those with poorly defined missions. Those laboratories with both well defined missions and close interaction with the users of their research appeared to be the most effective of all.[5] The Panel saw those

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1 "Europe's Technology Gap," The Economist, pp. 95, 96.

2 Canada Consulting Group (CCG), Research: Strategic Situation (Unpublished study prepared for Strategy and Plans, Department of Communications, 1984), p. 11.

3 Federal Laboratory Review Panel, Report of the White House Science Council (Washington: Office of Science and Technology Policy, Executive Office of the President, May 1983), p. 11.

4 Loc. cit.

5 Ibid., p. vii.

missions as involving roles "intermediate between those of universities and industry."[1]

Calls for a national strategy and more basic and applied research: Because of the increasing penetration by Japanese and other countries' products into the American market for high technology products, **a number of U.S. commentators working in the high technology area see the need for a national strategy for this sector.** According to Botkin, et al., "A national strategy must begin with an unabashed and strong commitment by the president of the United States. Not only must he articulate a vision of the future but he must craft long-term goals that account for both the knowledge-intensive nature of the economy and the international pressures bearing on it."[2]

The stage of the R & D cycle to be concentrated upon has become an issue in such debates. In the computer and communications areas, with the life cycle of a product shrinking to two or three years according to estimates by McKinsey and Hewlitt-Packard, there is an increasing emphasis on product development, especially by small and medium-sized firms. However, in the larger companies, such as A T & T, Xerox and IBM, between 10 and 20 per cent of R & D resources are spent on fundamental research, often in conjunction with the university community. This contrasts with the nearly exclusive developmental emphasis of BNR, Canada's largest private R & D institution. Indeed, after a visit to California, one knowledgeable Canadian observer commented: "In the refined world of Silicon Valley, BNR comes across as red-neck high-tech."

There can be no doubt, however, that the predominant R & D emphasis of the U.S. computer and communications industries is upon near-term development. At the same time, the Japanese successes have prompted many companies in this sector to consider a greater emphasis on co-operative research projects involving a number of companies and the universities and focussing more on basic and applied research. Examples of such co-operative research efforts are the Semiconductor Research Cooperative, the Microelectronics and Information Systems Centre[3] and the Microelectronics and Computer Technology Corporation in Austin which is working on artificial intelligence.[4]

The U.S. government is also involved in such projects, a good example being the Strategic Computing Program of the Defence Department's Advanced Research Projects Agency. The focus of the project is a number of military applications of fifth generation computer technology and its managers will be working extensively with both universities and industry.[5]

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1 Ibid., p. 2.

2 Botkin, et al., op. cit., p. 157.

3 Ibid., pp. 89-111.

4 Feigenbaum and McCorduck, op. cit., pp. 277-283.

5 Ibid., pp. 271-276.

1.2.3 The European Experience

The long-standing American dominance and growing Japanese challenge in these strategic technological areas has meant that in Europe, applications of micro-electronics, such as in telecommunications, "have moved to the top of the political agenda."[1] There is a rising debate about a growing "technology gap" between Europe and the United States and Japan.[2] Out of this debate, which has been going on since mid-1970s, has spawned a wide range of technology and industrial development programs. Though each country has approached this area in its own unique fashion, there have been important similarities.

Extensive government intervention: Despite significant variations, the most striking aspect of the European experience has been the massive intervention of governments in the economy. Indeed, in most European countries, governments play a greater role in determining the shape of every link in the innovation chain within these strategic technological areas than in Japan or the United States.

All European countries deploy a wide range of instruments intended to promote R & D, regional expansion and employment in every industrial sector. Indeed, "European governments have been sinking immense amounts of resources into the maintenance of industrial competitiveness, increasingly equated with technological excellence."[3] Government procurement has been an important tool in this endeavour, perhaps nowhere more than in these strategic technological sectors. In fact, "The vital role that procurement plays in these sectors, as well as in telecommunications, is common knowledge...its role alone must qualify the non-interventionist claim of any government."[4]

In addition, "Horizontal policy measures have consistently been complemented by an astonishing array of direct, but nevertheless cautious, forms of economic intervention. Indeed, a 'technological imperative' has demanded as much by way of 'government push' as 'market pull'."[5] These have ranged from occasional outright nationalization and massive industrial restructuring -- especially in France -- to the establishment of government-owned or funded labs to a very diverse panoply of government programs to help industry understand, develop and market new technologies and products. To a large degree, such assistance has been targetted at large firms which would be able to function as national 'champions' in strategic technological areas.

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1 "The born-again technology," The Economist (August 22, 1981), p. 3.

2 "Europe's Technology Gap," The Economist, p. 93.

3 Dirk de Vos, Governments and Microelectronics: The European Experience (Science Council of Canada: March 1983), p. 101.

4 Loc. cit.

5 Ibid., pp. 101, 102.

A lack of strategic consensus: Within European countries, most commentators see a lack of strategic consensus among government, industry and universities on long-term objectives and the kinds of policy instruments which should be deployed to meet them.

For example, in the United Kingdom, where the strength has been in the flexibility with which policy instruments are used, the director of the National Computing Centre stated: "Our strategic planning is diabolical. We skimp our homework.... U.K. industry needs to get its act together."[1] In West Germany, "At a time when even Germany's largest micro-electronics firm is experiencing technical and marketing problems, despite its healthy cash position, the need for strategic planning between governments and large players in the international field has become more acute."[2]

The government of France, of course, has made almost a fetish out of strategic planning. But these magnificently logical plans, with their eloquent and extremely ambitious objectives, rarely reached down to influence markedly the behaviour of the government officials who were actually delivering assistance to industry, with the result that there was -- according to critics -- "a veritable 'vaudeville administratif,' unimaginative, incompetent, out of touch with the real world, acting on the spur of the moment, without coherence...."[3] As a consequence, "Respectable authorities, both foreign and domestic, have repeatedly asserted that French industrial and technological policy has failed in its implementation of grandiose and expensive 'plans' because top-level national and bureaucratic co-ordination has not been matched by effective coordination at lower levels. In other words, France is not Japan. The state has not been able to put together its own act in the meeting-place with other integrated actors, least of all in an area like micro-electronics, which is not only integrative by nature but also part of a footloose international market."[4]

Targetted assistance and the role of government labs: In the last few years, there has been an increasing emphasis on targetting assistance more carefully in strategic technological areas. Government labs, in a variety of institutional manifestations have been one of the tools employed.

In the United Kingdom, as of 1982, the Science Council stated, "A greater degree of selectivity in public support is inevitable and already a growing theme in discussions of future policy. Not only is selectivity required from a technical and product marketing aspect, but also in the determination of the kinds of firms that ought to be favoured in the competition for scarce public resources."[5] The recently established Alvey Program of research and development in the artificial intelligence area is an example of one of the innovative policy instruments used in the context of

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1 The New Scientist, January 28, 1982, p. 224.

2 de Vos, op. cit., p. 79.

3 Ibid., p. 48.

4 Ibid., pp. 58, 59.

5 Ibid., p. 35.

this new emphasis on selectivity. Reporting to the Department of Trade and Industry, the program is funded by a number of departments, but half of the funding for specific projects must come from industry, with an industry steering committee setting priorities. The focus is upon pre-competitive industrial research involving collaboration between different companies. The program would seem to be more strongly supported by large companies.[1]

The same pattern is apparent in West Germany. As the Science Council reported in 1983, "government and the private sector perceive a growing need for targetting government assistance to specific technologies and firms, in parallel with the realization that economies of scale are unavoidable in some fields of high technology."[2] Among the instruments used in providing this targetted assistance are the extensive network of government funded research institutes and some of these have been reshaped to provide more focussed support which is of immediate industrial relevance.

For example, the Heinrich Hertz Institute, "A fairly typical German research institute without central relevance to industry(,) appears to have been transformed into an organization that is much more vital to the strategic industrial interest of West Germany's thrust into broadband communications."[3] The institute is wholly funded by government, with each project rigorously vetted for industrial relevance by the Department of Industry and Technology and requiring approval through an industrially oriented review process involving independent panels of non-government experts. Nominal management is the responsibility of a scientific council composed of university and industry representatives, and there is a strong emphasis on collaboration with the best German universities.[4] The Institute has "a rigorous focus in broadband communications,"[5] with a new and heavy emphasis on integrated optics work several years in advance of industry, with a view to leading industry into promising product areas. The target companies are the major West German telecommunications firms, and these apparently do take advantage of the institute's research.[6]

<u>European perspectives</u>: Most commentators tend to agree that these new initiatives represent an improvement over the past. As <u>The Economist</u> pointed out in November 1984, "Government support for R & D is a vital stimulus to innovation.... It is hard to overstate the benefits the American electronics industry received from defence and space spending on R & D in the two decades following the mid-1950s.... So Europe's recent fit of government projects to support electronics R & D is not misconceived."[7]

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1 Price Waterhouse Associates, <u>CCIS Feasibility Study Interim (Phase 1) Report</u> (June 1984), Appendix C, p. 18.

2 de Vos, <u>op. cit.</u>, p. 78.

3 Price Waterhouse, <u>op. cit.</u>, p. 10.

4 <u>Ibid.</u>, p. 19.

5 <u>Ibid.</u>, p. 10.

6 <u>Ibid.</u>, p. 19.

7 "Europe's Technology Gap," p. 96.

However, some doubt has been expressed as to the appropriateness of targetting so much of this support at large firms: "The trouble is that these programmes are repeating the same old European mistakes. The big boys are nosing into the trough first, as usual. Big firms are heading almost every Alvey project. The West German minister for research and technology, Mr. Heinz Riesenhuber, is a passionate admirer of the revolution Silicon Valley (with its small innovative firms) has wrought; but DM300m of his budget has just been given to Siemens, Germany's cash-rich and biggest electronics firm, for a joint development programme with the giant Dutch firm, Philips -- and this for a single product."[1] In the view of the author, "Europe's problem is that it is attached to stability in an age when stability is a comparative disadvantage" because of the pace of technological change and the fact that small new firms seem to be on the cutting edge of innovation.[2]

1.2.4 The Global Perspective

The Japanese, American and European experiences, though very different and far from providing models for rote imitation, provide useful indications as to the directions we might take and the questions we might ask in addressing the role of DOC's Research Sector. In particular,

1. **Because the pace of technological change is accelerating in an increasingly competitive global marketplace and successful national R & D efforts require commitments and planning frames 10 to 15 years from the product implementation stage, public sector initiatives in the R & D area are growing in importance, given that industry is usually unable or unwilling to undertake such expensive, high-risk and long-term commitments. Government owned or operated labs represent one of the key instruments used by governments in this context.** The Fifth Generation and VLSI projects exemplify this trend in Japan, as do the Alvey Program and Heinrich Hertz Institute in Europe and the Strategic Computing Program in the United States.

2. **All public sector initiatives to stimulate technology development should be carried out in the context of a fine-grained strategic consensus on technology policy shared by government, industry and the universities. One aspect of this consensus should be the targetting of particular technologies as strategic and the means of assuring their development.** Most commentators agree that the scope and power of this strategic consensus is one of the key factors explaining the astounding Japanese successes since the Second World War and especially those recent ones in the computer and communications areas. There are increasing demands for the establishment of national industry strategy for key technologies in the United States, and there is an increasing recognition of the need for such strategies in Europe.

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1 Loc. cit.

2 Ibid., p. 95.

3. This strategic consensus should include agreement on the role of government labs and the direction of their research programs, especially as these relate to strategic technologies. For this reason, government labs must have intimate ongoing interaction with universities and industry, with a view to ensuring that government work contributes to the over-all strengthening of the research infrastructure of the country in strategic technological areas. The numerous national projects in Japan are in many ways the exemplar of such an approach, and the burden of the Packard Panel's recommendations with respect to U.S. government labs was to assure that their interaction with industry and universities significantly improved. The Alvey Program and the Heinrich Hertz Institute reflect an attempt to take such an approach in Europe.

4. Within the context of a strategic consenus, Government labs should be driven by a clear sense of mission and focus on R & D activities which industry or the universities are not interested in or capable of undertaking. In other words, though all sectors of a national R & D complex should focus to some degree on strategic technological areas, co-ordination among them demands that they focus largely on different stages of the R & D cycle. In Japan, where the university community is not a very strong R & D player, the focus in government-sponsored national projects is very much on pre-competitive fundamental and applied research. In the United States, the Packard Panel felt that government labs should locate themselves on the R & D spectrum in a position which is intermediate between universities and industry.

5. An important consideration is the mix of domestic industries which are targetted for support through technology policies in general and government labs in particular. In Japan, though government labs work extensively with the large industry players, industrial and technology policies favour equal competition and the emergence of new firms in strategic technological areas. Through a variety of mechanisms, U.S. government procurement policies attempt to ensure that small, innovative firms benefit as well as larger companies. In Europe, however, the emphasis has very much been on the development of large companies to act as "national champions" in strategic technological areas -- a factor which, according to observers of the European scene, explains the lack of European success in highly innovative areas such as semiconductors and computers.

1.3 THE CANADIAN RESPONSE TO THE GLOBAL CHALLENGE

According to the Organization for Economic Development and Co-operation (OECD), R & D is "the single most important determinant of long run competitiveness" in telecommunications equipment.[1] The same holds true for the other industries associated with these technologies. Indeed, "(the) future growth of (these high technology firms) is dependent on high risk investments in research and development."[2]

By way of a first cut at assessing how well Canada has done over the last 15 years, it may be useful to review available data on the size of the over-all Canadian effort in comparison to other countries and the situation in the key components of the national research infrastructure -- universities, industry and government labs.

1.3.1 The over-all Canadian R & D commitment -- a drop in the global bucket

Canada's over-all national R & D effort pales in comparison to that of its major trading partners. For example, in 1981, Canada spent only 1.25 per cent of its gross domestic product on research and development; in the United States, the United Kingdom, Japan and France the comparable figure was well over two per cent.[3] In absolute dollar terms, Canada's lack of R & D scale was even more apparent, as Figure 1-3 shows. For example, in 1981, Canada spent about $4 billion on R & D, while the United States spent around $90 billion and Japan more than $30 billion.[4]

However, it is difficult to generalize from these figures to the communications and computer sectors. First of all, this sector is hardly typical of the whole in that its commitment to R & D is far higher than other sectors and communications in particular "is expected to be the leading industry in the Canadian economy for the 1982-1990 period.[5] Second, up-to-date international comparisons of resource commitments to R & D within specific industrial sectors are difficult to come by.

According to Northern Telecom, the Canadian R & D effort in the communications area represents about two per cent of world expenditures.[6]

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1 Quoted in Communications: Strategic Situation by the Canada Consulting Group Inc. (CCG) (Unpublished study prepared for the Department of Communications and presented July 23, 1984), p. 14.

2 Botkin, et al., op. cit., p. 4.

3 CCG, Research: Strategic Situation, p. 3.

4 Ibid., p. 4.

5 Interesearch, op. cit., p. 2.

6 Converation with Donald Chisholm, President, Innovation and Development, Northern Telecom, June 1984.

There are also indications that in proportionate terms Canada's R & D commitment has not been as great as that of our major trading partners in the strategic areas of communications equipment and electronic components. In a report published in 1984, the OECD ranked its member countries in terms of the proportion of their Net Domestic Product devoted on average from 1969 to 1980 to R & D on electrical machinery, communications equipment and electronic components. Canada ranked tenth -- behind the United States, the Netherlands, the United Kingdom, Sweden, Germany, France, Japan, Norway and Belgium.[1]

It can be seen, then, that in absolute terms, the Canadian commitment of resources to support R & D even in these strategic technological areas is minuscule in the global context. There are also strong indications that in proportional terms our commitment lags behind that of our major trading partners.

1.3.2 Canadian universities

The new importance attached to R & D in these strategic technological areas around the world caught Canadian universities at something of disadvantage. Since the radical expansion in higher education attendant upon the coming to age of the baby boom generation in the 1960s and early 1970s, universities have faced an ever tighter revenue situation. Indeed, as the Wright Task Force points out, "At a time when research demands are increasing, the number of operating dollars per student is decreasing in real terms. This correspondingly reduces the funds available for overhead support of sponsored research."[2]

To some degree, granting agencies such as NSERC have picked up the slack. For example, the amount of NSERC funds targetted for strategic grants in the area of communications and computers rose from $965,000 in 1979-80 to $3,475,000 in 1983-84; before this period, this area did not receive strategic grants support. In May 1983, the Council received $19.5 million over five years to support the development of a university-based national micro-electronics design network, which will be managed from Queen's University in Kingston. In January 1984, NSERC was awarded an additional $16.5 million over three years to support increased co-operation between university researchers and industry across a range of technological areas.[3]

However, there is some doubt about the degree to which universities will be able to make use of NSERC funds. According to Claude Lajeunesse, director of targetted grants at NSERC, "Universities will soon be put in the situation where they will have to turn down research money for fear of going

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[1] OECD Science and Technology Indicators, p. 60.

[2] Wright Task Force on Federal Policies and Programs for Technology Development, A Report to the Minister of State for Science and Technology (Ottawa: July 1984), p. 19.

[3] Natural Sciences and Engineering Research Council of Canada (NSERC), 1983-84 Report of the President (Ottawa, 1984), pp. 1, 11, 13.

broke."[1] The reason is that the universities must match each dollar of federal funding.

These trends and developments have important implications for university research. Because of the growing proportion of funds available for applied research in co-operation with industry and the simple fact of too many university researchers chasing too few funds, the universities are in proportionate terms carrying out less longer-range fundamental research and more applied and development work.

More important, **universities account for a declining proportion of the over-all Canadian R & D effort.** Figure 1-4 illustrates this reality in relation to the proportion of engineers and scientists working on R & D in Canada within the university, industry and government sectors.

These developments raise important questions about the role and capacity of the universities in contributing to a national R & D effort in these strategic high technology areas. **The Wright Task Force regards the universities as a "crucial link"[2] in the innovation chain because of their concentration on fundamental research topics which industry largely ignores. However, some observers believe academics are becoming less and less able or willing to perform that role:** "...there is an almost imperceptible drawing back by scholars from the whole convoluted process of research and writing. It is almost as if the entire academic community had become so demoralized that it has largely stopped performing its most important role. If that is so, it is a tragedy of major proportions."[3]

Beyond this, the relatively constrained circumstances of Canadian universities also have very important long-term implications for the Canadian research effort as whole in these key technological areas. According to the Canada Consulting Group Inc., the total number of graduates in mathematics and the applied sciences remained almost unchanged between 1971 and 1981, while growth in the number of engineering graduates came entirely from undergraduate degrees. During this period, students working for research-intensive post-graduate degrees actually declined in all areas of the physical sciences except computer science.[4] In short, **the development of expertise in these key technological areas is not keeping pace with the demand.**

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1 Lawrence Surtees, "Research financing formula poses problems at universities," Globe and Mail (November 23, 1984).

2 Wright Task Force, op. cit., p. 19.

3 David J. Bercuson, Robert Bothwell and J.L. Granatstein, The Great Brain Robbery: Canada's Universities on the Road to Ruin (Toronto: McClelland and Stewart, 1984), p. 124.

4 CCG, Research: Strategic Situation, p. 35.

1.3.3 Canadian industry

The situation of Canadian universities presents a sharp contrast to a Canadian industry which is now pouring considerably more money into communications R & D than it did in 1969 or even 1975. Indeed, in 1981, business enterprise accounted for 55 per cent of the scientists and engineers engaged in Canadian R & D, up from 45 per cent in 1975.[1] However, it should be noted that Canadian industry invests a significantly smaller proportion of the Domestic Product of Industry than industry in other major countries.[2]

This situation exists despite the growing number of federal as well as provincial programs intended to increase the level of R & D by Canadian industry. In addition to the R & D tax incentive, the major federal programs include:

- the DRIE Industrial and Regional Development Program (total annual grants and contribution budget -- $315 million),
- the DRIE-DND Defence Industry Productivity Program ($130 million),
- the NRC Industrial Research Assistance Program ($40 million) and
- the NRC Program for Industry/Laboratory Projects($24 million)[3].

None of these programs are targetted exclusively on the communications-computers industrial nexus, though it has benefited significantly from them.

Indeed, **because of the rapid evolution of the technologies with which these industries deal, they have increased their R & D expenditures at a rate which is considerably higher than that of Canadian industry as a whole.** Between 1975 and 1984, current intramural R & D expenditures by the communications equipment industry grew from $126 million to a projected $636 million.[4] Intramural R & D expenditures by communications equipment companies grew from 17 to a projected 28 per cent of all such expenditures by Canadian industry between 1980 and 1984.[5]

The same holds true for other related industrial sectors which are growing in importance as a result of the marriage of computer and communications technologies into what can only be described as integrated information systems. For example, current intramural R & D expenditures by

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1 Ibid., p. 30.

2 Ministry of State for Science and Technology (MOSST), Research, Development and Economic Growth (Ottawa, 1985), p. 3.

3 1985-86 Estimates (Part 11, The Main Estimates (Ottawa, 1985).

4 Statistics Canada, Industrial Research and Development Statistics, 1982 (with 1984 Forecasts) (Catalogue 88-202 Annual, June 1984), p. 82.

5 Ibid., p. 29.

Canada's business equipment industry grew from $10 million in 1975 to a projected $89 million in 1984.[1]

However, there is an important observation which must be made about much of industrial R & D. Most of it involves product development rather than longer-range research, especially by smaller and medium-sized Canadian companies. There is also little evidence of the increased emphasis on longer-range research that is apparent among our larger trading partners.

Clearly, **the size and sophistication of the industry with which the Research Sector deals have increased markedly in the last 10 years.** However, as noted above, the R & D commitment of even these industries is less in proportionate terms than the same industries within our major trading partners. There is also little evidence of a commitment to longer-range research in Canada, in contrast to that of many of our major trading partners.

1.3.4 Research at DOC

The DOC research program has been intimately involved with industry in a number of the technical areas which spawned the technological revolution over the last 15 years. Space, Telidon and fibre-optics represent notable examples.

However, it should be noted that DOC R & D expenditures now represent only about seven per cent of all industry-government expenditures in the area of communications equipment, as Figure 1-5 shows.[2] The Research Sector remains the second largest research establishment in Canada in the broad communications area, as it was in 1969; the largest is still, of course, Bell Northern Research.

Between 1976-77 and 1982-83, the Sector's budget (excluding space) remained roughly constant in real terms because of the inclusion of a number of sunset programs. According to the Sector's own preliminary estimates, however, the base budget declined by more than 40 per cent in the same period in real dollars.[3]

At the same time, given the rapid increase in industrial R & D budgets, the Sector's contribution to ongoing Canadian R & D in these fundamental technological areas clearly represents a shrinking proportion of the whole. And as well, given that there are strong indications that in proportionate terms the R & D budget of Canadian industry in the telecommunications equipment and electronic components area lags behind that of the industries of our major trading partners, the Sector's budget would seem to represent a declining proportion of a progressively less significant Canadian whole.

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[1] Ibid., p. 82.

[2] CCG, Research: Strategic Situation, p. 47.

[3] Research Sector, Department of Communications, DOC Research Sector: Budget Augmentation 5-Year Plan (Unpublished preliminary draft of discussion paper, 1983), p. 12.

For this reason and because of the substantial changes in the technology and in the university and industry communities with which the DOC research program must deal, there would seem to be a clear need for a rethinking of its role in relation to them, as well as its government clients.

However, it is important to keep these changes in perspective. Most of the research carried out within the DOC research program is comparatively long-range. As already noted, the substantial increase in industrial R & D has generally been in the area of short-term product development. For this reason, though the budget of the DOC research program is declining as a proportion of the national R & D commitment, the program remains the largest laboratory complex in Canada which is committed to longer-range research. Given the increasing emphasis upon longer-range research in Japan, the United States and Western Europe, it may well that the DOC research program constitutes a national resource for our efforts to remain abreast with our competitors with respect to these strategically important information technologies.

1.4 THE CANADIAN R & D DEBATE

In many ways, it is the global technological challenge and the apparent weakness of the Canadian response which has prompted a new debate on R & D and technology in Canada. In the recent reports of both the Senate Standing Committee on National Finance and the Task Force on Federal Policies and Programs for Technology Development, government labs were criticized for the roles they have assumed in relation to industry and to a lesser extent the Canadian university community. There was also a concern about the kinds of research they should be doing and this dealt to some degree with the stage of the R & D cycle on which they should be focussing.

1.4.1 Report of the Standing Senate Committee on National Finance

The Report of the Standing Senate Committee on National Finance was published in August 1984. Committee members were clearly determined to keep government out of research areas which should be the responsibility of industry. It stated: "...the Committee is concerned that the federal government is engaging in R & D that could be carried out and exploited by industrial firms. It recommends, therefore, that the intramural research and development programs of all departments and agencies, including the National Research Council, be reviewed to exclude from them any activities that could more appropriately and profitably be conducted in industry."[1]

While admitting the validity of in-house research in support of Departmental missions and the importance of basic research in strategic technological areas such as fibre optics and fifth generation computers, the Committee noted that "the government also conducts R&D in other areas such as

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[1] Standing Senate Committee on National Finance, Federal Government Support for Technological Advancement: An Overview (Ottawa: August, 1984), p. 44.

communications and chemical engineering which could be performed by industry where it would be more subject to the discipline of the marketplace."[1] The Committee called for much greater emphasis on contracting out by government labs.[2]

Finally, the Committee recommended that the government "increase its efforts, in co-operation with universities and the private sector, to strengthen mechanisms for collecting information on foreign technological developments and for disseminating it within Canada."[3]

1.4.2 Task Force on Federal Policies and Programs for Technology Development

The Wright Task Force recommended that "a review of all federal laboratories be carried out, with each laboratory being required to demonstrate to a designated central agency its relevance and usefulness."[4] An interdepartmental committee chaired by the Ministry of State for Science and Technology (MOSST) has already been established to explore implementation of the Wright report, and it has taken a particular interest in the role of government laboratories.

The Wright Task Force found that the "traditions of excellence" in government labs were "being undermined by a growing atmosphere of irrelevance and an excessively bureaucratic style."[5] The Task Force went on to comment that "the lack of clearly defined missions, plus an excess of administration, were the criticisms we heard most frequently."[6]

Its recommendations, in addition to calling for a strengthened peer review process, a reduction in "micro-management" and mechanisms and incentives for bringing government labs closer to industry, would require converting government labs into corporations (at the very least, Departmental or Schedule 'B' corporations) run by boards of directors fully representative of clients and with real power to set research priorities.

It saw a role for government labs in meeting specific government requirements and in serving industry. With respect to the latter role, it pointed out that, "If a federal laboratory purports to serve an industry, surely that industry is best able to define what that lab should be doing, and to judge how well it's doing it."[7] The Task Force also saw a need for greater interaction with not just industry but also "universities, scientific and technical training institutions, regional institutions such as

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[1] Ibid., p. 43.

[2] Ibid., pp. 44, 45.

[3] Ibid., p. 46.

[4] Wright Task Force, op. cit., p. 33.

[5] Wright Task Force, op. cit., p. 25.

[6] Loc. cit.

[7] Ibid., p. 26.

Provincial Research Organizations, trade unions, industry associations, consumer groups."[1]

1.4.3 Perspectives on the Canadian R & D debate

The conclusions and recommendations of the Senate Committee and the Wright Task Force are broadly consistent with the views expressed by the U.S. Federal Laboratory Review Panel, as well as with the Japanese and European experiences. All place growing emphasis on the importance of close and dynamic interaction between government labs and university and industry R & D establishments in the context of an increasingly fine-grained strategic consensus.

All believe that "market pull" is crucial to effective technology development -- a view which is implicit in the Senate report and explicit in the Wright Task Force report. It is worth noting, however, that the two Canadian reports -- especially the Wright report -- place so much emphasis on "market pull" that they may present a somewhat unbalanced view of the innovation process and certainly a view which is somewhat at odds with the best Japanese, American and European experience.

For example, the Wright Task Force states: "We think it's helpful to picture this innovation process as a chain which stretches from pure research to the introduction of new products. Like a real chain, it responds better if it's 'pulled' by market demand than if it's 'pushed' by research and technology development. The main thrust of our findings is that the federal government's involvement in technology development must be redefined to maximize the market's 'pull' on the innovation process."[2]

The inference would seem to be that all those engaged in R & D, including government labs, should respond passively to "market pull". However, in the case of much fundamental and applied research, no actual product exists and in many instances has not even been conceptualized; there can be no market without at least an envisaged product. The existence or even a conceptualization of a product often depends on the resolution of technical issues.

This is not to say that a sense of future markets, based on industry perceptions, should not shape the technological areas and issues which a research program explores. Indeed, the Wright Task Force makes a fairly convincing case -- not to mention the recent thinking in Japan, the U.S. and Europe -- that "market pull" should carry far greater weight in the activities of government labs. However, if "market pull" were the only criterion, there would have been no Japanese Fifth Generation or VLSI project, no industrial support role for U.S. labs and no Alvey Program or Heinrich Hertz Institute in Europe.

It is important, therefore, to emphasize that neither "market pull" nor "technology push" should alone be the driving force for a research program. Rather, it is the dynamic, ongoing interaction between the two

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[1] *Ibid.*, p. 27.

[2] *Ibid.*, p. 2.

which makes for successful R & D -- with "technology push" more dominant in the earlier stages of R & D and "market pull" prevailing towards the latter stages. Similarly, it is the dynamic ongoing interaction between universities, government labs and industry -- with each actively participating in the formulation of a co-ordinated national research program in the context of a fine-grained strategic consensus -- which makes for a successful national R & D effort.

The burden of this report is to show how a particular government lab -- the research program of the Department of Communications (DOC) -- can play such a dynamic and interactive role in the Canadian context.

1.5 THE PURPOSE OF THIS REPORT

The purpose of this paper is to review these criticisms and concerns in light of the literature on the subject, experience elsewhere and present practices in the DOC research program.

In carrying out this review, we also took into account the profound changes in the environment in which the Research Sector operates.

In particular, we have considered the significant advances in the technologies with which the research program deals. These advances have both transformed the subject-matter of the program and enhanced its importance. These technologies are now strategic technologies and are fundamentally important to Canada's future development.

This fact has changed the national environment in which the DOC research program operates. Expenditures by Canadian industry on R & D -- mainly product development work -- in these technological areas have increased dramatically, witn the result that the Research Sector's budget represents a declining proportion of the entire national commitment in these areas. The significance of university research has also declined as the universities' financial position has deteriorated -- an ominous sign with respect to the long-term vitality of the Canadian R & D effort in these knowledge-intensive areas.

The international environment has also changed. Other industrialized countries have intensified their R & D commitment to these strategic technological areas, and new and innovative approaches to national R & D efforts are making their presence felt. Canada's own R & D commitment represents only a minuscule proportion of the global whole, and there are strong indications that the entire Canadian industrial effort in these key technological areas is in proportionate terms less than that of industry in our major trading partners. This fact has unwelcome implications for the future health of the Canadian economy.

Clearly, given our own limited resources as a relatively small country, it is incumbent upon us to ensure that our own R & D expenditures in these areas are deployed and shaped for maximum effectiveness and efficiency.

The Japanese, American and European experiences, though very different, provide useful indications as to the directions we might take and the questions we might ask in addressing the role of DOC's Research Sector. In particular,

1. Because the pace of technological change is accelerating in an increasingly competitive global marketplace and successful national R & D efforts require commitments and planning frames 10 to 15 years from the product implementation stage, public sector initiatives in the R & D area are growing in importance, given that industry is usually unable or unwilling to undertake such expensive, high-risk and long-term commitments. Government owned or operated labs represent one of the key instruments used by governments in this context.

2. All public sector initiatives to stimulate technology development should be carried out in the context of a fine-grained strategic consensus on technology policy shared by government, industry and the universities. One aspect of this consensus should be the targetting of particular technologies as strategic and the means of assuring their development.

3. This strategic consensus should include agreement on the role of government labs and the direction of their research programs, especially as these relate to strategic technologies. For this reason, government labs must have intimate ongoing interaction with universities and industry, with a view to ensuring that government work contributes to the over-all strengthening of the research infrastructure of the country in strategic technological areas.

4. Government labs should be driven by a clear sense of mission and focus on R & D activities which industry or the universities are not interested in or capable of undertaking. In other words, though all sectors of a national R & D complex should focus to some degree on strategic technological areas, co-ordination among them demands that they focus on different stages of the R & D cycle.

5. An important consideration is the mix of domestic industries which are targetted for support through technology policies in general and government labs in particular.

The next chapter addresses all of these concerns by formulating general principles -- based on the best practices and procedures used in government and industry labs -- with respect to the appropriate role of government labs, their effective management, and their interaction with universities, industry and government clients.

FIGURE 1-1

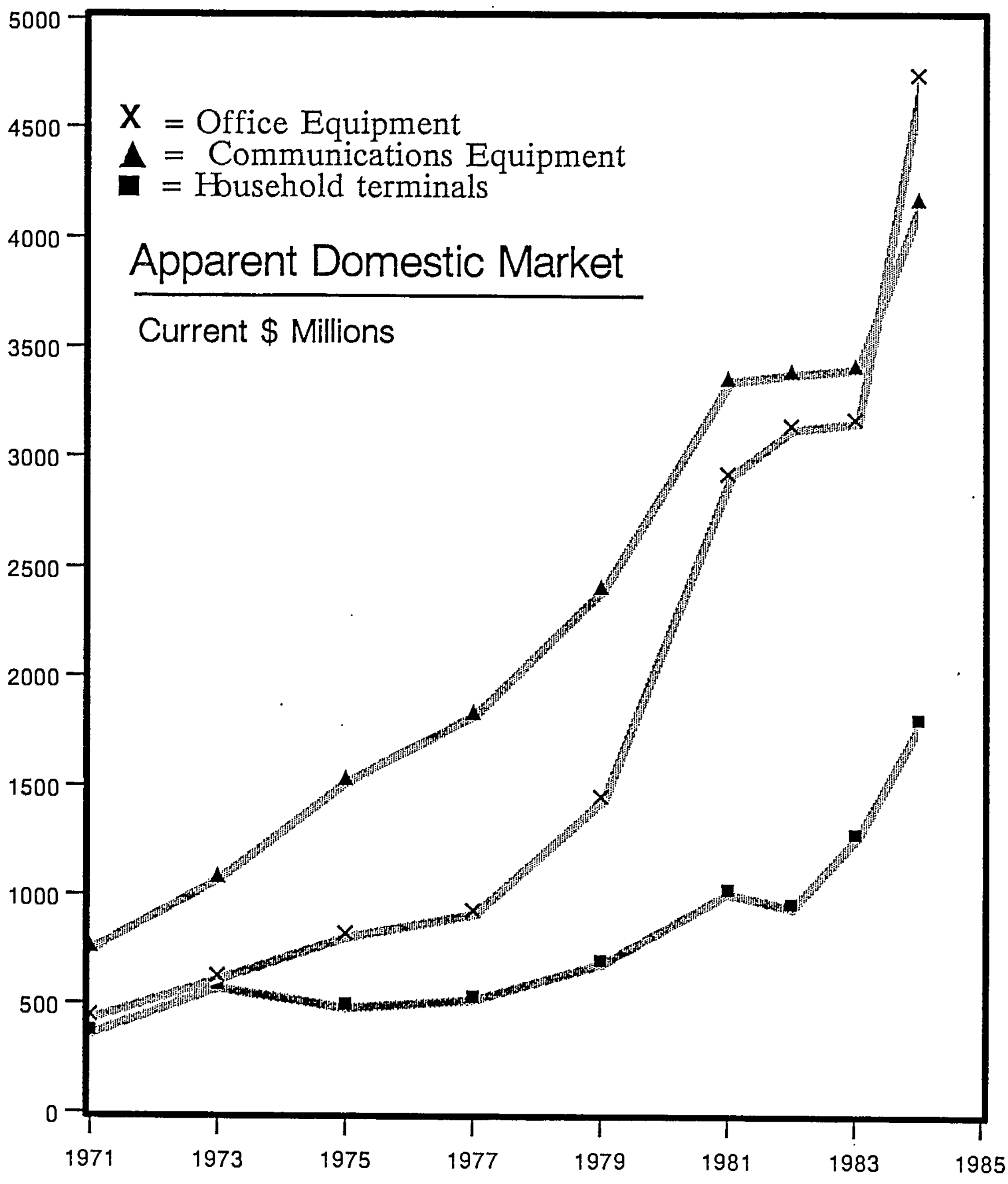
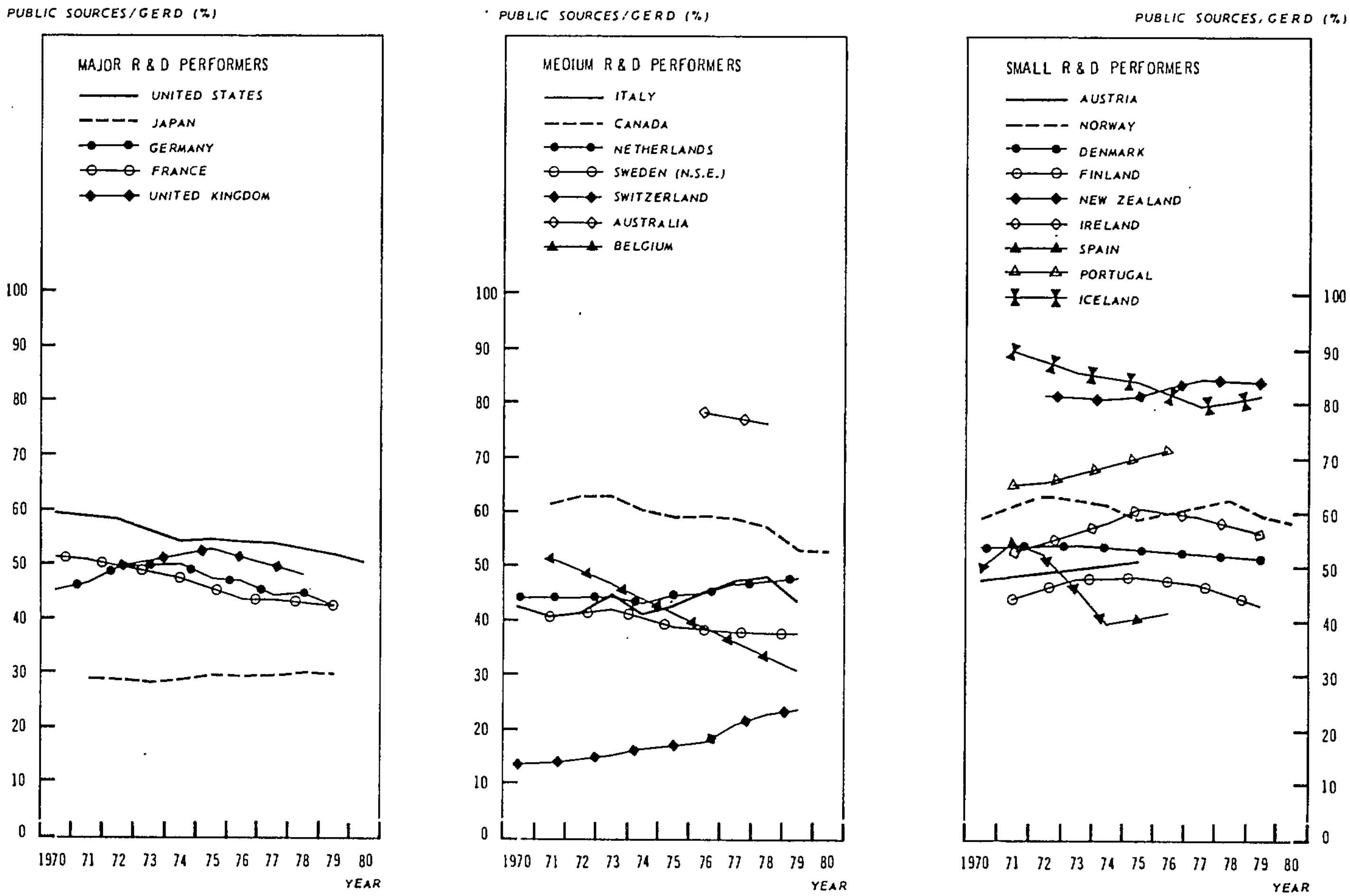

X = Office Equipment
▲ = Communications Equipment
■ = Household terminals
Apparent Domestic Market
Current $ Millions
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1971
1973
1975
1977
1979
1981
1983
1985

FIGURE 1-2

PUBLIC SOURCES AS A PERCENTAGE OF GERD (NSE + SSH) 1970 TO 1980

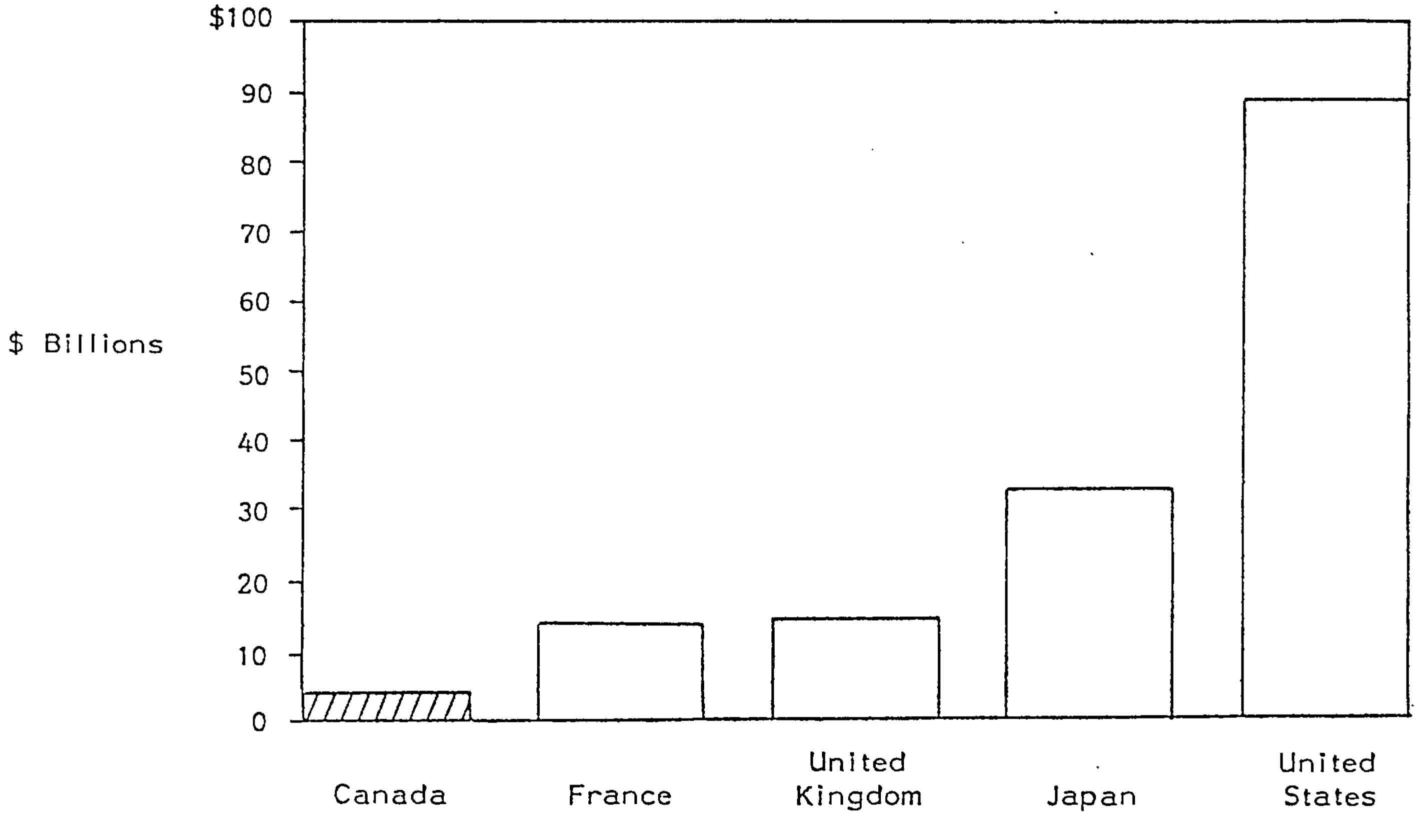


- 30 -

FIGURE 1-3

2. IN ABSOLUTE DOLLAR TERMS, CANADA'S LACK OF R&D SCALE IS EVEN MORE APPARENT

TOTAL R&D SPENDING BY COUNTRY, 1981

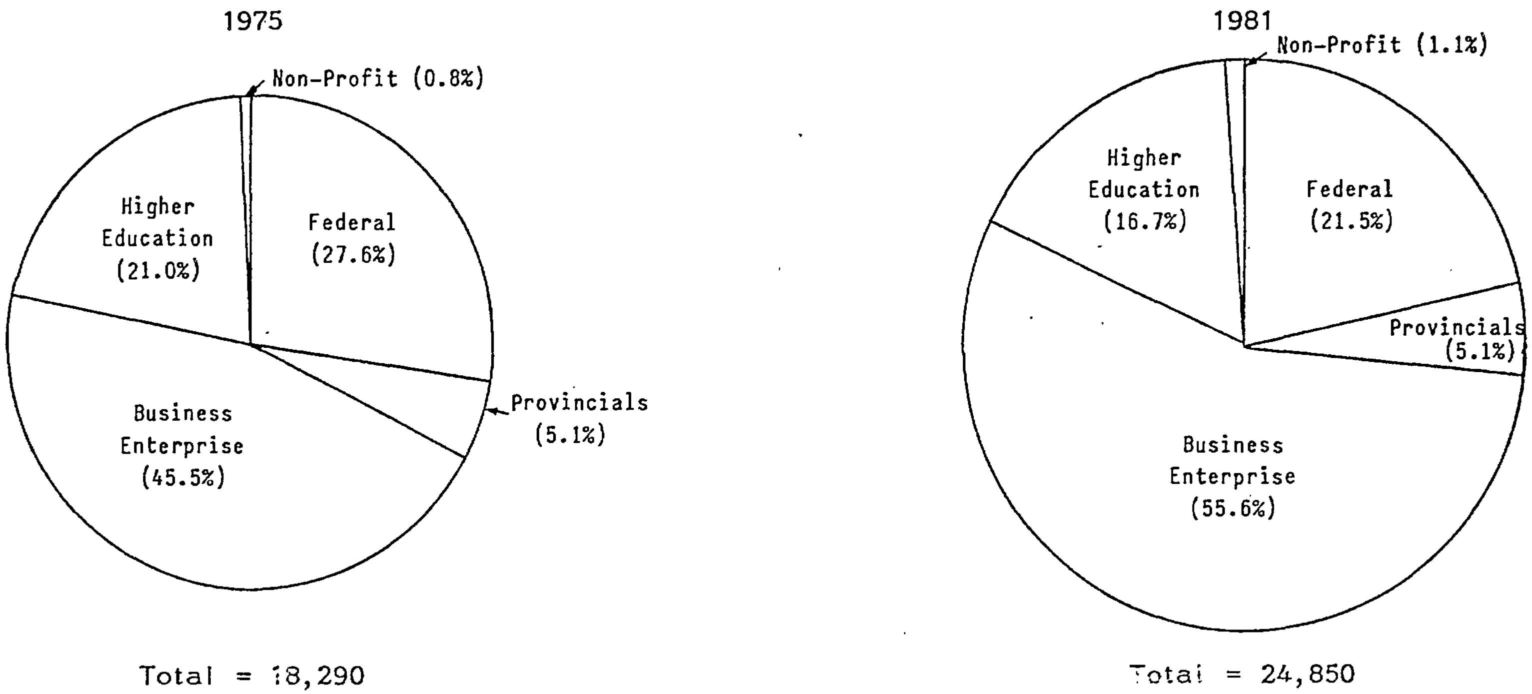


Source: Canada Consulting based on data obtained from Statistics Canada and the U.S. Bureau of the Census

FIGURE 1-4

BUSINESS ENTERPRISE ACCOUNTED FOR 55% OF SCIENTISTS AND ENGINEERS ENGAGED IN 1981, UP FROM 45% IN 1975

SCIENTISTS AND ENGINEERS ENGAGED IN R&D
NATURAL SCIENCES,* 1975-1981



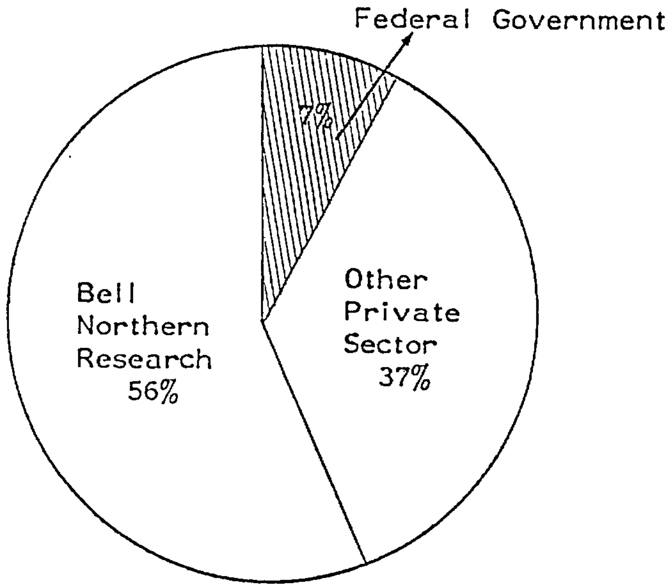
* Natural Sciences include physical sciences such as chemistry, mathematics and physics as well as non-physical sciences such as biology and the medical sciences

Source: Canada Consulting based on Statistics Canada data

FIGURE 1-5

FEDERAL GOVERNMENT COMMUNICATIONS RESEARCH REPRESENTS LESS THAN 10% OF TOTAL CANADIAN RESEARCH IN COMMUNICATIONS EQUIPMENT

CANADIAN COMMUNICATIONS RESEARCH EXPENDITURES, 1983



Total Communications R&D = $660 Million

Source: Canada Consulting based on data from Statistics Canada and Department of Communications

CONTENTS OF CHAPTER 2.0

Chapter 2.0

APPROACHING THE ISSUE -- SEVEN BASIC PRINCIPLES

There are no final or absolute truths about the conduct of research and development. It is a highly creative, risk-intensive and intellectual endeavour which does not lend itself to grand or easy generalization. However, it is such a complex enterprise that it must be approached at the theoretical level, if only to be able to draw order from the plethora of information on the subject and to generate some agreement on the terms and principles most immediately pertinent to the conduct of R & D in government labs.

To this end, we reviewed the literature on R & D and conducted interviews with a few of the major industry players in the United States. From this exercise, we gleaned seven theoretical principles which seem to define the best approaches and practices -- insofar as we can make them out -- with respect to the management of the R & D function in government and elsewhere.

(In the absence of any final truths on the subtle, complex and very intellectual enterprise which is research and development, there has emerged uncertainty and even disagreement about the terms which should be used to describe it. The same terms mean different things to different people, and no one has a monopoly on linguistic truth. In order to overcome this problem, we have attempted to define our terms -- especially the different stages of the research and development cycle -- as we move along.)

2.1 R & D IS A UNIQUE ENDEAVOUR REQUIRING UNIQUE MANAGERIAL PRACTICES

Effective R & D demands creativity, intellectual agility, a willingness to take risks and work which proceeds over relatively long time-frames. As a consequence, effective R & D management must combine firm accountability with sufficient flexibility to encourage intelligent risk-taking, personal initiative and high morale among staff.

2.1.1 The uniqueness of R & D

In early 1985, Treasury Board released a booklet prepared under the auspices of the Comptroller-General by a small group of federal R & D managers and intended to provide a framework and guidelines for the management of R & D in federal departments and agencies. This report observed:

- "THE CONDUCT OF RESEARCH AND DEVELOPMENT SHOULD BE TREATED AS AN INVESTMENT AND MANAGED ACCORDINGLY. In R & D, there tends to be a longer time delay between investment of resources, particularly human resources, and achievement of expected returns, than in many other types of operations.... This difference in planning horizons necessitates that R & D managers obtain executive recognition of the need for matching human resources to specific projects which go beyond the goverment's multi-year planning time frame."[1]

- "A MANAGEMENT SYSTEM FOR A RESEARCH AND DEVELOPMENT PROJECT MUST MAKE PROVISION FOR UNCERTAINTY IN THE THREE SIGNIFICANT VARIABLES OF BUDGET, PROJECT DURATION AND NATURE OF RESULTS. R & D is characterized by a greater degree of uncertainty than many other activities because these three variables cannot be defined independently."[2]

- "OPERATIONAL CONTROL OF RESEARCH AND DEVELOPMENT SHOULD BE SUFFICIENTLY FLEXIBLE TO PERMIT MANAGERS TO OPTIMIZE BENEFITS ASSOCIATED WITH UNEXPECTED RESULTS, RATHER THAN SOLELY ATTEMPTING TO MINIMIZE RISK OF FAILURE.... It must be recognized that only a portion of projects will pay off in the manner anticipated; others will pay off in unexpected directions by uncovering new opportunities and some will be failures or will uncover new, unexpected problems during their execution."[3]

- "RESEARCH IS STRONGLY PERSON-ORIENTED. IT IS THE PEOPLE WHO INJECT THE IMAGINATION, CREATIVITY AND INNOVATION WHICH ARE THE KEY STONES OF THE SUCCESSFUL R & D PROJECT."[4]

- "...BECAUSE OF UNCERTAINTIES, TIMING AND RISK, R & D ACTIVITIES REQUIRE A HIGH DEGREE OF AUTHORITY AT THE WORKING LEVEL, UNLIKE MOST OTHER GOVERNMENT ACTIVITIES."[5]

2.1.2 The failure of micro-management

Flexibility, informality and decentralized authority would seem to be key ingredients in the success of an R & D organization. These requirements are often at odds with the more structured governmental environment. At least such was a major finding of both the Wright Task Force[6] and the U.S. Federal Laboratory Review Panel, which was chaired by David Packard of Hewlett-Packard and reported to the White House Science Council.

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1 Office of the Comptroller-General (OCG), The Management of Research and Development: Framework and Guidelines (Ottawa: Treasury Board), p. 4. Upper case theirs.

2 Loc. cit. Upper case theirs.

3 Ibid., pp. 4, 5. Upper case theirs.

4 Ibid., p. 5. Upper case theirs.

5 Ibid., p. 6. Upper case theirs.

6 Wright Task Force, op. cit., p. 32.

The Packard panel coined the term, "micro-management," to describe this clash between bureaucracy and the environment required for successful R & D. In the words of the panel, "It is clear to the Panel that excessively detailed direction of laboratory R & D activities from agency headquarters, known as micro-management, has seriously impaired R & D performance in some laboratories. Numerous detailed external directions are given as to how work should be done, while at the same time, the overall missions and goals of the laboratories are inadequately defined. This trend must be reversed."[1]

The Panel and the Wright Task Force also argued that civil-service personnel constraints were creating serious problems for government labs. According to the panel, "The key to a laboratory's success is a high quality and properly motivated scientific staff. The inability of many Federal Laboratories -- especially those under Civil Service constraints -- to attract, retain, and motivate qualified scientists and engineers is alarming."[2] The Panel recommended that personnel matters in labs be handled outside the normal civil service personnel systems and that federal agencies should provide budgetary constraints on labs but give laboratory directors the freedom to decide how to work within such constraints.[3]

The Panel and the Wright Task Force saw similar problems with the funding processes for government R & D, which in the panel's view "impede rational planning and effective conduct of R & D activities."[4] The panel saw existing processes as arbitrary and time-consuming, emphasizing that "laboratory directors need more flexibility to allocate funds at their laboratories."[5] In order to improve the situation, the Panel recommended that funding be provided on a predictable multi-year basis, that from five to 10 per cent of funds be devoted to independent R & D, and that federal labs be permitted to carry forward remaining funds into the next fiscal year.[6]

2.1.3 Accountability and micro-management -- the lack of relationship

This concern with enhanced flexibility did not mean that the Wright Task Force and the Packard panel did not emphasize accountability issues. Indeed, in the view of the panel, "perhaps the most serious deficiency of the Federal Laboratories is accountability."[7] It saw government labs as unique in this sense because they were not subject to peer review as was the case with universities, nor were they subject to market discipline, as was

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[1] Federal Laboratory Review Panel, op. cit., p. 9.

[2] Ibid., p. 6.

[3] Ibid., p. 7.

[4] Ibid., p. 8.

[5] Loc. cit.

[6] Loc. cit.

[7] Ibid., p. 9.

the case with industry labs. Instead, they were subject to the agencies to which they reported, and "in most cases, agencies' oversight means an excessive amount of reporting and paperwork, but inadequate scrutiny of the quality and relevance of the laboratories' activities."[1] In short, micro-management was no guarantee of accountability.

2.1.4 Conclusion

In conclusion, it can safely be said that one of the most critical issues facing government labs -- and the agencies or departments to which they report -- is that of preserving sufficient flexibility while maintaining firm accountability.

2.2 OPTIMAL UNIVERSITY LINKS REQUIRE COMMITMENT TO FUNDAMENTAL RESEARCH

Close links between universities and government-sponsored research programs are central to the effective mobilization of a country's research resources, especially in a relatively small country such as Canada. For such links to be optimized, government sponsored research programs must have some commitment to fundamental research and such a program should be developed and up-dated in conjunction with the universities.

2.2.1 The importance of the university connection

The Wright Task Force was emphatic on the importance of universities in the innovation process: "Universities now play a central and strategic role in Canada's overall research effort. They tend to take the longer view; although most university research is fundamental, and is concerned with the earlier stages of the innovation chain, it is a crucial link in that chain."[2]

This view was echoed by the recent Bovey Commission on Ontario universities as it formulated its strategy for future development: "The first element in the proposed strategy is a recognition of the vital importance of higher education, in an increasingly knowledge-based society and international economy, as an investment in the development of valuable human capital. Secondly, and of equal importance in such a context, is university research and scholarship as an investment in the development of knowledge which is a critical element in the growth and vigour of society. Universities have become an integral component of the modern knowledge-based technology-driven society and economy. As one respondent to the Commission put it: 'University education has become too important to leave up to the universities. Our national wellbeing is at stake."[3]

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1 Loc. cit.

2 Wright Task Force, op. cit., p. 19.

3 The Commission on the Future Development of the Universities of Ontario, Ontario Universities: Options and Futures (December 1984), p. 5.

The Wright Task Force also identified a trend in the U. S. towards increasing interaction between government and universities -- a trend which it felt was much less powerful in Canada.[1] According to a recent U.S. science board study, "the universities and DOD (Department of Defense) need each other. DOD needs the scientists and engineers trained by universities; it needs the faculty pool of scientists and engineers working in the DOD area as originators of new ideas and as expert advisers and consultants."[2]

One reason for this growing recognition of the importance of the university connection is the role of Stanford University in the development of Silicon Valley in California. According to Everett Rodgers and Judith Larsen, "The role of Stanford University, and specifically that of its visionary vice-president, Frederick Terman, was critical to the beginning of Silicon Valley. In 1920, Stanford was just a minor league, country-club school. By 1960 it had risen to the front ranks of academic excellence. The rise of Stanford University implemented the take-off of the Silicon Valley microelectronics industry. And Silicon Valley helped put Stanford University where it is today.[3]

Attempts to emulate the success of Silicon Valley are now occurring throughout the United States, usually with consortia of companies trying to stimulate university-based fundamental research related to their corporate strategies. There is, for example, the Semiconductor Research Cooperative (an IBM-led consortium of high technology companies supporting pure research in universities, but "concentrated in major generic areas and institutions rather than spread out among a large number of universities and heterogeneous subject areas");[4] the Microelectronics and Information Systems Centre at the University of Minnesota (through which a consortium of Minnesota high technology companies sponsor research, teaching and co-operative programs in areas of interest them);[5] and the Microelectronics Centre of North Carolina (a state-encouraged initiative, the Research Triangle Park employs 20,000, has $1 billion worth of buildings and is located close to three universities.[6] There are many other such examples of the university-industry co-operation in the United States, including a score of joint R & D centres operated by the National Science Foundation's

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1 Wright Task Force, op. cit., p. 19.

2 Quoted in "The Impact of Increases in Defense R & D Expenditures on the U.S. Research System," Emerging Issues in Science and Technology, 1982: A Compendium of Working Papers for the National Science Foundation (Washington: National Science Foundation, 1983), p. 39.

3 Rogers, et al., op. cit., p. 30.

4 Botkin, et al., op. cit., pp. 94-96.

5 Ibid., pp. 96-98.

6 Ibid., pp. 105-109.

Industry-University Co-operative Research Program.[1]

Industry parks on or near university campuses are also proliferating in Britain,[2] and there are a number of Canadian examples of joint industry-university R & D activity. For instance, new institutions have emerged on the boundary between universities, government and industry -- research factories such as the Institute for Plant Biotechnology, the Petroleum Recovery Institute, the Centre for Cold Ocean Resources Engineering and many others.[3] There is also "an astounding array of government programs in support of university-industry interaction" within Canada.[4]

Broadly speaking, there are two reasons why greater effort is being made to draw universities into a more active contribution to the innovation process within western industrialized societies.

First, there is the possible industrial benefits from the research carried on at universities. In this context, the Silicon Valley model is very persuasive, as are the examples of university research ideas which have been or are now in the process of being commercialized, sometimes outside their country of origin. This sense of lost opportunities is captured by Professor Joel Moses, head of the Electrical Engineering and Computer Sciences Department at MIT: "How should we deal with the fact that many of the ideas for the Fifth Generation Computer Project (now located in Japan) came from MIT? We explained them to American industry but they wouldn't go for it. The importance of parallel processing and artificial intelligence was not fully recognized by IBM and the other American computer companies. Instead, Japan was quicker to see the application possibilities. Now that Japan has announced its intentions, however, we begin to see some movement by American industry in these areas."[5]

Second, universities are the major source of highly skilled and trained personnel. In the United States, industrial involvement with universities is a recruitment tool and a means of assuring students are trained in desired areas, and there is a new urgency being attached to this relationship. According to John Young, president of Hewlett-Packard and chairman of the President's Commission on Industrial Competitiveness, "Careful study of the situation leads me to two principal conclusions: (1) foreign competition in its various forms is indeed serious and meeting it will require our best strategic response, and (2) such a response will require better management, improved research and development effectiveness,

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1 John Walsh, "New R & D Centres Will Test University Ties," Science (Vol. 227, January 11, 1985), pp. 150-152.

2 "Planting science parks in Britain," The Economist (March 16, 1985), pp. 88-90.

3 James B. MacAulay in collaboration with Paul Dufour, The Machine in the Garden: The Advent of Industrial Research Infrastructure in the Academic Milieu (Ottawa: Science Council of Canada, Discussion Paper D84/1, March 1984), pp. 79-118.

4 *Ibid.*, p. 8.

5 Botkin, *et al.*, *op. cit.*, p. 110.

and new expectations for quality. A necessity in all these areas is the ready availability of well-trained engineers and computer scientists. Achieving this goal will require well-directed co-operative programs among industry, government, and educational institutions."[1]

Clearly, the universities represent a vital link in the innovation chain, and there is a powerful growing trend towards drawing them into much more intimate and direct involvement in the over-all process of innovation within western industrialized countries. Though this process is not as far advanced in Canada as in the United States, it can be argued that its encouragement should have even greater priority here, given that university research represents a larger proportion of R & D expenditures here than it does south of the border, as figure 2-1 illustrates.[2]

2.2.2 Universities and government labs

The importance of universities to the over-all innovation process has not been overlooked in the two most important reports on government labs in North America during the last three years. The U. S. Federal Laboratory Review Panel, which reported to the White House Science Council, called in 1983 for increasing collaboration between federal labs and universities -- an appeal which was echoed by the Wright Task Force.[3]

Indeed, the panel saw the breaking down of barriers between government, university and industrial R & D as central to the role of government labs: "The ultimate purpose of Federal support for R & D is to develop the science and technology base needed for a strong national defense, for the health and well-being of U.S. citizens, and for a healthy U.S. economy. Federal laboratories should recognize that they are an important part of the partnership with universities and industry in meeting this goal. A strong co-operative relationship must exist between Federal laboratories, universities, industry and other users of the laboratories' research results."[4]

The Packard Panel based this role for government labs on the argument that the United States was facing an unprecedented military and economic challenge and that government labs, isolated from universities and industry, were a luxury the country could no longer afford: "The United States can no longer afford the luxury of isolating its government laboratories from university and industry laboratories. Although endowed with the best research institutions in the world, this country is increasingly challenged in its military and economic competitiveness. The national interest demands that the Federal laboratories collaborate with universities and industry to ensure continued advances in scientific knowledge and its translation into

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1 Young, op. cit., p. 173.

2 CCG, Research: Strategic Situation, p. 10.

3 Wright Task Force, op. cit., p. 27.

4 Federal Laboratory Review Panel, op. cit., p. 11.

useful technology."[1]

The same argument can be made much more forcefully for a smaller country such as Canada with its far smaller national commitment to R & D both in absolute and per capita terms. In fact, as early as 1969, the Science Council stated that "There is a need in Canada to achieve more co-ordination and a closer co-operation between the sectors of universities, governments and industries."[2] More recently, the Council observed: "In these times of financial stringency and rationalization of resources the traditional 'three solitudes' of government, industry and university, must collaborate more effectively and pool their research talents. Any undertaking of such proportions demands financial commitment and should be defined as a national goal."[3]

Clearly, it is desirable to intensify collaboration between government labs and universities.

2.2.3 Conditions for effective collaboration

If collaboration between government labs and the university research community is to be effective and meaningful, it must be sensitive to the present pressures upon university research.

As noted in the previous chapter, these pressures are first of all financial. In its recent report, the Bovey Commission estimated that, because of the decline in university revenues over the last decade and a half, the capacity of Canadian universities to support sponsored R & D declined by almost 30 per cent in real dollars between 1970-71 and 1982-84; in Ontario universities, the decline amounted to almost 40 per cent in the same period.[4]

According to the Wright Task Force, there are even strict limits to the capacity of universities to take advantage of federal research funding: "Because most federal funding covers only the incremental research costs, such as supplies, technicians' salaries and equipment, it is estimated that each grant dollar a university receives from Ottawa forces it to spend at least another dollar on facilities, researchers' salaries and other overheads. There is a thus a very real ceiling on the extent to which additional funding under the present arrangements can produce additional research. The ability of the universities to shoulder their portion of a growing research bill is strictly limited."[5]

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1 Loc. cit.

2 Science Council of Canada, University Research and the Federal Government (Ottawa: Report No. 5, 1969), p. 11.

3 Challenge of the Research Complex: Proceedings of a Symposium on Policy Mechanisms for Collaboration and Transfer of Science and Technology Among Industry, University and Government, Co-sponsored by the Science Council of Canada and the Public Service Commission of Canada (Volume 1: August 1981), p. 5.

4 Bovey Commission, op. cit., p. 57.

5 Wright Task Force, op. cit., p. 21.

There has also been some resistance within the university community to the growing trend towards closer links with government and industry and a consequent increased expectation that university researchers would carry out more applied research. As James MacAulay and Paul Dufour point out in a recently published Science Council discussion paper, "Perhaps the major barrier to the adoption of industrial research by universities is the idea that academic science must be somehow pure and above strictly utilitarian considerations."[1]

Dr. Arthur Bourns, past president of McMaster University, expanded on this theme at 1980 Science Council symposium: "When considering the problem of strengthening linkages between the three sectors (government, universities and industry), the universities ask themselves to what extent they can become involved in shorter-term industrial research without undermining fundamental teaching and basic research. Engineering faculties have always been involved in applied research, yet in the natural sciences high quality basic research is usually regarded as being the most stimulating and providing the best training for students."[2]

Dr. Bourns concluded that "Ideally, short-term research should be carried out (by universities) <u>in addition to</u> and <u>not at the expense of</u> basic research, a view which is reflected in NSERC's five year plan."[3]

Any scheme to assure effective and meaningful collaboration between government labs and universities must take into account these realities of the university environment -- both the financial pressures and the anxiety that applied research might displace fundamental research.

What then should be the role of government labs vis ã vis the universities? In the view of the U.S. Federal Laboratory Review Panel, the roles of government labs are "intermediate between those of universities and industry. Both Federal Laboratories and universities are very important to support a high rate of technological advance in the U.S."[4]

Within the context, the Panel argued strongly for strong and dynamic interaction between government labs and universities. Clearly, if such interaction is to be meaningful and effective, government labs must be in a position to carry out research which is in some sense meaningful to the university community. In other words, government labs should carry out some fundamental research -- the research of maximum interest to university researchers -- to provide a basis for meaningful interaction with the universities. This does not mean addressing virtually any fundamental research topic, but only those which fall within the mission of the laboratory and meet government needs -- that is, directed fundamental research. It was no doubt with such research in mind that the Packard Panel

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1 MacAulay and Dufour, <u>op. cit.</u>, p. 12.

2 <u>Challenge of the Research Complex</u>, p. 15.

3 <u>Loc. cit.</u>

4 Federal Laboratory Review Panel, <u>op. cit.</u>, p. 2.

recommended that government labs "perform basic and applied research in areas where the Federal government has a legitimate responsibility."[1]

The conduct of some directed fundamental research by government labs labs -- not to mention universities -- may also be in industry's interest. According to Dr. Norman Eaton, director general of the Welding Institute of Canada, "speculative research and the investment in expertise and equipment for early stage development may be difficult to justify to (private sector) management. Support from a central R & D institute, particularly for group-sponsored collaboration, should be an attractive solution. More fundamental research, which is an integral part of an overall planned program, should be undertaken by universities and government laboratories."[2]

Indeed, even a research-intensive manufacturer of telecommunications equipment such as Northern Telecom admits a dependence on external sources of more fundamental research: "Most firms, even in the high-technology field, concentrate on product development, obtaining base technology from external sources. Northern Telecom, for instance, conducts almost 100 percent of its applied research using base technology derived from government, industry and university labs around the world."[3]

The challenge, of course, is to ensure that the directed fundamental research carried out by government labs complements that of the university community and provides a firm basis for co-operation and collaboration between the two. In the view of the U.S. Federal Laboratory Review Panel, "A proper balance of basic research activities between the laboratories and the universities is important to maintain both the nation's scientific base and educational capability. A good way to ensure a proper balance is to insist upon excellence as a criterion for support (of work by government labs). The competitive peer review process, though imperfect, is a good mechanism for evaluating basic research (in government labs)."[4]

The Panel also saw a need for an "oversight function" by "an external committee which should include include strong industry and university representation. This committee would spend enough time at the laboratory to become familiar with the laboratory's strengths and weaknesses. It would focus on productivity <u>and</u> on the excellence, relevance and appropriateness of research."[5]

Other commentators see a need for more formalized and more wide-ranging forms of collaboration. Dr. Eaton, for example, felt that the

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1 <u>Loc. cit.</u>

2 <u>Challenge of the Research Complex</u>, pp. 42, 43.

3 "Research and Development: What Role for Governments?", <u>Forum: A Newsletter for Northern Telecom managers</u> (Volume 2, No. 1, February 1985).

4 Federal Laboratory Review Panel, <u>op. cit.</u>, pp. 9, 10.

5 <u>Ibid.</u>, p. 10.

fundamental research activities of universities and government labs should be part of an over-all planned program.[1] The long-range plans of the Alberta Research Council call for "exchange of staff, participation of graduate students in research programs, joint seminars, visiting professors, shared facilities and projects, university staff on the Research Council, advisory committees, employment of university staff as consultants and research contracts with universities."[2]

In addition, whatever form of collaboration is sought, it is clearly desirable to ensure -- to the degree possible, given the difficult financial state of Canadian universities -- that the government pay the full costs to the university of such collaboration and any research carried out for the government. Given that government labs assume an intermediary role between university and industry, they should probably also work to bring about arrangements under which relevant university research would be jointly funded by government and industry.

Formal meaningful collaboration with the university research community will have important benefits. First, it should permit government labs to be much more effective in recruiting new personnel -- an important consideration. Second, by ensuring that the research programs of government labs and university researchers complement each other, it should permit a greater concentration of national resources in strategic technological areas. Third, collaboration with universities should constitute one of the bases for a more meaningful accountability on the part of government labs -- an important consideration, given that, as noted in the previous section, traditional mechanisms to assure accountability in the public service have only limited effectiveness.

2.2.4 Conclusion

Universities represent a crucial link in the innovation chain, and wide-ranging efforts are being made in most western industrialized countries to involve them more closely in the innovation process. Government labs should, therefore, co-operate closely with universities, with a view to ensuring that university research complements the rest of the national R & D effort, strengthening the vital educational functions of the universities and and replenishing their own aging personnel resources. The most effective basis for such co-operation is some degree of involvement by government labs in fundamental research in the context of external peer reviews and oversight by university representatives, as well as a range of other formal co-operative arrangements between the government lab and the university research community. Given the difficult financial situation of most Canadian universities, this formal co-operation should not involve additional costs to the universities, and government labs should collaborate with industry in funding university research.

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1 Challenge of the Research Complex, p. 43.

2 Alberta Research Council, Long Range Plan (Edmonton, 1979).

2.3 FUNDAMENTAL VS. APPLIED

Organizationally and in relation to the environment in which they are conducted, fundamental research and applied R & D are very different activities, drawing on different sources of information, driven by different concerns and priorities and possessing quite different clients.

2.3.1 The difference between fundamental research and applied R & D

R & D is by no means a homogeneous activity. Indeed, there are basic differences between fundamental research activities and applied R & D activities, and these have important implications for the way each should be organized and managed.

Fundamental research focuses on searching for and understanding the causal mechanisms or critical linkages involved in phenomena or events. Fundamental research involves science as opposed to technology and is characterized by considerable uncertainty at the scientific level. Its purest practitioners can often, though not always, be found in the university environment, and their motive is the discovery of new knowledge. When conducted outside universities, it retains close linkages with the university environment and is conducted within a relatively loose and unstructured organizational context.

Applied R & D, in contrast, has generally as its ultimate objective the creation of marketable and manufacturable products, though it may also be aimed at providing a technical solution to special problem or at producing something which would be used in a very specialized application. It involves technology as opposed to science, and its purest practitioners can be found in industry. The uncertainty here revolves around whether the resulting product will be both manufacturable and marketable or, in the case of a very specialized need, useful in light of very particular requrements. As a result, those working on applied R & D must emphasize close links either to specialized users or to the marketing and manufacturing aspects of the enterprises to which they belong. User needs and generally marketing and manufacturing considerations are fundamental to their work. Usually, applied R & D is conducted in a relatively structured organizational context governed by tight schedules.

Figure 2-2 at the end of the chapter summarizes the essential differences between fundamental research and applied R & D.

2.3.2 The relationship between fundamental research and applied R & D

Applied R & D is, of course, dependent on the new ideas, concepts and techniques generated through research work. Indeed, it is arguable that the existence of strong, rich research programs is vital to advances on the developmental side, especially radical advances. However, the relationship between the two is by no means direct; there is no clear single track or assembly line by which a research idea becomes the object of a development project.

Ronald Graham, a mathematician at the Mathematics Centre in the U.S. Bell Laboratory organization, commented as follows on the tangential relationship between research and development: "...just down the hall there are some people working on an electron-beam method that will be used to etch circuits on chips. They have a very precise deadline. But that kind of research has limitations. The major developments are unexpected. If you really knew what you were trying to do, that would often be the biggest part of the battle. There does not seem to be any obvious way of knowing how some development here will impact on something over there. You just hope you have good people who are excited and that they can communicate."[1]

Most research ideas, in fact, do not become development projects: for example, the discovery by U.S. Bell Lab scientists of the cosmic noise left over from the universe-creating Big Bang has yet to find an application in telephony,[2] though the pay-off in prestige for the lab and AT & T was considerable. Even research notions which become the object of development work usually do not result in a marketable product. Indeed, James Brian Quinn, a leading U.S. researcher on corporate strategies, states that only one about one in 20 development projects in the private sector results in an actual product.[3]

2.3.3 Organizational differentiation between fundamental research and applied R & D

Whatever the relationship between fundamental research and applied R & D, there is no disagreement that recognition of the distinction between the two is crucial to the effective management of each.

As Lane, Beddows and Lawrence emphasized in a recent comparative study of U.S. government labs and the U.S. Bell Laboratory, "This study and the bulk of previous research would support the rule of thumb that more organic mechanisms and roles align with the earlier stages of knowledge generation, and more formal and programmed mechanisms and roles align with the latter stages. Organic mechanisms and roles are characterized by a more open, face-to-face communication network, including horizontal and diagonal channels, by more participative decision making, by the deemphasis of status differentials and detailed role specifications. The more formal and programmed mechanisms and roles are characterized by constraints on communications outside the vertical authority channels, more authoritative decision making, more status differentials, and more reliance on specific role descriptions, detailed planning and scheduling, and formal performance measurement systems linked to formal rewards and sanctions."[4]

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1 Quoted in Jeremy Bernstein, Three Degrees Above Zero: Bell Labs in the Information Age (New York: Charles Scribner's Sons, 1984), p. 27.

2 Ibid., p. 215. The discovery did, however, define the ultimate limits of what could be achieved in the area of earth-space communications.

3 Cited in Thomas J. Peters and Robert H. Waterman, Jr., In Search of Excellence: Lessons from America's Best-Run Companies (New York: Warner Books, 1984), p. 209.

4 Henry W. Lane, Rodney G. Beddows and Paul R. Lawrence, Managing Large Research and Development Programs (Albany: State University of New York Press, 1981), p. 154.

The distinction between fundamental research and applied R & D, as portrayed in Figure 2-2, is by no means an academic one. It is central to the research operations of major U.S. industry players such as IBM, Xerox and AT & T:

- At IBM, roughly 10 per cent of the $3 billion R & D budget is spent on fundamental research; the director of research reports directly to the chairman of the board and the work of this unit is largely determined by the scientists themselves; the remainder of IBM's development budget is spent on applied R & D governed by rigidly structured schedules leading directly to manufacturing, and development labs report directly to operating units.[1]

- At Xerox, roughly 20 per cent of the budget supports research involving fundamental science and conducted in a spirit of free inquiry; the remaining 80 per cent of the budget supports more applied work which is closely tied to production activities.[2]

- at Bell Labs, roughly 10 per cent of a budget of about $2 billion is allocated to fundamental research[3] (as a researcher in one of these labs commented, "This place is small and informal and the lines of authority are on a personal basis".[4]), while the remainder of the budget supports applied work closely tied to the concerns of Western Electric and AT & T operating divisions.[5]

All of these companies have separate budgets for fundamental research activities as opposed to applied R & D. Usually, these different activities are found in different locations.

In addition, fundamental research programs in these companies report directly to senior management and sometimes to the chairman of the company's board. Representatives of all three research labs also agreed on the importance of excellence and on close relations with universities. The fundamental research labs are in fact an important source of prestige for the companies.

In contrast, the applied and developmental labs are closely tied to the operational and manufacturing arms of the company. Tight schedules, structured organization and a careful attention to marketing and

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1 Richard Stursberg, "California Dreaming" (Unpublished memo to SMC, Department of Communications, June 7, 1984), pp. 7, 8.

2 Ibid., p. 8.

3 John Walsh, "Bell Labs on the Brink, Science (Vol. 221: September 23, 1983), p. 1269.

4 Quoted in Lane, et al., op. cit., p. 105.

5 Ibid., pp. 102, 103.

manufacturing considerations are characteristic of development work in all three companies.

2.3.4 Conclusion

In conclusion, it is clear that effective management of research and development demands their separation in both organizational and budgetary terms. However, it is important to be pragmatic in applying this principle. In large research organizations, it is possible to spin off separate labs devoted exclusively to fundamental research. In smaller organizations, limited resources and laboratory facilities dictate that the separation between the two be less complete. It should be emphasized, though, that some separation is necessary even in smaller laboratories to preserve the integrity of each of these very different R & D activities.

2.4 THE PRIMARY FOCUS OF GOVERNMENT LABS -- LONG-TERM DEVELOPMENT FOR GOVERNMENT

The primary focus of government labs should be long-term development or applied research conducted to meet government needs.

2.4.1 The problem of technology transfer

Technology transfer is a very difficult process and, as a consequence, most research ideas remain undeveloped. In our own interviews in Silicon Valley, the term, "throwing innovations over the wall,"[1] captured the haphazardness of the process of converting research ideas into marketable products. The chancy quality of this process is very much a concern at both IBM and Xerox, and both are working towards improvements.

The difficulties of the technology transfer process also explain why, as already noted, developmental labs of major U.S. companies such as IBM and Xerox are closely tied to the manufacturing and marketing sides of their operations.[2] In the case of AT & T, both Western Electric (the manufacturing arm) and long lines (the operational arm) become ever more intimately involved in projects after they enter their developmental stages, as depicted in Figure 2-3.[3]

Bell Northern Research (BNR) is much less research-oriented than the U.S. Bell Labs, Xerox labs or the IBM labs. In many ways, it operates in the near-term development area very much like a private contract research institute. Both Bell Canada and Northern Telecom, if they so desire, can go to an organization other than BNR to get development work done. There is, in

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1 Taylor, "Object: the Mission of Research Centres," California Dreaming.

2 Stursberg, California Dreaming, pp. 7, 8.

3 Lane, et al., op. cit., p. 103.

short, a clear client or user-supplier relationship between BNR and the operating and manufacturing arms of the Bell family. As a result, if BNR is to retain its present level of business, it must be fully responsive to the marketing, manufacturing and operating imperatives which drive Northern Telecom and Bell Canada. Indeed, as a general rule, actual product development is carried out by Northern Telecom and Bell Canada.[1]

Clearly, it is fundamental to successful industrial development work that it be driven by the exigencies of manufacturing and marketing. As the Wright Task Force pointed out, "successful industrial research depends on close liaison between the people in the labs and the people on the firing line -- those responsible for manufacturing and selling."[2]

Government research establishments are, of course, significantly more insulated from the market and the imperatives of manufacturing. It follows that, if industrial R & D establishments have difficulty in transforming their technology into manufacturable and marketable products, the obstacles facing government research establishments will be more sizeable still. As the Wright Task Force pointed out, "The least effective technology development is 'supply-driven', where the research institutions, rather than an external market, define the problem and, at their own speed, seek solutions. Sometimes they come up with brilliant solutions for which there is no problem -- and products for which there is no market."[3]

2.4.2 <u>Nature of government support role</u>

What, then, is the proper role for government R&D? The answer is that, just as industrial R&D best supports industry, government R&D should best support government missions. In a report which generally tends to see a diminished role for government labs, the Wright Task Force commented: "It is perfectly legitimate, we believe, for the government to support research which improves a department's capacity for:

- testing or monitoring;
- establishing codes, standards or regulations;
- maintaining data bases;
- operating a national facility, such as a wind tunnel or a particle accelerator;
- addressing national or regional problems, such as acid rain;
- carrying out federal obligations in areas of national security and under various international agreements, providing in conjunction with

1 Interview with Bell Canada officials, May 25, 1984.

2 Wright Task Force, <u>op. cit.</u>, p. 3.

3 <u>Ibid.</u>, p. 2.

> universities a 'window' on the international scientific community, and maintaining a national scientific competence in certain key scientific sectors."[1]

Government R&D labs do have a role, then, in serving departmental missions.

2.4.3 The procurement-support role

Given the task force's emphasis on government procurement as a means of enhancing technology development,[2] it may well be that government labs also have a role in supporting that procurement function.

In a recent Science article, Richard R. Nelson and Richard N. Langlois argue: "**In cases of government procurement for defense, space, or similar clearly defined public projects, the government is itself the user-demander. It thus has knowledge of its own needs and, usually, at least a modicum of expertise in the technology it proposes to use. Motivation and knowledge line up fairly well in such circumstances, and the government is frequently able to sponsor effective R & D on the relevant technology.** To the extent that the technology can be easily transferred to commercial application, the result is the well-known 'spillover' into civilian technology."[3]

2.4.4 Types of applied R & D

Applied R & D is by no means a homogeneous stage in the R & D cycle, and the question of which stage a lab should be focussing on is crucial to effective management.

Towards the fundamental research end of the applied R & D spectrum, there is **applied research or long-range development**, which essentially addresses a specific, usually practical problem -- defined on technical grounds in relation to marketing, operational and/or manufacturing considerations -- in a technological area which is still uncertain. Generally, this kind of R & D takes place from three to 10 years from the actual placing of a product or service on the market. There is less of a tendency for the information needed for and resulting from such work to be proprietary.

At the other extreme is **near-term development** -- usually commencing about two or three years from actual marketing -- in which work on a clearly defined product or service, where the major technological problems have been overcome, is essentially shaped by marketing, operational and manufacturing considerations. There is much greater tendency for the information required and created by such work to be proprietary.

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1 Ibid., pp. 27, 28.

2 Ibid., pp. 13-17.

3 Richard R. Nelson and Richard N. Langlois, "Industrial Innovation Policy: Lessons from American History," Science (Vol. 19: February 18, 1983), p. 816.

The difference between the two is the degree to which they are driven by marketing, operating and manufacturing considerations. In the case of near-term development, these are clearly predominant. In the case of long-term development, there can be little doubt that one or more of these considerations will be relevant, but the relationship is somewhat more remote.

2.4.5 Labs should focus on long-range development in support of Departmental missions

Most of the applied R & D conducted by government labs in support of government would seem to involve long-range development or applied research.

In the case of work done in support of specific departmental missions, the ultimate outcome is often not a product but advice -- with respect to, say, technical issues associated with regulation or standards or some policy concern. Sometimes, such advice is based on research which addresses a specific problem -- that is, applied research or long-range development. Frequently, it is a result of the expertise and information acquired by the government researcher through reading of the literature and attending scientific conferences.[1]

Nelson and Langlois also see R & D by government labs in support of government procurement activities as essentially involving applied research or long-term development: "...our case studies suggest that the potential for the generation of spillover by procurement-related government R & D support may be limited to the early stages of a technology's development, when government and civilian demands are not yet specialized. As a technology matures, the requirements of the government and the private sector normally diverge. This means not only that spillover diminishes but also that military and commercial R & D increasingly compete for resources. In the mature phases of a technology development, spillover may be as much to the military from the commercial sector as the other way around."[2]

It would seem then that government labs acting in support of government should work mainly in the areas of applied research or long-range development.

2.4.6 The importance of a client orientation and results discipline

Just because the mandate of a government lab is to serve government, there is no guarantee that the needs of the government client will be met.

The Wright Task Force discovered that this was not always easy to achieve: "Because their main client is the federal government, these laboratories often have even greater difficulty in defining their missions than do labs whose main function is to support industry goals. Inertia, irrelevance, overlapping departmental mandates and jurisdictions are clear and present dangers. These intra-government relationships often lack the

1 See Section 2.6 of this chapter.

2 Nelson and Langlois, op. cit., p. 816.

results-oriented discipline which characterizes most market transactions."[1] In other words, a real effort must be made to ensure that in fact government labs are meeting the needs of government clients.

For example, in the case of applied research intended to support a Department's policy development, regulatory or standard-setting activities, it would be desirable if a lab's Departmental clients played some role in defining the problems to be attacked by applied research activity. Clearly, the definition of the problem will to a large degree determine whether the ensuing research results are relevant to Departmental clients.

This responsiveness to the needs of government clients is especially important in the procurement area. As Nelson and Langlois point out: "It is important to recognize that the efficacy of government procurement-related R & D depends on the knowledge-advantage that comes from the government's position as user and on the political legitimacy of its mission as justified on grounds other than spillover benefits (to the private sector)."[2] Clearly, in all cases, a government lab's work in this area must be driven by governmental procurement needs and must reflect a clear understanding of those needs. Indeed, if other objectives start to predominate, then the effectiveness of the R & D support to procurement declines.

The identification of government R & D needs is by no means an easy task. Often, the needs are vague and viewed as unrealizable and therefore impractical by potential government clients because they are unaware of the technology. For this reason, it may be desirable for the government lab to be fairly entrepreneurial in its efforts to match needs with technological possibilities. The interaction between government labs and actual or potential clients should therefore be dynamic, involving an ongoing dialogue to define needs precisely and develop a clearly responsive applied R & D program.

Because of the difficulties associated with needs identification and its over-riding importance, the process of identifying needs and R & D program development should be formalized and involve both the lab management and the client. A formal approach to this process is also important because the traditional financial and administrative mechanisms used to assure accountability in government are not very effective in their application to government labs, as the first section of this chapter noted. Indeed, a clear horizontal accountability to government users of R & D is in our view one of the foundations of the over-all accountability of a government lab. For this reason, it may well be desirable to build control mechanisms into this formal, ongoing process which takes into account the high-risk nature of any R & D endeavour.

Clearly, just as industrial development labs are driven by and accountable to manufacturing and marketing imperatives, government developmental work serving departmental missions must be formally driven by a clear sense of departmental clients' needs, as portrayed in Figure 2-4 at the end of this chapter.

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1 Wright Task Force, op. cit., p. 28.

2 Nelson and Langlois, op. cit., p. 816.

2.4.7 Conclusion

The primary focus of government labs should be upon applied research and long-range development in support of government needs. In this endeavour, it is vital that there be effective formal links between the government lab and its government clients and that these enhance the over-all accountability of the government lab.

2.5 ROLE VIS A VIS INDUSTRY

Government labs should only be involved in applied R & D on behalf of industry if, as the Wright Task Force pointed out, "it is in the national interest and if:"

- "the risks or expenditures involved are too high, or the potential payoff too small or too far down the road, to attract private industry;

- "the industry is too fragmented to conduct the necessary R&D."[1]

Within this context, the most effective focus for government sponsored R & D will be on projects intended to meet government needs, but with potent commercial implications. Government R & D programs should carry out only long-range development or applied research in house, and contract out to industry near-term development. Such programs could also involve the management of technical services and large multi-user facilities for industry when industry is unable to provide these itself. In all cases, the direction of such work on behalf of industry should be driven by a clear sense of industry's needs.

2.5.1 Types of industries to be supported

Clearly, if a government lab is performing an industrial support role, it should not be duplicating or carrying out work which private industry is quite able to do itself.

In industrial sectors where the companies are large and conduct considerable R&D themselves, the need for government assistance is smallest and the risk of duplication is clearly sizeable. It follows that the industries targetted for assistance should be characterized by fragmentation with a large number of small firms.

In this context, it should be noted that in new technological areas it is the small companies which are often the most innovative. This is particularly true for the new information technologies. For example, in California's Silicon Valley, 70 per cent of the firms have one to 10 workers, and 85 per cent have fewer than 50 employees, as Figure 2-5 at the end of the

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1 Wright Task Force, op. cit., p. 26.

chapter shows.[1] Small firms have difficulty supporting R & D, and the presence of Stanford University and sizeable military funding was very important in the early days when the U.S. Department of Defense purchased about 40 per cent of semiconductor production.[2] At the same time, the "costs of doing research have been escalating"[3] and, as already noted, there are a growing number of examples in the United States of joint projects involving state governments, industry and universities.[4]

"Why should individual companies not merely increase their own internal research efforts or interact one-to-one with selected universities? While such an approach is feasible, a joint effort can bring to bear the necessary critical mass to attack a crucial research area. A joint effort can avoid an overlap of endeavours that is all too often the case when individual companies pursue their own insular research agenda."[5]

The need is, of course, greater in the case of smaller companies which have less resources to support R & D. Beyond this, as already noted, they are far more innovative. In a recent article, the Economist questioned the emphasis of European governments on providing R & D support to large, established and "unadventurous"[6] firms instead of small innovative firms that will make more productive use of such support: "The trouble is that these programs are repeating the same old European mistakes. The big boys are nosing into the trough first, as usual. Big firms are heading almost every Alvey project. The West German minister for research and technology, Mr. Heinz Riesenhuber, is a passionate admirer of the revolution Silicon Valley has wrought; but DM300m of his budget has just been given to Siemens, Germany's cash-rich and biggest electronics firm, for a joint development programme with the giant Dutch firm, Philips -- and this for a single product."[7]

The Economist went on to argue that "Europe need not yet despair over being behind America and Japan. The pace of change in the industry means that another train shows up soon after the one you just missed. Nor should Europe be afraid of relying on a lot of small firms (along with big ones) to compete with Americans and Japanese. The successful small ones grow big very fast, and they produce the fresh ideas that keep established rivals on their toes."[8]

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1 Rogers, et al., op. cit., pp. 58, 59.

2 Ibid., p. 39.

3 Erich Bloch, Vice President, Technical Personnel Development, IBM Corporation, "Industry and Universities: The Case for a Joint Research Effort In the Semiconductor Industry," Trade Wars, Botkin, et al., p. 183.

4 Botkin, et al., op. cit., pp. 89-111.

5 Bloch, op. cit., p. 184.

6 "Europe's Technology Gap," The Economist (November 24, 1984), p. 94.

7 Ibid., p. 96.

8 Ibid., p. 98.

Clearly, a persuasive case can be made for support by government labs to the smaller firms in the broad communications-computer area.

2.5.2 Focus on applied research in-house

As already noted, the Wright task force argued that government labs should only conduct R & D in support of industry when risks or expenditures are too high or the pay-off too small or remote to attract industry. Long-range development or applied research is generally characterized by distant pay-offs and considerable risks with respect to results.

As already noted, there are obvious difficulties in the conduct of purely industrial R & D by government labs. As the task force pointed out, "It is an axiom of industrial research that not every great idea makes a great product. But when government is the player, it is very difficult to abort an unpromising research project let alone one which seems to show promise once it's got started. In industrial research, admitting failure or abandoning concepts that work technically but won't sell is a routine and accepted part of the process. In government, however, acknowledgement of failure is often postponed as long as possible."[1]

Nelson and Langlois also approached this subject very cautiously: "When there is no recognized public sector demand for a technology, the government's ability to fund R & D effectively and to guide the development of that technology is more limited. The government does not then have access to the sorts of information necessary to guide allocation, and may in fact be blocked from getting the information."[2]

In their view, "these problems may be attenuated if the government restricts its attention to areas, such as so-called generic technology, that are a step or two removed from specific commercial application. The reason is that at this 'directed basic' level of research, the knowledge involved has a large public component: much of it is the sort of nonpatentable and nonspecific knowledge -- broad design concepts, properties of materials, and testing concepts -- that is generally shared among scientists and does not pose a strong threat to proprietary interests."

"In a sense, such generic work falls in between the sorts of work that an academic researcher, pursuing fashionable questions within the bounds of a standard scientific field, would tackle and the kinds of results-oriented research that would interest most corporate R & D laboratories."[3] In the terminology we have adopted here, such work would involve applied research or long-range development.

This view has received support from other sources. Indeed, as early as 1979, the U.S. budget "reflected a growing realization that the appropriate role of the Government is to emphasize longer-term (relatively

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1 Wright Task Force, op. cit., p. 5.

2 Nelson and Langlois, op. cit., p. 816.

3 Loc. cit.

lower cost) research for the the future and new technology options rather than major commercial scale (and relatively higher cost) demonstrations."[1]

It can be seen, then, that if a government lab is conducting R & D in house on behalf of industry, it should focus on the area of long-range development or applied research.

2.5.3 Role with respect to near-term development

As already noted, the closer an R & D project is to the development of a finished product, the more marketing, manufacturing and operational considerations are crucial to effective work. Government labs, insulated as they are from market discipline, should generally leave near-term development for industry to industrial labs which are very much subject to such discipline.

In addition, near-term development work by government on behalf of industry can result in unwelcome overlaps with industrial efforts. As Nelson and Langlois point out," In many cases, government attempts to enter the business of commercial applied R & D led to (i) duplicating private efforts or (ii) subsidizing those efforts and thereby replacing private with public funds or (iii) investing in designs the private sector has long abandoned as unpromising."[2]

Do government labs, then, have any role at all with respect to near-term development for industry?

Clearly, the main object of government R & D on behalf of industry must be transfer of technology to industry. Both the Wright Task Force[3] and the Standing Senate Committee on National Finance[4], as well as the U.S. Federal Laboratory Review Panel[5], saw contracting out of near-term development work as the most effective means of technology transfer and of building a greater R & D capability in the private sector. All argued for a greater emphasis by government labs on contracting out.

The Japanese Ministry of International Trade and Industry has also emphasized contracting out as a means of technology transfer in ICOT, its Fifth Generation computer project. According to Edward Feigenbaum and Pamela McCorduck in The Fifth Generation," MITI funds for support of company groups

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1 George Tolley and Stuart Townsend, "Commercialization and the Assessment of Federal R & D," Federal R & D and Scientific Innovation, ed. Leonard A. Ault and W. Novis Smith (Washington: American Chemical Society, 1979), p. 135.

2 Nelson and Langlois, op. cit., p. 818.

3 Wright Task Force, op. cit., pp. 30, 31.

4 Standing Senate Committee, op. cit., pp. 44, 45.

5 Federal Laboratory Review Panel, op. cit., p. 11.

began to flow in 1983. These funds will flow through ICOT and be disbursed by contract for work performed."[1]

The ICOT research team is mainly composed of young scientists from industry, and it is hoped that the contracting out process will ensure that their employers take full advantage of the technologies their scientists learn about. As Feigenbaum and McCorduck put it, "ICOT, with its intellectually aggressive collection of researchers, will nurture young shoots of innovative work and transplant them to the industrial labs. The point of the contract mechanism is to ensure that these young shoots receive the necessary and appropriate care so that they will grow into healthy, commercially viable plants."[2]

There will, however, be a certain delicacy in the way this contract mechanism is used; in other words, "the contract mechanism...will not be applied in a heavy-handed way. Each firm (participating in the project) has asserted one or more key areas of interest, and ICOT will respect these and work within that framework."[3]

There is no doubt that contracting out should be used discriminately. The report of the Standing Senate Committee on National Finance[4] endorsed the view of the Economic Council of Canada that contracting out should occur in areas where the net benefits are clearest. In its 1983 report, the council stated: "(The) Benefits (of contracting out) tend to be high in relation to costs for projects with specific research objectives, easy-to-quantify outcomes, little uncertainty, and relatively little need for significant specialized facilities. In the opposite case -- more typical of complex, advanced research, often of a basic nature -- contracting out may have negative net benefits relative to in-house research."[5] In short, contracting out is most effective for work closer to the product development end of the spectrum -- that is near-term development work.

The Economic Council also suggested that contracting out is most effective when firms are given as much flexibility as possible in defining how to meet the terms of the contract: "When letting out a contract, an effort should be made to ensure that technical approaches are not set too early in the process. Federal departments, wherever possible, should define the ends and leave the technical means by which performance standards are met up to the firm (or firms) involved in the project.... Wider application of this rule could contribute to promoting the development of R & D and technological expertise in Canadian firms."[6]

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1 Feigenbaum and McCorduck, op. cit., p. 117.

2 Loc. cit.

3 Loc. cit.

4 Standing Senate Committee, op. cit., pp. 44, 45.

5 Economic Council of Canada, The Bottom Line: Technology, Trade and Income Growth (Ottawa, 1983), p. 86.

6 Ibid., p. 47.

It would seem, then, that, when government labs are acting on behalf of industry, they should carry out long-term development or applied research in house, then contract out the near-term development work in order to transfer the technology to industry.

2.5.4 The priority focus for applied R & D aimed at industry

Whether a government lab is doing applied research and long-range development or contracting out near-term development, the lab must clearly be selective in terms of the projects it undertakes. Some will obviously be more useful to industry than others. But how is the laboratory to differentiate one from the other? As noted in the previous section, government labs are relatively insulated from market pressures and thus are not terribly effective in responding to commercial realities. It is this fact which makes many observers sceptical about the capacity of government labs to do R & D which can benefit industry.

The previous section also emphasized that government labs are most effective with respect to R & D intended to meet government needs. The reason is that, as a part of government, government labs are uniquely positioned to understand and be responsive to government needs. More important, the R & D conducted to meet government needs can have significant commercial spin-offs. Indeed, Nelson and Langlois point out that transfers of technology from government labs to industry are most effective when the government itself is a procurer or "user-demander"[1] of the resulting technology.

The Wright Task Force agrees: "A system which involves present and prospective contractors in the development of specifications, and which funds R & D programs well in advance of the time the resultant products will be needed, would be of immeasurable benefit. It would allow Canadian firms, operating under long-term government contracts, to produce prototypes well in advance. It would make possible a fairer, more balanced evaluation of these prototypes. It would give the contracting companies additional time in which to develop foreign markets for their innovations. And it would help foster a climate in which success was rewarded, and risk taking was not penalized."[2]

Government procurement is now widely recognized as key instrument of industrial development in the high technology area. For this reason, a priority focus of government labs in house should be procurement-related applied research and long-range development which industry is unable or uninterested in doing itself. Beyond laying the technological basis for meeting government procurement needs, such work should be undertaken with a view to ultimately transferring the technology to industry by contracting out the near-term development work. The actual meeting of the procurement need with a finished product would be essentially the responsibility of industry.

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1 Nelson and Langlois, op. cit., p. 816.

2 Wright Task Force, op. cit., p. pp. 15, 16.

2.5.5 Relation to industry

As noted in the previous section, the definition of future government needs -- in the procurement area or elsewhere -- with a view to building an R & D program around them, is by no means a straightforward exercise. It is in fact a complex process which should involve an ongoing dynamic interaction between the government lab and its government client. Even if these future needs are fairly precisely identified, there may be a number of possible technical routes to their fulfillment. Some of these routes may result in technology and products with significant commercial potential; others may not.

To the degree a government lab is interested in ensuring that its work brings maximum benefit to industry, it must try to ensure that it selects the technical route -- and perhaps the definition of government needs -- with the most commercial potential for domestic industry. The question of commercial potential would revolve around an understanding of future markets, technology trends and domestic industrial capabilities, actual or potential. As already noted, the relative insulation of government labs from the marketplace means that it is often difficult for them to decide whether one technical route has more commercial potential than another. For this reason, it is vitally important that government labs have formal and effective links with industry.

The Wright Task Force commented: "If a federal lab purports to serve an industry, surely that industry is best able to define what that lab should be doing, and to judge how well its doing it."[1] Given that government needs must also enter into the equation, it may be that the task force goes too far here. However, there can be little doubt that industry input is critical, and is generally not sufficiently influential with respect to the direction of the research programs of many Canadian government labs. As the Task Force emphasized, "This is easier said than done. Most federal laboratories engaged in industrial research are eager to clarify their missions and enhance their usefulness to their clients. But effective consultative mechanisms are lacking. We found many arrangements which were SUPPOSED to foster consultation, but were merely window-dressing."[2]

There is also ample support in the literature for the position that there must be effective formal mechanisms for assuring full consultation with industry. For example, as early as 1979, one can find statements to the effect that "Government needs to be better educated in the realities of the marketplace; but even in civilian research and development, its actions cannot be guided solely by them. Nor is the reconciliation of government and industry interests simply a matter of consulting one another...what is required is the institutionalization of private sector participation in public policy decisions and management. This proposition is radically at odds with the more extreme versions of the 'hands off' philosophy of some executives in industry and the 'arm's length' philosophy of some officials in government.... 'Institutionalization does not mean the establishment of

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1 Ibid., p. 26.

2 Ibid., p. 27. Capitalization theirs.

permanent relationships between agencies and firms or industries.... Rather, the task is to formalize procedures and ground rules for negotiating limited collaboration among government, industry and universities for specific mutual goals, facilitating reconciliation of interests that are at odds, and protecting the public interest in preserving competition."[1]

The U.S. Federal Laboratory Review Panel, of course, saw the need for industry clients of a government lab to take part in the exercise of an "oversight" function over the lab's activities.[2]

Such formal linkages with industry are important for another reason. As noted in the first section of this chapter, traditional accountability mechanisms within government tend to result in micro-management rather than genuine accountability in the case of government labs. Formal links with industry involving both industry advice and oversight of a government lab's program could well enhance the lab's over-all accountability within government by providing an independent measure of how well the lab meets industrial objectives.

It can be seen that, to the degree a government lab is expected to contribute to industrial development objectives, its priority focus must be on meeting government needs in areas of maximum commercial potential in the context of formal and effective links with industry.

2.5.6 Conclusion

Government labs have a role in R & D in support of industry when:

- the R & D is in the national interest,
- the R & D needed is too risky, too expensive or too remote in terms of a pay-off for industry to do it itself, and
- the industry is characterized by small and medium-sized companies.

In such circumstances, government labs should focus their in-house effort in the area of applied research or long-range development. Near-term development work should be contracted out to industry in order to transfer the technology. The priority focus for both kinds of R & D should be on work which meets government needs in areas of maximum commercial potential. For this reason, it is vitally important that formal and effective mechanisms be in place to ensure that the work in question meets industry's needs.

Figure 2-6 illustrates the role of government labs vis-à-vis universities and industry and in relation to our original research vs. development paradigm.

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1 Stephen A. Merrill, "The Political Nature of Civilian R & D Management," Federal R & D and Scientific Innovation, p. 11.

2 Federal Laboratory Review Panel, op. cit., p. 10.

2.6 AN INTERNATIONAL MONITORING AND DOMESTIC DISSEMINATION ROLE

Government labs have an important role in monitoring technology developments in other countries and disseminating the resulting information to public policy-makers, industry and university researchers.

As noted in the previous chapter, total Canadian expenditures on R&D in communications, both by government and the private sector, represent only two per cent of the world total.

As a corollary, it is clear that most of the R&D on new communications and information technologies is being conducted outside this country. Of course, most countries are in this position, and in fact the adaptation of new technology from abroad has been an important feature in the industrial development of most countries. As the Wright Task Force observed, "It is important to remember that Northern Telecom did not invent the digital switch; IBM did not invent the digital computer and the Japanese did not invent the industrial robot."[1]

In recent years, this dependence on foreign technology has grown for most countries. Take the United States, for example. As its National Science Foundation recognizes, "U.S. leadership in scientific and technological fields has given way to shared, or even lost, leadership...."[2] This observation applies even more forcefully to Canada, which never had a clear leadership position, except in a few small areas.

Predictably, it is the Japanese who seem to understand the implications of this situation better than anyone. As Charles J. McMillan points out in his recent book on The Japanese Industrial System, "Another factor often overlooked in Japan's technology policy is the collective capacity to carry out what might be called 'environmental scanning' or surveillance of market and technological trends globally. Various studies have documented the systematic approach to learn from Western companies...and and this learning desire is often expressed in the Meiji slogan Wakon Yosai ('Western technology, Japanese essence')."[3] Though Japanese industry is heavily involved in such activity, "The government itself has been an important vehicle for monitoring...foreign technology."[4]

The National Research Council, in its long-range plan published in 1980, drew the lesson for Canada. "Canada's total output of technology amounts to less than one per cent (1%) of the total world output.... It is a matter of considerable urgency that efforts be made to bring the ninety-nine per cent (99%) of world technology forcefully and more

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1 Wright Task Force, op. cit., p. 4.

2 National Science Foundation (NSF), "International Co-operation in Science: The U.S. Role in Megaprojects," Emerging Issues in Science and Technology, 1982, p. 1.

3 McMillan, op. cit., p. 103.

4 Ibid., p. 104.

conveniently to the attention of the possible exploiters, which are mainly in industry."[1]

Most other industrialized countries are in the same position. However, according to the Economic Council of Canada in its 1983 study on technology, trade and income growth, "although there are some exceptions, case studies show that often the process of diffusion of technical change into and throughout Canada occurs more slowly than in other Western developed nations, and not only in the manufacturing sector, but in the service sector as well."[2]

Clearly, such research intelligence would also be extremely useful to government policy-makers who often must develop policy in light of global technological trends.

The Economic Council recommended that the federal government put greater emphasis on the adaptation of new ideas, products and processes already in use abroad and not in Canada.[3]

However, the gathering and analysis of such technical information requires personnel with technical expertise. Much of the most valuable information available at international conferences is gathered through informal contacts with colleagues from other countries. However, in order to receive such information, it is necessary to have technical information to offer in return. For this reason, researchers in government labs represent an important resource with the respect to the collection of information abroad and its dissemination within Canada.

Attendance at such conferences can also increase the effectiveness of government labs. As Richard P. McBride pointed out in a recent discussion paper prepared for the Science Council, "It is clear that science progresses faster than printed papers and journals can reflect. It is at meetings that scientists learn about new ideas and experiments that are under way or being planned. Journal articles are frequently two or more years behind the creative edge of science. Science meetings must be seen in this light by those who allocate the funds. Meetings are also important in that they provide a form of feedback to scientists from their peers. Scientists often work on highly specialized topics and it is only at meetings that they meet similar specialists who can appreciate or challenge their thinking. Scientists often comment on the renewed enthusiasm they feel after attending a meeting."[4]

Government labs are generally also involved in the increasing numbe number of international R & D programs now being put into effect. In the

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1 National Research Council, The Urgent Investment: A Long Range Plan for the National Research Council of Canada (Ottawa, 1980), p. 68.

2 Economic Council of Canada, op. cit., p. 61.

3 Ibid., p. 80.

4 Richard P. McBride, Discussion Paper -- Continuing Education for Scientists: Suggestions for Integrating Learning and Research (Ottawa: Science Council of Canada, October 1984), p. 27.

information technology area, perhaps the best known of these is the European Strategic Program for Research and Information Technology (ESPRIT), which links together "a significant proportion of key European engineers from government, industry, and universities"[1] for joint pre-competitive research on advanced microelectronics, softrware technology, advanced information processing, office automation and computer integrated manufacturing. The technical results of such projects are then made available to all participants.[2]

The range of international scientific and technological activities is very large and "encompasses a variety of substantive activities. These range from support of military and political alliances through the use of more applied R&D, to very informal linkages among members of the global scientific community concerned with the advancement of knowledge and the most basic aspects of research. Such activities are pursued through many different organizational and managerial arrangements, including bilateral or multilateral government relationships, or the use of international organizations. Many different participants perform a variety of roles in these cooperative ventures. The most significant actors are national governments, private corporations, and universities."[3]

Because so many of such co-operative arrangements are intergovernmental, government labs continue to play an important role in this area. In many cases, such arrangements represent an opportunity to concentrate more critical mass in important areas. However, for the researchers who participate, they can also produce a wealth of valuable information which is useful to other R&D players on the domestic scene, especially small and medium-sized companies who often lack the resources to take part in such arrangements.

Clearly, scientists in government labs are uniquely qualified to play a systematic role in the gathering, analysis and domestic dissemination of information on new ideas, products and processes already in use abroad andnot in Canada. The assumption of such a role would have important benefits to Canadian industry, policy-makers and university researchers, as well as increasing the effectiveness and relevance of R & D carried out in government labs.

1 OTA, Information Technology R & D, p. 272.

2 Ibid., p. 274.

3 NSF, "International Co-operation," p. 2.

2.7 THE QUALITY OF VISION AND THE NOTION OF CRITICAL MASS

Research and development is most successful when it is driven by a clear, realistic and compelling vision of its ultimate importance to its users -- a vision which to the degree possible is shared by those users. For the vision to be credible, however, sufficient resources -- enough critical mass -- must be available to make the vision at least appear achievable. The vision itself may help in this respect -- by focussing a research program so that there are enough resources concentrated in critical areas.

2.7.1 The centrifugal forces

As previously noted, the Office of the Comptroller-General in its framework and guidelines for R & D management in the federal government argued: "Research is strongly person-oriented. It is the people who inject the imagination, creativity and innovation which are the keystones of the successful R & D project. Management must nurture and stimulate these characteristics and channel them in the desired direction. Success depends strongly on the competence, motivation and morale of the staff. Management practices should support the application of creativity, flexibility and scientific judgement to bring about the successful execution of R & D activities."[1]

The OCG goes on to emphasize: "In particular, because of uncertainties, timing and risk, R & D activities require a high level of authority at the working level, unlike most other government activities."[2]

Such a prescription, though necessary to effective R & D, would seem to have the effect of setting up strong centrifugal forces in an R & D organization, with individual researchers or research units going off in their own directions in a manner which is inconsistent with any over-all objectives or goals. As noted in the first section of this chapter, micro-management does not constitute a counter to such centrifugal forces and indeed at worst can even intensify those forces and at best can serve to undermine "the imagination, creativity and innovation which are keystones of the successful R & D project."

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[1] OCG, op. cit., p. 5.

[2] Ibid., p. 6.

2.7.2 The importance and limits of setting objectives

The OCG does suggest a number of other mechanisms intended to counter such centrifugal forces. These include: "dynamic and effective leadership",[1] the positioning of executive level R & D management at a high enough level within the Department to be able to educate key individuals on the importance and nature of technological innovation,[2] the deliberate use of strategic planning,[3] the intelligent use of operational planning mechanisms,[4] the preparation of work plans[5], a deliberate approach to project and program selection,[6] the use of effective operational control and program evaluation mechanisms[7] and over-all reviews of the R & D function.[8]

All of these approaches and mechanisms are useful and important, though in some cases their overzealous application can result in self-defeating micro-management. The Office of the Comptroller-General in its report also acknowledges that these mechanisms are not sufficient in themselves and argues that the exercise of setting objectives is much more crucial: "The setting of objectives is a statement of strategy for leading the organization. Objectives give a purpose and provide stable guidelines for determination of policy, procedures, standards and responsibilities. But even more important when developed through participation and when understood and accepted by everyone as being mutually supportive to their own needs, the objectives become the keystone to organizational performance and hence effective performance."[9]

In the view of the OCG, the objectives should take into account four variables: "The first relates to ensuring that there is a mandated direction for the R & D effort. The second relates to understanding the external environment and client needs. The third must take into consideration the ability of the R & D organization to respond to the needs; that is the human and physical resources. The fourth takes into account the interactive process necessary to balance what is desired to what is possible; that is what strategies are available to the department and how do these influence the setting of objectives."[10]

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1 _Ibid._, p. 8.

2 _Ibid._, p. 7.

3 _Ibid._, pp. 12, 13.

4 _Ibid._, pp. 14, 15.

5 _Ibid._, p. 15, 16.

6 _Op. cit._, p. 17, 18.

7 _Ibid._, p. 17, 18.

8 _Op. cit._, p. 10.

9 _Ibid._, p. 12.

10 _Ibid._, pp. 9, 10.

The OCG was emphatic that such objectives should not define the means used to attain them: "R & D objectives should be devised to specify what the R & D organization will do but not how to do it."[1] With respect to what the organization does, the OCG argued that "R & D objectives should state, in as great detail as practicable, the results to be achieved by the R & D activity and present the links between the activity and the programs it serves."[2]

There is nothing here to which one can take exception. The setting of objectives is vital, and the OCG rules for objective-setting are as good as any. There are, however, a few elements which are missing. For example, the OCG does not address the question of deciding upon priorities between objectives. More important, it seem to assume that somehow that departments will have no difficulty resolving conflicts between objectives and that it is easy to arrive at a coherent set of objectives. Such conflicts and questions of priority lie, of course, at the heart of the policy-making and objective-setting process.

Presumably, such issues would be settled through the rational analysis of resources available and client demands, with input from the lower levels of the R & D organization. The result would be a series of very carefully ordered and extremely precise objectives, which would mean -- according to the OCG -- "that the objectives and the activities oriented towards their achievement will have the reasoned support of all personnel."[3]

The basic difficulty with such an approach is that it contains within a bias towards prudence and against risk-taking. In addition, a list of objectives is rather uninspiring. As Peters and Waterman point out in their study of American's excellent companies, "We have observed few, if any, bold new company directions that have come from goal precision or rational analysis."[4]

Of course, a government lab is very different from a private company. However, we would argue that the differences between the two make it even more essential that the former rely on more than simply the setting of objectives to infuse it with a sense of purpose. A government lab is an organization which depends for its effectiveness on the imagination and creativity of its people, and it is located in a bureaucratic context which all too easily can stifle precisely those qualities. The rational setting of objectives is, of course, necessary in itself and absolutely vital in such an environment. But there must be something more.

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1 Loc. cit.

2 Loc. cit.

3 Loc. cit., p. 12.

4 Peters and Waterman, op. cit., p. 51.

2.7.3 The need for a consensual vision

In this report, we have called this something more "vision". There are probably other words which might be used. Certainly, it is so intangible that it is difficult to describe.

However, according to an American observer, it is the greatest strength of the Japanese Fifth Generation Project: "They have two hundred people with a unified vision. That's very powerful. We know more than the Japanese, but no one has developed a plan like they have."[1] The vision to some degree is a shared one. "The 200 would include not only the forty researchers at ICOT, but all the researchers in the firms that would contract to do work under ICOT's direction."[2] In other words, the vision of this government lab is shared by its major industry clients.

But what exactly is this quality of vision? Peters and Waterman perhaps define it best: "While it is true that the good companies have superb analytic skills, we believe that their major decisions are shaped more by values than by their dexterity with numbers. The top performers create a broad, uplifting, shared culture, a coherent framework within which charged-up people search for appropriate adaptations. Their ability to extract extraordinary contributions from very large numbers of people turns on the ability to create a sense of highly valued purpose. Such purpose invariably emanates from love of product, providing top-quality services, and honoring innovation and contribution from all."[3]

The key thing here is not the corporate cheerleading quality, but the profound sense of purpose and worth which characterizes both the top companies and the Japanese government lab. Both in fact are suffused with a strong internally driven purpose and a powerful outward orientation. Again Peters and Waterman put it best: "Quite simply, these companies are simultaneously externally focused and internally focused -- externally in that they are truly driven by their desire to provide service, quality, and innovative problem-solving in support of their customers; internally in that quality control, for example, is put on the back of the individual line worker, not primarily in the lap of the quality control department."[4]

In the literature on R & D management, a similarly dualistic perspective is felt to be vital. In this case, of course, the duality is between the technical logic of researchers and the logic of the political and other demands from the outside environment. The two can be opposed, but "the manager must create a synthesis, or new logic, which is operationally consistent with the 'truths' of each opposing logic."[5] Lane, Beddows and Lawrence terms this process "dual advocacy" and describe the role of the R&D

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1 Feigenbaum and McCorduck, _op. cit._, p. 27.

2 _Loc. cit._

3 Peters and Waterman, _op. cit._, p. 51.

4 _Ibid._, p. 323.

5 Lane, _et al._, _op. cit._, p. 145.

D administrator in carrying it out as follows: "In his or her concern for organizational integrity, the administrator becomes concerned with the whole innovation process, sees the interrelationships which comprise the gestalt, and becomes committed to his or her role in the process. The dual advocate realizes that no important problem or undertaking is so simple that the answer lies within one logic. The dual advocate serves to promote a synthesis -- the creation of a new situation or substance out of two inputs having different identities. It is not an easy role."[1]

We would go further. In light of the Japanese example and Peters' and Waterman's comments on effective management, we would argue that it is essential for R & D labs to convert that synthesis into an animating vision of the laboratory's role, a vision which respects and integrates both the technical logic of successful R & D and the external demands of the client. In other words, the vision must acknowledge -- even embrace enthusiastically -- both the the needs of the researcher and the over-all significance of the technology to potential clients and users.

2.7.4 The notion of critical mass

The existence of a strategic vision, with credible objectives flowing from it, is critical to the effective functioning of any R & D operation. It is, however, especially crucial in the case of government labs because they are not subject to the market disciplines of industrial labs, disciplines which tend to winnow out unproductive or less relevant R & D activities.

The resulting trend in many government labs towards the proliferation of projects of dubious relevance has been documented by the U.S. Federal Laboratory Review Panel: "The Panel observed that some of the laboratories did have a clearly defined for a part -- often a major part -- of their work, but the balance of the work was often fragmented and unrelated to their main activity. This phenomenon frequently occurs when a national need that justified the original mission of a laboratory becomes of lower priority. The laboratory then tends to diversify into other work to occupy its staff and preserve institutional stability."[2]

The difficulty with this process of diversification is that it tends to result in a progressive spreading out of the lab's resources among an ever growing number of projects, with the result that priority areas are often starved. As the Packard Panel observed, "The breadth of research activities at most Federal Laboratories could be reduced and the depth increased in those areas of demonstrated excellence and mission relevance."[3] In other words, in the case of many government laboratories, it would be better if they undertook fewer activities so that they could develop critical mass in those areas which are of real strategic importance. In brief, less is often more for government labs, and a strategic vision is crucial to assuring a strategic allocation of R & D resources.

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1 Ibid., p. 146.

2 Federal Laboratory Review Panel, op. cit., p. 4.

3 Ibid., p. 5.

If this vision is shared by industry and university researchers working in the same area, then it may be possible to ensure that the activities of all the major R & D players complement each other and thus increase the critical mass of the national R & D effort in key technological areas. Certainly, this is one of the most important lessons of the Japanese experience.[1] It is a lesson which the U.S. Federal Laboratory Review Panel would like to see applied in the United States.[2] A similar increasing emphasis on selectivity is also evident in major Western European countries.[3]

In Canada, the case for such an approach is even stronger. With a much smaller R & D base than most of these countries and with R & D representing a significantly smaller proportion of GDP,[4] it is vitally important that Canada deploy its R & D resources in the most effective and efficient manner. Indeed, only if the R & D activities of government, industry and universities are complementary and mutually reinforcing will it possible to generate sufficient critical mass in the strategic technological areas where we must be able to compete. The development of a strategic vision for government labs -- one which is shared by government users and clients and industry labs and university researchers working in related areas -- represents an important step towards making that objective a reality.

2.7.5 Conclusion

The reality is that the formulation of such a vision for a government lab, and the creation of a consensus around it, will be extremely challenging. However, it is absolutely vital that this synthesizing vision be shared not just by lab personnel but by the labs' government clients, its industry clients and -- to the degree it performs fundamental and applied research -- university researchers. Clearly, such a vision must be very compelling.

It is in many ways the most important conclusion of this chapter that such a consensus can only be achieved if those whom a government lab serves -- government clients and users of its research, industry and the university research community -- are intimately involved in the process of defining its strategic vision and setting its broad research direction. In short, it is crucial that there be formal and effective links with government users, industry and the university research community and that these links involve a meaningful oversight of the lab's activities.

The existence of such links are vital for another reason. As noted in the first section of this chapter, the traditional forms of accountability used within government are not terribly effective when applied to government labs. While they provide a narrow financial and administrative accountability, they do not ensure that senior management, Ministers or Parliament will understand exactly what a government lab is doing. The

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1 See pages 6 and 7 in Chapter 1.

2 Federal Laboratory Review Panel, op. cit., p. 11.

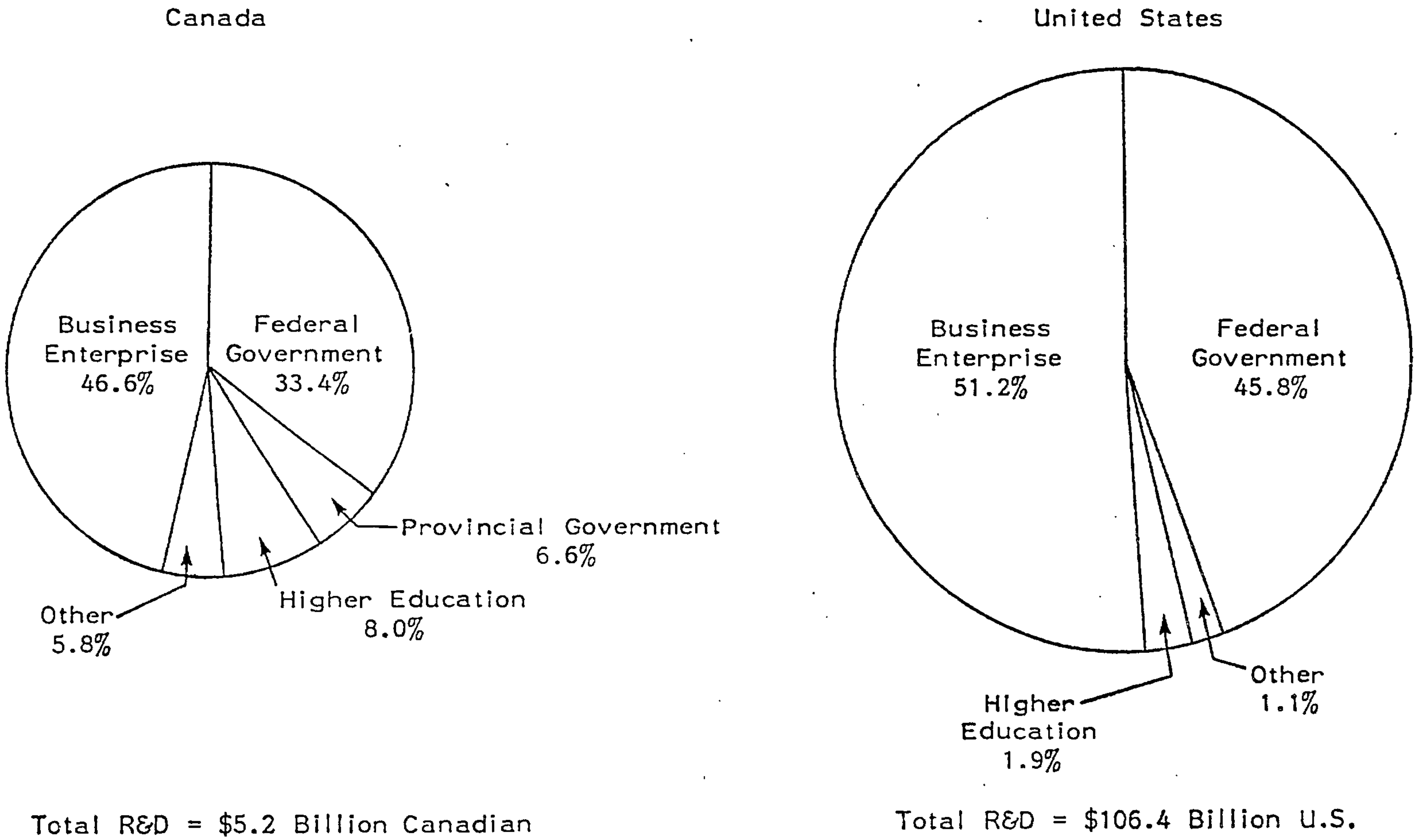
3 See pages 14 and 15 in Chapter 1.

4 See pages 17 and 18 of Chapter 1.

reason is, of course, that the implications and significance of many R & D projects -- based as they are on technical assumptions -- are not transparent to the layman. The existence of a strategic vision should enhance that transparency and thus the accountability of government labs. Even more crucial is a clear sense of the degree to which the actual work conducted meets the needs of those it is intended to serve -- government clients and users of the research, industry and the university research community. Only if these groups have a formal role in commenting on the work of the lab can the relevance of the research program be assessed. In other words, effective and formal links with government clients and users of research results, industry and university researchers lie are crucial to ensuring that a government is fully and meaningfully accountable to senior management, Ministers, the government and Parliament.

1. OVERALL, THE CANADIAN PUBLIC SHARE OF RESEARCH FUNDING IS SIMILAR TO THE U.S. ALLOCATION, ALTHOUGH CANADIAN UNIVERSITIES AND PROVINCIAL GOVERNMENTS ARE PROPORTIONALLY MUCH MORE IMPORTANT THAN THEIR U.S. COUNTERPARTS

SOURCES OF R&D FUNDING
CANADA VS. UNITED STATES, 1983



Source: Canada Consulting based on data obtained from Statistics Canada and the U.S. Bureau of the Census

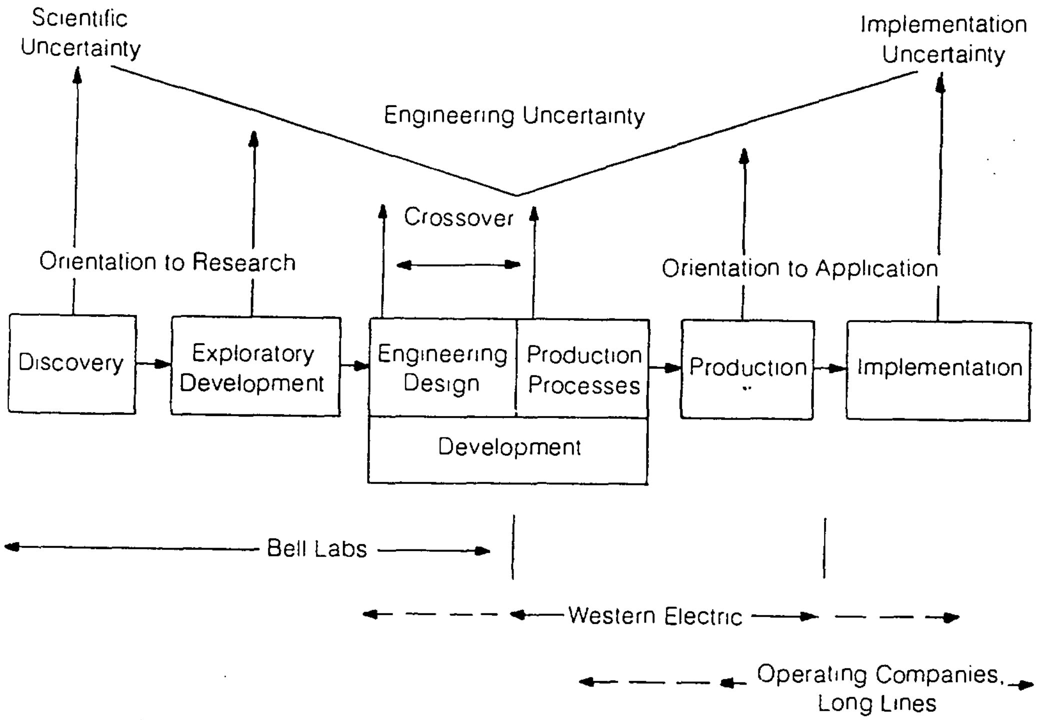
Figure 2-2

Research vs. Applied R & D

FUNDAMENTAL RESEARCH		APPLIED R & D
- focus on science		- focus on technology
- advance knowledge		- manufacturable and marketable products or fulfilling specialized requirements implementation
- scientific uncertainty	few research ideas	- uncertainty about implementation
- links to universities	are developed	- marketing and manufacturing considerations and/or specialized users' needs crucial
- unstructured organization		- structured organization
- loose schedule		- tight schedule

FIGURE 2-3

Involvement of AT & T Manufacturing and Operational Arms
in Bell Labs R & D



SOURCE: Lane, Beddows and Lawrence,
Managing Large R & D Programs

Figure 2-4

Models for effective development work --

industry and government

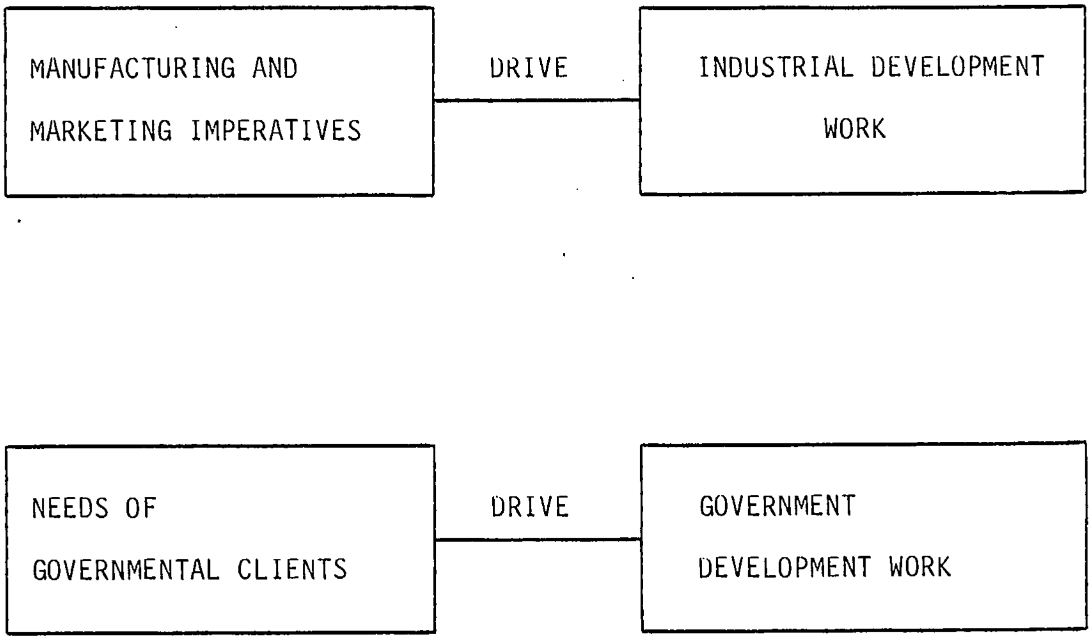
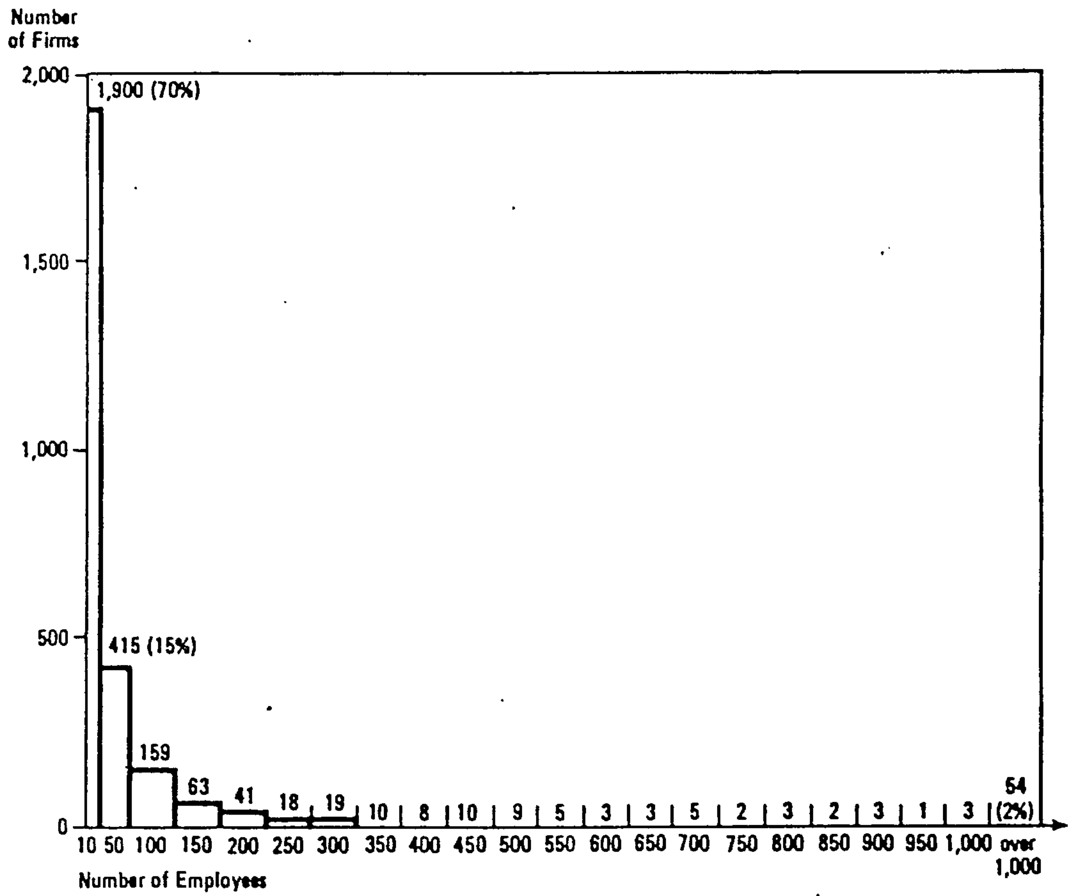


FIGURE 2-5



SOURCE:
Everett M. Rogers and Judith K. Laren, <u>Silicon Valley Fever</u> (New York: Basic Books, 1982.

Figure 3.2. More than two-thirds of the electronics manufacturing firms in Silicon Valley employ fewer than ten workers.

Figure 2-6

Role of Government Labs in R & D

FUNDAMENTAL RESEARCH	APPLIED R & D	
	LONG RANGE DEVELOPMENT OR APPLIED RESEARCH	NEAR TERM DEVELOPMENT
Primarily University Labs	Primarily Government labs in close collaboration with:	Industrial Labs Predominate
A small role for Government Labs linked to universities	- government clients - industry - universities	Do some work under contract to gov't

CONTENTS OF CHAPTER 3.0

Chapter 3.0

HISTORICAL PERSPECTIVE

The experience of the DOC research program over the past 16 years -- that is since it was incorporated into the newly established Department of Communications -- will tell us much about the challenges and difficulties of carrying out research in the broad communications area within a government lab in a country such as Canada. More important, a historical perspective will explain how and to some degree why the current structure and organization of activities within the Research Sector came into existence.

Most important of all, such a perspective will help us to isolate some of the factors which help explain the strengths and weaknesses of the DOC research program -- as well as providing an important means of testing the validity of the principles defined in the previous chapter.

3.1 THE OLD DRTE

The creation of a research capability at the Department of Communications (DOC) coincided with the creation of the Department itself. In 1969, the same year the Department was established, the Defence Research Telecommunications Establishment (DRTE) was formally transferred from the Department of National Defence (DND) to DOC and became the Communications Research Centre (CRC).

With the transfer, DOC gained control of a research centre with a solid reputation in international circles -- especially in NATO, NORAD and the United States -- and a strong public image as the spearhead for Canadian space achievements.[1] It was, however, a research centre which had been almost exclusively preoccupied with supporting DND objectives.[2]

At the time of the transfer, the primary task of DRTE had been to keep DND abreast of the state of the art in the broad communications and radar areas. This meant a significant emphasis on fundamental research, which absorbed from 15 to 20 per cent of the DRTE budget.[3]

The DRTE research program placed considerable emphasis on the gathering and analysis of scientific data on the ionosphere and the

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1 J. C. Madden, A Basis for R & D in the Department of Communications (Unpublished discussion paper, September 1976), p. 6.

2 G. W. Holbrook, Communications R & D -- the DOC Role (Unpublished discussion paper, *circa* 1975), p. 5.

3 Interview with Research Sector personnel, Summer 1984.

propagation of radio waves.[1] These activities laid the basis for the Alouette and ISIS satellite programs, through which Canada became the third country in the world -- after the USSR and the U.S. -- to enter the space age. However, it should be noted that the missions of these satellites were scientific and technological -- for example, the gathering of data on the ionosphere and the impact of solar disturbances on communications.[2]

The DRTE also carried out defence-related research on radar and the electronic and signal-processing aspects of sonar, as well as electronic warfare and counter-measures.[3]

In 1969, this highly regarded research organization, with its strong orientation towards defence concerns and its significant emphasis on fundamental research, joined a newly formed Department of Communications which for some time would be groping to define its own role. The one clear certainty was that the orientation of the new department would be towards civilian rather than defence concerns.

3.2 THE CONTINUING DND RELATIONSHIP

The preoccupation with defence-related concerns continued to some degree after 1969 because, under the terms of the transfer agreement, CRC was expected to carry out communications and radar research for DND on a cost-recovery basis.[4] The arrangement is still in effect and involves approximately $8 million in DND funds[5] -- from 15 to 20 per cent of Research Sector expenditures.

Under the agreement, DOC is to provide the infrastructure needed to carry out R & D for DND.[6] At the outset, there was "considerable concern in DND that the level of research related to defence matters may decline and the ability of DOC to supply the required consultation, assistance and innovation may also decline."[7] These doubts continue right up to the

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1 Holbrook, op. cit., p. 5.

2 Department of Communications, From Alouette to Anik and beyond (1982), pp. 1, 2.

3 Holbrook, op. cit., p. 5.

4 The agreement is embodied in an exchange of letters in January 1969 between the Ministers responsible for the Department of Communications and the Department of National Defense -- Eric Kierans and Leo Cadieux, respectively.

5 Jacques Marcotte, "Military R & D Program at CRC (Memorandum to John Sifton, October 10, 1984).

6 Loc. cit.

7 Page 4 in Appendix A of letter from Leo Cadieux, Minister of National Defence, to Eric Kierans, Postmaster-General (January 9, 1969).

present and have recently been expressed at the Deputy Minister level, along with expressions of appreciation about the quality of the research.[1]

The DND benefit from the arrangement was clear. Defence-related R & D at CRC could draw on expertise across the wide range of civilian R & D conducted by the Research Sector.

But DOC also benefited. The greater willingness of DND to fund speculative research helped build up the technology base of the DOC research effort and could result in important developments. For example, one factor in the development of Telidon was early funding by DND of speculative research on image communications.[2]

Clearly, **though the continuing DND relationship has remained uneasy, it has contributed to the strength of the DOC research program.**

3.3 FROM RESEARCH TO DEVELOPMENT AND BACK AGAIN

The move to DOC in 1969 led to significant changes in the DRTE-CRC research program, and the reorientation involved much more than a switch from defence to civilian concerns in R & D.

As already noted, while DND had been willing to fund considerable fundamental research as a means of keeping abreast of the state of the art for defence purposes, DOC had much more of a service orientation and a correspondingly greater concern to support applied research intended to meet the communications needs of Canadians. As a result, "The trend towards applied research and experimental development accelerated such that in 1975/76 less than 1 per cent of the total effort was considered to be basic research"[3] -- in contrast to 15 to 20 per cent before the transfer.[4]

With this move away from fundamental research and into more applied work, industrial objectives and ties with industry also assumed a growing importance. Another important factor was the federal government's

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[1] In April 1984, the Department received a letter on this subject from D.B. Dewar, Deputy Minister of National Defence, and from J.R. Killick, Assistant Deputy Minister (Materiel). More recently, the matter has been raised by the deputy ministers of both departments with the Clerk of the Privy Council.

[2] Ministry of State for Science and Technology (MOSST), Technology Transfer by Department of Communications: A Study of Eight Innovations (Ottawa: MOSST Background Paper no. 12., 1980), pp. 32, 33.

[3] Research Sector, Budget Augmentation Five-Year Plan, p. 2.

[4] Interview with Research Sector staff, Summer 1984.

make-or-buy program, which was announced in the early 1970s. "CRC had responded to the onset of the buy/make policy by retraining a number of its research scientists in contract management. By 1974 an in-house capability existed for providing the scientific authorities essential to good contract research both in industry and the universities. Additionally a system of liaison officers had been established on a reciprocal basis with the major carriers, with the research divisions of the manufacturing industry and the graduate faculties of the universities."[1]

The new emphasis on applied research was evident in optical communications work which had important industrial spin-offs and involved significant transfers of technology[2] and the conduct of field trials -- such as the one in Elie, Man. -- in conjunction with industry. There was also a move away from fundamental research on the ionosphere, radio propagation and the environment into more applied topics intended to support the Department's responsibilities for spectrum management, standard-setting and the extension of communications services, especially using satellites.[3]

3.3.1 Space

In the space area, the change was even more dramatic.

As noted in the DOC Annual report of 1970-71, "Following the decision to introduce satellites as an element of the domestic communications system, the Government moved to emphasize applied rather than pure research in its satellite research program."[4] The resulting Hermes and Anik B programs, which ultimately served broad communications and industrial development objectives in contrast to the more scientifically and technically oriented Alouette and ISIS programs, meant large injections of resources into developmental work and even technology promotion.

The reorientation at CRC was far-ranging. As G.W. Holbrook, a former CRC director-general, put it, "significant changes in program and organization had been effected"[5] by 1974. "Most significant among program changes was the Communications Technology Satellite Program (CTS).... By 1974...it was accounting for half of the annual budget of CRC and brought over 100 contract and term personnel onto the site. It was also occupying more than 70% of the research services at CRC in support of the project."[6]

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1 Holbrook, op. cit., p. 6.

2 MOSST, Technology Transfer by Department of Communications, pp. 36, 37.

3 Interview, Research Sector personnel, Summer 1984.

4 Department of Communications, Annual Report 1970-71 (Ottawa, 1971), p. 1.

5 Holbrook, op. cit., p. 5.

6 Loc. cit.

In fact, by the mid-1970s, space R & D in support of these programs and other departments had come to assume so much importance that the activity was consolidated into a new Space Sector with responsibilities for technology promotion and industrial development as well as R & D.

The space program has been singularly successful: it has spawned new Canadian technologies and helped build a Canadian space industry. The CRC has also become the centre of expertise within the federal government for the design and implementation of spacecraft systems and sub-systems.

3.3.2 Informatics and Telidon

Informatics did not really exist as a distinct field before 1969, but DRTE did carry out work in at least one area which is now classified as "informatics" -- the development of computer-aided design techniques needed to support the DND space program.

After the transfer, the emphasis shifted to interactive graphics for communications purposes. In the mid-1970s, DND's need for advanced display systems to support war-gaming exercises helped generate a close working relationship between CRC and NORPAK, a small Canadian electronics manufacturer. In 1978, DOC publicly demonstrated Telidon using the equipment developed by NORPAK with CRC technology as its basis.[1]

By 1985, the Department of Communications will have invested almost $60 million in the development of Telidon products and services,[2] while Canadian industry has put up a like amount. Telidon has not won the predicted[3] widespread acceptance in homes and offices, but the program has managed to create a Canadian manufacturing capability and won widespread support for the Telidon standard internationally and, more important, among major industry players in the United States.[4]

The Office Communications Systems (OCS) program was another major program which was strongly oriented towards product development considerations and industry. It involved field trials of new office technology in selected government departments, requiring extensive liaison with industry and users, as well as considerable technology promotion activity.[5]

The Telidon program, as well as the OCS and Elie programs, had a profound impact on the CRC research program. According to the draft

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1 MOSST, Technology Transfer by Department of Communications, pp. 32-34.

2 Report of the Auditor General of Canada to the House of Commons: Fiscal Year Ended 31 March 1983 (Ottawa, 1983), p. 230.

3 John C. Madden, Videotex in Canada (Ottawa: Department of Communications, 1979), pp. 27, 28.

4 Research Sector, Budget Augmentation Five-Year Plan, p. 6.

5 See, for example, the description of the program in Trying out the future: Office Communications Systems in the Federal Government (Ottawa: Department of Communications).

discussion paper on the five-year plan, "The research and development process in any laboratory is evolutionary in nature, and at a given time it may be required to emphasize any one of the following links in the chain of R & D activities: fundamental research, applied research, experimental development and technology transfer and promotion. In recent years, the Research Sector (excluding space) has emphasized the latter of these activities with 70% of its budget for Telidon, OCS and Elie."[1]

3.3.3 Reversal of the trend

In the last two or three years, there has been a move away from developmental work and technology promotion activities, back towards the research end of the R & D spectrum.[2]

This move was given significant impetus by the winding down of Telidon-related activities and the establishment of the Technology and Industry Sector, which took over the technology promotion and industrial development activities associated with the space, OCS and Telidon programs, as well as assuming new responsibilities in the areas of technology and policy assessment. The creation of the new sector, in fact, represented in many ways an attempt to draw a clear boundary between "research" activities and industrial policy and development activities within the Department.

The focus of the Sector now is mainly on what could be described as applied research[3] rather than activity towards the product development end of the R & D spectrum. Though reduced, however, a significant amount of the latter activity continues, some of it in house, most of it under contract to industry.

3.3.4 Conclusion

Clearly, the balance between fundamental research, applied research and development work has shifted considerably over the last 15 years. The early move towards applied research and development work occurred essentially on an incremental or program-specific basis. The later move away from strictly development work reflected an attempt to draw a boundary within the department between "research" activities and industrial development activities. These shifts corresponded to changes in the emphasis on linkages with industry, though these tended to take place on an incremental or program-specific basis.

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1 Research Sector, Budget Augmentation Five-Year Plan, p. 2.

2 Interviews with Research Sector personnel, Summer 1984.

3 Loc. cit.

3.4 RELATIONSHIP WITH THE REST OF DOC

The role of research within DOC has always been difficult to define in a manner sufficiently concrete to have specific implications for research priorities. The lack of such a definition, either in statutory instruments or in specific policy, has occasioned difficulties. For example, the Sector has -- with the major exception of space and Telidon, as well as environmental and interference studies -- led a life largely separate from the policy centres of DOC. And even space and Telidon were originally research-driven projects that were later incorporated into the work and thinking of the rest of the Department.

3.4.1 Difficulities of the transition from DND

In a 1971 report commissioned by DOC, Philip Lapp saw the central problem at CRC as a lack of research goals which are clearly understood by both scientists and senior management. "If there are organizational difficulties at CRC, most likely they would spring from a lack of well understood goals and objectives, because the writer found during the interviews (at CRC) no lack of motivation on the part of the people contacted,"[1] he stated, and went on to propose as one of his key recommendations that a planning directorate be established at CRC.[2]

While commenting upon the consequences for CRC of the transfer to DOC, John Madden, a former CRC director general, described the implications of this lack of well understood goals and objectives: "The adjustment to the change has been difficult for scientist and bureaucrat alike. With the exception of the space program which gained, at least temporarily, a special project status, the attempts of those at Shirleys Bay and at Headquarters to define mutually agreed 'relevant' research programs appear to have been discouraging."[3]

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1 Philip Lapp, The Communications Research Centre -- A View from Outside (Unpublished consultant's report, 1971), p. 28.

2 Madden, A Basis for R & D, p. 3.

3 Ibid., p. 6.

3.4.2 Acknowledged importance to DOC's reputation

There was, of course, a recognition that the research program was crucial to the reputation and credibility of the Department. DOC annual reports and other public documents in the 1970s and early 1980s tended to give more emphasis to research achievements than almost any other activity.[1] The space program and Telidon were indeed centrepieces in the image which the Department presented to the public and indeed both resulted in the establishment of a significant Canadian industrial presence in their respective areas.

Among the significant achievements of the research program are:

- the design and construction of Canada's first satellites, the Alouette-ISIS series; two of the ISIS satellites are still operating some 15 years after initial launch;

- design and construction of Communications Technology Satellite (Hermes), the world's first 14/12 GHz satellite and most powerful non-military satellite to date, which was launched in 1976 to conduct experiments in tele-education, tele-health, public administration and community interaction;

- first field trial in world of direct-to-home satellite television broadcasting with medium-powered Anik B, leading to establishment of B.C. Knowledge Network and Inuit Broadcasting Corporation;

- development of transportable television uplink terminals for satellite news-gathering and stabilized earth stations for off-shore rigs;

- demonstration of world's first mobile aircraft-to-aircraft link via satellite; development of first single-chip voice-coding unit;

- successful demonstration for DND of satellite-aided search and rescue system, resulting in saving of more than 300 lives;

- development of a range of active oscillators, opto-electronic devices, filters and couplers, resulting in successful transfers of technology to industry and the issuing of 60 invention notices and 20 patents;

- successful field trial demonstration in rural Manitoba of the use of fibre optics to deliver integrated (TV, FM radio, telephone and data) services to the home;

- in addition to supporting all major civilian and military radar procurements in Canada, the development of technology for digital processing of data from synthetic aperture radar for measurement of

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[1] In the introductory highlights for virtually every DOC Annual Report since 1970-71, some aspect of the research program has had a prominent place.

the thickness of fresh-water and sea ice and of the water content of soil;

- leadership in the understanding of Arctic propagation effects on terrestrial and space communications and in effects of precipitation on communications between earth and space;

- development of integrated VHF and HF trail and remote camp radio communications system;

- development of first fully operational facility for monitoring and analyzing land mobile use of radio channels;

- development, and successful transfer to industry, of competitive HF communications systems for radio telephony and data, including a mobile radio data terminal;

- development of Telidon, which in 1983 became in updated form the officially recognized North American standard for videotex and teletext systems; and

- many significant contributions in behavioural research in the areas of human factors, social impact and evaluation.

As a consequence of this record, there were few within DOC few who would argue with Madden's statement in the mid-1970s that **"without an R & D arm, the department would consist simply of a small policy formulating head attached to a regulatory body with GTA clinging to one side."**[1] Madden goes on to argue, in terms that seem strangely relevant today, that "In government organizational terms there might be a strong tendency to dismember the department totally, perhaps moving GTA to DSS, radio regulation to MOT or CRTC and the policy head to MOT or Secretary of State. This would be perfectly satisfactory if one did not accept the basic premise underlying the department's creation that communications are important enough to warrant a separate department."[2]

3.4.3 Difficulties in defining goals

Awareness of the importance to the Department of the research program did not mean a corresponding agreement about the goals and objectives it should be pursuing. In the mid-1970s, two CRC directors-general, John Madden[3] and G. W. Holbrook,[4] grappled with this difficulty as they tried to formulate a role for DOC in communications R&D. Neither were able to win a consensus for their proposals.

The Communications Research Advisory Board (CRAB), appointed in 1974 to provide advice on the research program from industry representatives, saw the lack of focus in the DOC research program as a direct product of a

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1 Madden, A Basis for R & D, p. 24.

2 Loc. cit.

3 See J. C. Madden, A Basis for R & D in the Department of Communications (Unpublished discussion paper, 1976).

4 See G. W. Holbook, Communications R & D -- the DOC Role (Unpublished discussion paper, circa 1975)).

similar lack of focus in the Department as a whole. In 1978, it stated: **"In its deliberations the Board encountered great difficulty in identifying a specific focus or common denominator to evaluate the DOC Research Program. It quickly became clear to members of the Board that it is time for stock-taking and direction-setting in the Department. By this we mean that the Department should identify the key issues it is facing, and the objectives of its research program should flow from this set of priorities."**[1] The same concern was repeated in every subsequent CRAB report through to the last in 1982-83.[2]

3.4.4 Operational solitudes

This situation was further complicated by the fact that research topics were often too technical for the rest of the Department to grasp fully and that the Sector's planning documents were often opaque to the Department as a whole.

As the Auditor General noted in his comprehensive audit of the Department for 1982-83, "The Sector follows a tradition of relying heavily on meetings and discussions for planning and controlling its projects. Although planning documents are produced to meet central agency requirements, these generally do not contain sufficient information for project planning and control purposes."[3] Or, it might be added, for ensuring that the rest of the Department had a full understanding of what the Sector was doing. In fairness, it should be noted that the planning documents of a number of other DOC sectors had similar weaknesses.

This situation meant, of course, that there was often no agreement across sectoral boundaries on the relevance of research goals and projects to the Department's over-all mission.

In this context, as already noted, the move towards the developmental end of the R & D spectrum was inevitably evolutionary and incremental. Change happened as a consequence of specific demands or programs, not as a result of any over-all vision or gestalt of the role of research in DOC.

While this was to be expected in a new department which was itself groping for a mission in a rapidly evolving technological area, the result was that agreement on research goals was at best temporary and ad hoc. As a

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1 Communications Research Advisory Board (CRAB), 1978 Report of the Communications Advisory Board (Ottawa: Department of Communications, August 1978), p. 9.

2 See CRAB, Report of the Communications Research Advisory Board 1979 (Ottawa: Department of Communications, 1980), pp. 5, 6; CRAB, Report of the Communications Research Advisory Board 1980-81 (Ottawa: Department of Commuications, 1981), pp. 13, 14, 32; CRAB, Report of the Communications Research Advisory Board 1981-82 (Ottawa: Department of Communications, 1982), pp. 11, 12, 15-20, 24; and CRAB, Report of the Communications Research Advisory Board 1982-83 (Ottawa: Department of Communications, pp. 24, 42.

3 Report of the Auditor General for Fiscal Year Ended 31 March, 1983, p. 215.

consequence, the only time when research goals were systematically considered and accepted by the Department as a whole was when temporary bridges could be built, as was the case with space, Telidon and a number of other programs.

3.4.5 Conclusion

It can be seen, then, that **over the past 15 years there has been a continuing uncertainty about the role of research within DOC and a sense that neither DOC's mission nor existing planning mechanisms provided sufficient guidance for the setting of research priorities. In short, the difficulty was as much with the evolving mission of the Department as a whole as it was the research program.**

3.5 RECENT DEVELOPMENTS

In the last three years, there have been three important developments which bear directly on the long-standing concerns about the role of research within DOC and the larger environment. They underlay, for example, the elaborate consultative exercise within the Research Sector intended to develop a five-year plan for research at DOC. To a large degree, these same concerns were taken into account in the philosophy underlying the establishment of a new departmental lab, the Canadian Workplace Automation Research Centre, at Laval, Quebec. Finally, these concerns also underlay the proposal to establish a Canadian Communications, Informatics and Space R & D centre as a not-for-profit corporation with the CRC as its nucleus.

3.5.1 Budget Augmentation 5-Year Plan

In 1981, the Research Sector was considerably different from what it is today. For example, at that time, the Sector did not undertake space-related R & D (which was the responsibility of the then existing Space Sector) but was intimately involved in product development work, field trials and technology promotion for Telidon and office communications systems (which are now largely the responsibility of the Technology and Industry Sector).

However, there was considerable concern about the degree to which its resources were tied up in applications-oriented sunset programs which would eventually end.[1] No doubt the CRAB reports on the need for planning reinforced this concern. Whatever the reason, the Sector inaugurated a comprehensive planning exercise with a view to formulating a five-year plan which would serve to justify the transfer of money from sunset programs to the Sector's base budget.

The planning process was elaborate. Managed by the Director General for Research Policy and Programs, it involved systematic consultation with all CRC directors-general and directors. All were asked to explain in some detail the nature of the work they were then performing and the difficulties they perceived in the existing situation. The directors were also asked to propose in some detail, through their directors-general -- who would in turn consolidate the proposals -- future programs with appropriate justifications.

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1 Interview with Research Sector personnel, Summer 1984.

It was felt that these would lay the basis for a significant augmentation of the Sector's base budget.[1]

By late 1982, this participatory exercise was largely completed and a preliminary draft of a Cabinet Discussion Paper[2] had been prepared. The plan listed the Research Sector's achievements, diagnosed its problems and made proposals for its future, and these deserve consideration both in themselves and as illustrations of the views of Sector staff.

The object of the draft discussion paper was "to report the achievements of DOC's Research Sector with a view to proposing a 5-year restructuring plan for an increase in activity designed to deal in a more adequate way with a phenomenon which more than anything else will irrevocably change the lifestyles of Canadians during the last part of this century, the information revolution."[3] A large proportion of the paper was devoted to a description of those achievements.[4]

However, the paper noted: "The above successes have not been achieved without severe strain on the Research Sector."[5] In particular, according to the discussion paper, they meant "a much reduced research base",[6] with 70 per cent of the Sector's budget devoted to the developmental end of the R&D spectrum and a significant (40 per cent) decline in its base budget and the corresponding "dominance of sunset activities."[7]

In the view of the Sector, the dominance of applications-oriented sunset programs had a number of negative consequences for the Sector. First, because of their temporary nature, the positions required to support them were also temporary, making it more difficult for the Sector to recruit top-notch professionals.[8] Second, in order to carry out such programs -- usually on behalf on other DOC sectors or other federal Departments -- the Sector had to assign "research scientists to engineering, promotional and managerial duties.... These people over the years are lost to research because they lose touch with their former field of expertise, and it is too costly to retrain them as scientists."[9] As a result, "The part of the research base which has disappeared in favour of applications development

1 Loc. cit.

2 Research Sector, DOC Research Sector: Budget Augmentation 5-Year Plan (Unpublished Draft Discussion Paper, circa 1982-83).

3 Ibid., p. 1.

4 Ibid., pp. 5-11.

5 Ibid., p. 12.

6 Loc. cit.

7 Loc. cit.

8 Loc. cit.

9 Loc. cit.

must be replaced on an urgent basis if more applications are to be realized in the future."[1]

After looking at the difficulties within the Research Sector, the discussion paper looked at the growing significance of the technological revolution in communications and underscored the importance of R & D in Canada. Then the paper looked at the Canadian situation: "There is, however, relatively speaking, little research and development in these fields in Canada. A number of private companies carry out research aimed largely at product development in these fields, with Bell Northern Research, the giant of the league. The Communications Research Centre of DOC is the largest government establishment in this field, while there is no provincially funded communications research lab apart from a number of small groups based in Universities."[2]

It was this analysis which lay the basis for the definition of a new role for the Sector: "Under such circumstances, **the DOC Research Sector is in a unique position to act as a catalyst and leader of the national efforts in the communications and information research disciplines.** In a few areas, such as videotext, the research sector has essentially assumed this role. There are, however, several important technologies that are vital to the fields of communications and information in which the government research efforts are weak or non-existent. If DOC is to be a broad leader in this area, its research in many areas must be broadened and strengthened; otherwise, it will be impossible to take a broad and balanced approach to developments within the information revolution."[3]

Beyond providing a fairly detailed description of new research programs, the discussion paper defined two main priorities for the Sector: technology development, and technology assessment and application development.

In the view of the drafters of the discussion paper, "Technology development is achieved by means of a multi-stage process starting from basic research, leading to applied research, experimental development and, ultimately, the development of a prototype which may be transferred to industry for commercialization. For that purpose the Research Sector proposes to set up the equivalent of a communication and information 'technology production factory'."[4]

The paper saw an increased emphasis on fundamental research as vital to such an undertaking: "The success of a technology development program is directly proportional to the quantity and quality of fundamental research performed in the laboratory promoting such a program. Fundamental research performed at the CRC in the 1950s and 1960s has made possible the very successful satellite, radio technology, fibre optics and videotex applications of the late 1970s and early 1980s. Fundamental research

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1 Ibid., p. 13.

2 Ibid., p. 14.

3 Loc. cit.

4 Ibid., p. 21.

resources of the Research Sector have been seriously depleted in the process. If other successful applications are to be realized between now and the end of the century, it is of crucial importance that the research base of the CRC be replenished. The economic well being of Canada depends on it. About 15% of the new resources requested in this proposal are therefore to be applied to fundamental research."[1]

The paper viewed the Sector's second basic priority -- technology assessment and application development -- as "a vitally important extension of the R & D process. It is only with implementation of an on-going coherent technology assessment and application development activity that the fruits of research and development activity can be fully reaped. A permanent Information Technology Assessment and Application Development activity program is proposed to bring promising state-of-the-art information technologies out of R & D laboratories to realize their maximum potential benefits. Within the context of this activity the formulation and implementation of joint cooperative projects with the private sector and other levels of government is envisaged to achieve its goals and objectives."[2]

These goals and objectives were to have been:

". To assess state-of-the art technologies potentially useful for the improvement of informatics products, systems, services and networks;"

". To plan, design and implement programs to foster the applications of promising information technologies and services and the development of indigenous Canadian industrial capabilities for the creation of employment and export markets;

". To assess the impacts and potentials of informatics in terms of competitiveness and productivity improvements in industry, effective and efficient information access by the public, and improvement of the quality of economic and cultural life for the users;

". To develop and implement strategies to rectify regional information disparities."[3]

Flowing from these priorities was a large number of research thrusts which, taken together, would have meant that the Sector's budget would have risen by a multiple of its present level.[4]

Before the necessary hard decisions could be made, the project was overtaken by events. The decision to establish the Workplace Automation Research Centre added a significant new dimension to the Sector while at the

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1 Loc. cit.

2 Loc. cit.

3 Ibid., pp. 21, 22.

4 Interviews with Research Sector personnel, Summer 1984.

same time raising doubts about the Sector's chances of tapping funds for other research programs. The reorganization of the Department significantly changed the scope of Sector activities by adding space R & D to its mandate while at the same time spinning off to the new Technology and Industry Sector its technology promotion and applications programs in the Telidon and office communications area. Finally, the government decided to explore the CCIS notion, which transformed the planning equation for the Sector.

These events effectively ended efforts to develop a five-year plan and, needless to say, did not contribute to Sector morale.[1] **The resulting uncertainty has also seriously hindered the capacity of the Sector to undertake long-term strategic planning in the last few years.**

3.5.2 The establishment of CWARC

Establishment of the Canadian Workplace Automation Research Centre (WARC), also called the Jeanne Sauvé Institute, was announced in 1983 and staffing has begun. There were significant differences between the concept for the centre and the Sector's five-year plan, though of course the documentation for the latter was still in preliminary draft form.

In developing the concept for the Centre, much more careful and explicit attention was paid to ensuring formal and effective relationships with the rest of DOC and with other federal departments. The plans for the Centre call for and define close linkages with other Research Sector branches and other DOC sectors -- specifically, Technology and Industry (with special emphasis on GTA), Spectrum Management, Policy and Arts and Culture -- as well as other federal departments.

The consultative approach employed in developing the plans for the Centre reached far outside DOC -- again in contrast to that involved in developing the five-year plan, which could be characterized as an elaborate exercise in internal participatory democracy. For example, in developing its operating philosophy and program of research in workplace automation -- perhaps the most promising application for information technology -- extensive consultations were carried out with industry to give the new lab a clear strategic focus which would be relevant to industry.

The industry discussions led to agreement concerning the operational philosophy of the Centre. In particular it was emphasized that the product development cycle and time horizons of industry, particularly smaller companies, are very short. However, the market advantage is determined by the ability to develop a competitive edge in the application of new technologies. Consequently, if Canadian industry is to take advantage of the research at the Centre to improve its competitive posture, the Centre must:

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1 Loc. cit.

"i) be at the leading edge of science and technology - well ahead of industry -- so that industry can obtain expert guidance and leadership from it;

"ii) establish mechanisms for continuous and efficient transfer of research results to industry....;

"iii) be an integrator and focussing mechanism for a variety of technologies and sciences, many of which will also be the subjects of research in the other branches of the Research Sector;

"iv) be the focal point for dissemination of information and exchange of personnel both on a national and an international basis. This includes the setting up of a national information gathering and dissemination network as well as interdepartmental consultation.

The definition of the role of the Centre was also similar in its outward orientation to that found in the five-year plan. Considering that the rapid development of the field, given recent technological advances, is placing Canadian industry in a precarious situation, and is creating the prospect of trade deficits of alarming proportions even if there is a strong Canadian presence in the Sector ($2,097,000,000 in total shipments for 1982), the role of the Centre was defined as being primarily to carry out and focus the Canadian research and development efforts in this critical area.

The Work Place Automation Research Centre in Montreal, will be the largest laboratory in Canada devoted exclusively to research and development in all aspects of office automation. As such, it will play a critical role in spearheading the Canadian research effort. In fulfilling its role, the Centre will work closely with other branches of the Department, private industry, and the Canadian scientific community, in building a strong base of competence and expertise in Canada.

The plans for the Centre also tended to go further than the five-year plan in defining links with industry and the university community, though of course this difference may also arise from the fact that the five-year plan was incomplete when the exercise came to an end. The Centre's plans call for a decisive planning role for a representative advisory board[1] and an ultimate goal of drawing up to 50 per cent of scientific staff from industry and universities.

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1 Jacques Lyrette, "Groupe de travail sur les politiques et les programmes fédéraux de développement technologiques," Memorandum to B. C. Blevis, October 3, 1984.

3.5.3 The CCIS study

A concern about the strategic focus of the Research Sector and its relevance to industry, as well as a recognition of the budgetary and administrative constraints upon R & D inside government lay at the heart of the decision by the former Assistant Deputy Minister for Research to ask the Department to explore the viability of setting up a not-for-profit R & D corporation sponsored jointly by government and industry and utilizing the CRC as its nucleus.[1]

A consortium of consultants, led by Price Waterhouse, was hired by the Department to assess the viability of the proposed Canadian Communications, Informatics and Space R & D centre (CCIS).

In the course of the study, the consultants interviewed 52 industry spokesmen, though only seven professed in-depth knowledge of the CRC as a whole. Of the 40 who expressed opinions on the CRC, the vast majority had praise for the expertise and past achievements of particular CRC individuals and units. However, only six expressed a positive view of the CRC as a whole.[2] According to the consultants, "with regard to current research activities, private sector interviewees felt they had little input to priorities and little knowledge of current programs and results. There is concern about the aging of key personnel, the continuation of lines of research whose relevance has diminished, a lack of results orientation and management discipline, the absence of a sense of strategic direction or purpose, and rigidities due to public service personnel and budgetary practices."[3]

The consultants, while acknowledging the validity in principle of a CCIS, concluded that it could not be achieved at the present time because it:

- lacked the support, either financial or moral, of industry;

- put continuing funding by government at some risk;

- would involve serious problems of implementation; and

- did not respond effectively to widely varying needs in different fields.[4]

Price Waterhouse suggested a number of alternatives to CCIS for consideration, and these, though based on outside perceptions rather than analysis of the research program, raise fundamental questions about the future role of the Research Sector. These included:

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1 Interview with Research Sector personnel, Summer 1984.

2 Price Waterhouse Associates, CCIS Feasibility Study: Interim (Phase 1) Report (Unpublished study submitted to the Department of Communications in June 1984), p. 4.

3 Ibid., p. 5.

4 Ibid., p. 11.

- the establishment of an informatics institute or agency, possibly on the CCIS model and with WARC at its nucleus,[1]

- the removal of space R & D and the David Florida Laboratory to a new national space organization which would either be a separate body or part of NRC,[2]

- the return to DND of the research program conducted on behalf of DND,[3] and

- the conduct of a strategic review of R & D the Sector conducts on behalf of government.[4]

It was the results of the CCIS study which more than anything else prompted the present review of the Research Sector.

3.5.4 The impact of recent developments

These recent developments have had important consequences for the Research Sector. Certainly, they have affected the morale of its personnel; indeed, concern about morale has been expressed in virtually every interview we conducted with Research Sector managers. In addition, since the end of the five-year plan exercise and as a result of the CCIS study and now our own review, the uncertainty about the future of the sector has been so great that there has virtually been no strategic planning going on within the Research Sector outside of that directly related to WARC.

The lack of such activity is serious, given that, at no time since the establishment of the Department, have such pressing questions been raised from so many sources about the role of the Research Sector -- its responsibilities with respect to fundamental research and its over-all role in relation to industry and government.

It should be noted, however, that the DOC research program is not exceptional in this respect. The Wright Task Force, the recent report of the Standing Senate Committee on National Finance and the report of the U.S. Federal Laboratory Review Panel have asked similar questions about all federal government labs in Canada and the United States, and now a similar review of government labs is under way in Australia.

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[1] Ibid., pp. 12-18.

[2] Ibid., pp. 20, 21.

[3] Ibid., pp. 22-24.

[4] Ibid., pp. 18-20.

3.6 PERSPECTIVES ON THE LAST 15 YEARS

There are certain constants in this summary history of the research program since its transfer from DND in 1969. These are:

- DND's continuing desire to repatriate the program;
- in the absence of any over-all view of the role of research within DOC, a pattern of incremental shifts in the balance between fundamental research, applied research and development work; and
- a growing anxiety within the Sector about its declining capability to carry out fundamental research;
- a continuing concern about the role of the Sector and over-all research priorities in the context of:
  - the link between the research program and the rest of DOC, and
  - links with industry.

While the research program has had a number of significant achievements over the past 15 years, these concerns represent fundamental issues to be addressed in the context of the Research Sector review. However, it is necessary to keep them in perspective. First of all, they are not unique to the DOC Research Sector; as the Wright Task Force, the U.S. Federal Laboratory Review Panel and other reports have indicated, all government labs -- and even many industrial labs -- face the same issues. Second, they are not new; these issues have been with us for 15 years, as has been the case with most other research establishments, both in government and the private sector.

In a very real sense, these issues represent concerns which every generation must address in its own way and in the context of the realities which face it. If there is a difference in the present situation, it lies in the importance which the resolution of these issues has acquired because of the potentially transformative impact of the new information technology on national economies around the world. In a very real sense, it was this sense of urgency which gave the impetus to the Wright Task Force and the flood of recent reports on this subject.

CONTENTS OF CHAPTER 4.0

Chapter 4.0

STRATEGIC ASSESSMENT OF R & D AT DOC

The purpose of this chapter is to provide a strategic assessment of R&D at DOC in light of the theoretical principles defined in Chapter 2.0. The discussion will range from an examination of the Department's managerial practices in the R&D area to an analysis of the role of the R&D program in relation to its government clients, industry R & D establishments and universities.

In the previous chapter, we saw how research at DOC has evolved over the past 16 years. Before commencing our strategic assessment, it will be useful to understand just what the Department's R & D program looks like now. It should be noted that three Sectors of the Department now operate technical establishments, though the largest and only ones with a clear research orientation are, of course, now in the Research Sector.

4.0.1 Research Sector

As Figure 4-1 illustrates, the Research Sector's R & D effort is now organized into four subject areas:

- space technology and applications,
- radar and communications technology,
- information technology and systems R & D, and
- workplace automation.

A branch, headed by a director-general, corresponds to each of these subject areas.

However, it is important to understand that the actual R & D work of the Sector is carried out in two laboratory complexes -- the Communications Research Centre (CRC) at Shirley's Bay, and the Workplace Automation Research Centre (WARC) in Laval, Québec.

The Communications Research Centre provides the home and facilities for three branches of the Sector.

The Space Technology and Applications Branch at CRC represents the R & D component of the old Space Sector; the rest of it, which focuses more on industry development, technology promotion and marketing, is now part of DOC's Technology and Industry Sector. As a result, the relationship between the Research and Technology and Industry Sectors in the space area is intimate and sometimes difficult. The Branch is also the centre of expertise within the federal government on space technology and the design and implementation of spacecraft systems.

The **Radar and Communications Technology Branch** at CRC has been least affected by the shifts in emphasis within the Research Sector and departmental reorganizations. As well as carrying out innovative work in the areas of fibre-optics and optoelectronics, it carries out work in the areas of radio communications and radio propagation. Through research in these areas and most importantly on radar, the Branch provides one of the Sector's most significant interfaces with the Department of National Defence.

With the winding down of Telidon and the transfer of responsibility for Telidon promotion and marketing, as well as the Office Communications Systems Program, to the Technology and Industry Sector, the **Information Technology and Systems Branch** at CRC has tended to move somewhat back from the developmental end of the spectrum and focus more on applied research on the software and human factors related to new communications technology, as well as standards issues. In fact, the branch is the principal source of the technical personnel who are central to DOC's participation in international negotiations on standards in the informatics area.

The new Canadian Workplace Automation Research Centre in Laval, deals with many areas which are relevant to the work of the Information Systems and Technology Branch, but focusses on applications of new information technologies in the workplace.

All four directors-general report directly to the Assistant Deputy Minister (Research), as does a Director General for Research Policy and Programs.

4.0.2 Involvement of other Sectors

Both the Technology and Industry Sector and the Spectrum Management Sector operate technical establishments.

The Technology and Industry Sector is responsible for the David Florida Laboratory. Located on the CRC site at Shirleys Bay, the lab is a national facility for the environmental testing and integration of spacecraft and spacecraft components, primarily for Canadian aerospace companies.[1] The Sector also operates a Prime Contractor Support Program, an MSAT program, an LSAT program, a Telidon Exploitation Program, an Office Communications Systems Program -- all of which have an R&D component which is provided by the Research Sector.

The Spectrum Management Sector also operates a lab which develops test methodology and specifications for radio systems, calibrates and repairs equipment used in spectrum management, certifies radio equipment upon request, and carries out an ionospheric sounding program, mostly for the Department of National Defence.

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1 As a result of the May 1985 Budget, the David Florida Laboratory will be moving to full cost recovery.

The focus of this chapter will be upon the activities and programs of the Research Sector for the most part, but their relationship to the technical activities of other sectors will also be investigated.

4.1 R & D IS A UNIQUE ENDEAVOUR REQUIRING UNIQUE MANAGERIAL PRACTICES

Effective R & D demands creativity, intellectual agility, a willingness to take risks and work which proceeds over relatively long time-frames. As a consequence, effective R & D management must involve both firm accountability and sufficient flexibility to encourage intelligent risk-taking, personal initiative and high morale among staff.

The DOC research program presents a very mixed picture with respect to flexibility and accountability. There are important factors favouring a flexible approach to R & D management at DOC, but these are often outweighed by bureaucratic rigidities intended to assure accountability.

4.1.1 Indications and sources of flexibility

According to the paradigm suggested in Chapter 2, flexible management of R & D is strongly associated with intelligent risk-taking, personal initiative and high morale among staff -- all factors associated with effective R & D.

There are some indications that, at least to some degree, such a climate does exist within the DOC research program. For example, the Sector may well be more willing to take intelligent risks than many other government labs.

This is an important finding, given that the Wright Task Force saw risk-averse behaviour as one of the key weaknesses of all federal technology development programs, including government labs. However, the task force pointed to a DOC project -- along with a few from other departments -- as exemplifying a willingness to take risks: "...SED Systems Inc. received a number of government R & D contracts during its start-up and it now employs more than 300 people. For the government departments involved, backing these firms with purchase orders was a risky thing to do. The technology-development programs they sponsored might not have resulted in useful products. The public servants responsible for procurement might have been accused of 'wasting' government funds. But the result was the establishment of a significant Canadian presence in several high technology areas, and the creation of hundreds of new jobs in the private sector."[1]

In the late 1960s and early 1970s, the early -- and thus risky -- development of a government-industry program in the fibre-optics area by the CRC helped lay the foundations for Canadian industrial involvement in this technological area in the late 1970s and early 1980s.

It can be argued that the origin of the Telidon program lay in the willingness of senior management in 1977 to allow researchers (who grumbled,

[1] Wright Task Force, *op. cit.*, p. 14.

after demonstrating the Prestel system, that they could do it better) to develop and demonstrate an improved videotex system.[1]

Present projects in the areas of integrated optics, gallium arsenide and SHARP (Stationary High Altitute Relay Platform) would seem to indicate a continuing willingness on the part of the Research Sector to take intelligent risks on the exploration of relatively new and unproven technologies.

Managerial flexibility is, of course, not the only factor which explains this willingness to take risks; other factors will be considered in the following sections of this chapter. However, our interviews with Research Sector personnel would seem to indicate that there is a willingness on the part of most Research Sector managers to give researchers, in the context of over-all departmental and research priorities, considerable latitude in the definition and development of projects.[2]

Indeed, we were informed that technical projects usually originate at the working level when they are not in response to an external request. In the view of one CRC director, this situation arose because "The highest level of management which can knowledgeably propose or assess project details is the director -- more senior levels must concentrate on general overview or broad policy."[3] In many ways, this position makes sense, given the degree of specialization and the rapid evolution of knowledge in virtually every technological area which the Sector addresses. It would be difficult for a senior manager both to manage and to keep up with the latest developments.

The managerial flexibility within the Research Sector is strongly suported by a corporate culture which is quite unlike that in other DOC sectors. This culture emphasizes collegiality and informality in decision-making to a very high degree and tends to value scientific achievement and transfers of elegant technology to industry.

There is also a sustaining belief that the Sector is a major centre of expertise in the communications area within Canada and that it has a history and tradition of world-class achievement. There is a sense that because of this expertise and history of achievement the Sector tends to grasp better than most of industry and the rest of DOC the way the technology should evolve in light of Canadian interests. There is some impatience with industry short-sightedness and lack of appreciation of the importance of R & D to future growth. There is also an impatience with bureaucratic constraints and a strong desire to get on with the job.[4]

Managerial flexibility and the decentralization of authority within the Sector, combined with a corporate culture which emphasizes informality, collegiality and a sense of the value and importance of the work it performs, clearly contribute to a willingness to take risks and the effectiveness of the R & D performed by the Sector. However, it should be emphasized that all

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1 Madden, Videotex, pp. 20, 21.

2 Interviews with Research Sector Personnel, Winter 1984.

3 Loc. cit.

4 Loc. cit.

of these qualities exist to a large degree despite -- rather than because of -- the bureaucratic context in which the Sector operates.

4.1.2 Bureaucratic constraints and the illusion of accountability

The interaction between the informal, collegial culture of the Sector and the formal administrative, financial and planning machinery of a government department has in fact occasioned certain problems. Indeed, in many ways, this interaction fits the Packard model of the clash between "micro-management" and the flexible management required for effective R & D.

A Sector like the others: From both a financial and administrative viewpoint, the Research Sector is treated essentially like the other sectors in the Department of Communications. In other words, from a financial and administrative viewpoint there is very little recognition in the Department's formal financial and administrative arrangements that R & D is a unique endeavour.

As the Packard Panel pointed out[1], these arrangements can cause severe problems for a government lab:

- The Panel emphasized that, given the unpredictability of the R & D endeavour, R & D managers should have as much flexibility as possible in managing their resources. The Panel recommended in particular that managers be given a budget and then be permitted to determine how they divide these resources among salaries, capital expenditures, goods and services, etc.[2] Under present Treasury Board rules, Research Sector managers are generally locked into rigid person/year allocations, goods and services budgets, capital expenditure allocations, etc. For the most part, they must receive Treasury Board approval for any significant change in any of these allotments, as well as approval from DGPA, ADMFM, the Senior Management Committee and the Minister for seeking such a change. Within this context, managers can seek approval for moving resources between salaries and other kinds of expenditures, though this will involve considerable paper-work and might involve releasing personnel. The system in other words does not really acknowledge the need for flexibility on the part of R & D managers.

- In recognition of the unpredictability of R & D and the need to eliminate wasteful spending at the end of the fiscal year, the Packard panel[3] and the Wright Task Force[4] recommended that government laboratories be allowed to carry forward remaining funds into the next fiscal year. At DOC, the carrying forward of lapsing funds into the next fiscal year requires a Treasury Board submission, and Treasury Board is increasingly unwilling to approve such submissions.

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1 Federal Laboratory Review Panel, op. cit., p. 9.

2 Ibid., p. 7.

3 Ibid., p. 8.

4 Wright Task Force, op. cit., p. 32.

- Given the fundamental importance of high quality, motivated personnel to the R & D endeavour and the difficulty in attracting and retaining such people in government labs because of Civil Service personnel systems, the Packard Panel recommended that government labs be permitted to have their own scientific/technical personnel systems.[1] All personnel matters associated with the Research Sector are now handled through DGPA and are subject to the rules of the Public Service Commission and Treasury Board. Because of the nature of these rules and the delays and paper-work associated with creating, classifying and filling positions, DOC's Research Sector is often unable to respond quickly when a quality person becomes available in the very competitive high-technology labour market. The same problems arise with respect to retaining them by offering promotions. Research and development work is very much a young person's game, and the rigidity of government personnel systems -- as well as the present economic situation and the national shortage of highly qualified personnel[2] -- may well explain why the age of Research Sector scientists is significantly older on average than in major laboratories in the private sector.[3] It may well be that this situation reflects a deterioration within the Research Sector of the human resources which are at the heart of a successful R & D endeavour.

- Equally important, effective R & D often demands a fairly fluid and unencumbered movement of personnel between directorates and divisions according to the dictates of different projects. Because of the rigidity of Public Service Commission classifications, such movement is inhibited and can sometimes mean that Research Sector personnel are penalized for their usefulness. In addition, according to Research Sector personnel, public service classifications provide insufficient incentives and rewards for the activities associated with technology transfer, as opposed to scientific publication.[4]

- Partly because of Treasury Board restrictions and partly because of Departmental procedures which do not make special provision for the special needs of an R & D group, approval for travel to scientific conferences -- especially outside the country -- by Research Sector personnel is much more difficult than in many other research environments, perhaps even the National Research Council,[5] which are subject to the same Treasury Board restrictions. As a result, Research Sector personnel say they are handicapped in their ability

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1 Federal Laboratory Review Panel, <u>op. cit.</u>, p. 7.

2 CCG, <u>Research: Strategic Situation</u>, p. 35.

3 Price Waterhouse, <u>CCIS Feasibility Study</u>, Appendix D.

4 Interviews with Research Sector Personnel, Summer 1984.

5 Though we have not made an explicit comparison of travel procedures at the NRC and the Department, an interview in Summer 1984 with B.D. Leddy, Vice President for Administrative and Personnel Affairs at NRC, indicated that travel approval procedures are significantly more streamlined at the NRC.

to publish -- an important criterion for advancement in scientific and technical categories. More important, they say they are also severely limited in their access to developments elsewhere or to discuss concepts with others working at the state of the art, given that there is usually about a two-year delay between presentation of a paper at a conference and its publication in article or book form.[1]

- There is an increasing incidence of "micro-management" in the relationship between the sector and some of its major government clients, both outside and inside DOC. For example according to Research Sector personnel, there is a trend in the DND relationship towards the funding of ever shorter projects for ever shorter periods of time. Similarly, according to Research Sector personnel, the same also happens in the projects it is involved in with the Technology and Industry Sector -- especially in the space area. In these projects, the Technology and Industry Sector not only sets the policy and program direction, but also often manages technical projects, doling out money to the Research Sector for research and technical services in small amounts to cover short periods of time.[2]

The basic purpose of these bureaucratic restraints is in many ways to enhance the accountability of the Research Sector to its clients, the Department, the Minister, the government as a whole and Parliament. They do succeed in part in that there would seem to be real accountability in narrow financial and administrative terms with respect to specific projects. However, as Packard discovered in the case of detailed reporting and other requirements for federal laboratories in the U.S.,[3] these mechanisms do not guarantee accountability -- or even much understanding -- with respect to the over-all direction of the research. Interviews with senior managers in other DOC sectors revealed little understanding of the thrust and significance of the over-all research research program.[4] The Price Waterhouse study on the viability of CCIS revealed that industry also had little grasp of these matters.[5]

There are also costs associated with achieving this narrow financial and administrative accountability. There are indications that the ultimate impact of this micro-management is to contribute to a dispersal of the Research Sector's limited resources over a large number of small projects and perhaps to a loss of critical mass in key areas. This tendency has been

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1 Interviews with Research Sector Personnel, Summer and Fall 1984.

2 <u>Loc. cit.</u>

3 Federal Laboratory Review Panel, <u>op. cit.</u>, p. 4.

4 Interviews with DOC Managers, Summer, Fall and Winter 1984.

5 Price Waterhouse, <u>op. cit.</u>, p. 4.

accentuated by the informal and collegial decision-making processes of the sector. For example, informal interaction with other DOC sectors, other federal departments and industry would seem to have resulted in the piece-meal proliferation of small projects, developed in response to specific client demands,[1] rather than in response to those demands within the context of some over-all scientific plan informed by an over-all and strategic sense of government and client needs.[2]

There are other costs too arising from the present arrangements. As already noted, existing mechanisms seriously limit the flexibility which is so central to the R & D enterprise -- especially flexibility with respect to staffing and resource allocation, as well as the capability of the Sector to remain abreast of new technological developments and to respond innovatively to changing technical requirements. In the view of Research Sector managers, these rigidities have in turn impaired the Sector's productivity.[3] Given that flexibility may well be the defining characteristic of responsible R & D management and that clear-cut responsibility for a program is the necessary prerequisite for full accountability, it may well be that micro-management has in fact diminished the over-all accountability of the Research Sector.

No one can question the need for mechanisms to assure financial and administrative accountability. But, in the case of the Research Sector, the number and range of such mechanisms severely limits the managerial flexibility which is so central to the responsible and effective conduct of R & D. This situation raises a fundamental question. To what degree can effective, results and client-oriented R & D be carried out within a government department? Would some form of quasi-independent status or varying degrees of privatization provide a more conducive environment for an effective R & D program? Some possible answers to these questions are discussed in Chapter 5.0.

Administrative and technical services: The major Research Sector laboratory complex is, of course, the Communications Research Centre located at Shirley's Bay. At present, on-site technical and administrative services are provided by DGPA. A somewhat different arrangement is employed at the Laval laboratory.

The original rationale for having DGPA provide these services at CRC was that there was more than one sector using the site -- the Research Sector and the former Space Sector, as well as the Defence Research Establishment there. In such circumstances, it seemed to make sense that these essential support services be provided by DGPA -- a group which was not associated with either Sector and provided common services to the entire Department. In addition, it was felt that such an arrangement would remove the burden of

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1 Interviews with Research Sector personnel, Summer and Fall 1984.

2 The need for the Research Sector to develop such a strategic vision, and its failure to do so, are discussed in the final section of this chapter.

3 Interviews with Research Sector personnel, Summer and Fall 1984.

administering and delivering such services from organizations whose main purpose was the conduct of R & D.[1]

These support services fall into three major categories:

- **technical services**: including engineering and scientific services (a model shop for prototype devices), scientific imagery (photographic services), graphic arts, scientific design services and instrumentation services;

- **site services**: including model shop services, site development planning, capital works services and heating services; and

- **other support services**: including library services, materiel management services, facilities services (accommodation, telecommunications facilities, etc.), personnel services (including official languages), mail room and records management services, and security services.

Because of the departmental reorganization two years ago, the Research Sector would appear to have become the largest user of these services. The R&D functions of the old Space sector have returned to the Research Sector; only the David Florida Laboratory and a number of small applications programs at CRC come under another sector, the Technology and Industry Sector. In terms of budget and person/years, the Research Sector would appear in 1984-85 to have called on well over three-quarters of the resources in the technical services area. In terms of site services, the figure would appear to have been around 80 per cent; and for other support services, probably around 90 per cent. The other major user, identified in DGPA documentation, is the David Florida Laboratory.[2]

These figures are only approximate, of course, and use of these services by the small Technology and Industry Sector applications contingent at CRC are included in the CRC figures. The figures also do not include use by other Sectors of these services. For example, DGIS makes use of the photographic services of the scientific imagery unit. However, according to DGPA personnel, use made of these services by Headquarters is in fact negligible compared to CRC and the David Florida Laboratory. The Defence Research Establishment at Shirley's Bay also makes use of these services, especially the site services.

The relatively preponderant use of these services by the Research Sector is one of a number of considerations raising the question as to whether a common services group such as DGPA should provide these services. It may in fact be preferable to have the research program itself manage many of these services and reach formal agreements with the Technology and Industry Sector and other users of the services.

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1 Interview with Personnel and Administration Sector Managers, January 1985.

2 DGPA, "Split of CATS between ADMR and ADMTI," (1984-85), p. 5.

Certainly, many of these services are very specialized and integral to the R & D function. The technical services clearly fall into this category, as may some of the site services. Indeed, before 1976, the Assistant Deputy Minister for Research was reponsible for the provision of all site services, including those provided to the Defence Research Establishment at Shirley's Bay. Library and materiel management services also can also become highly specialized activities when intended to serve an R & D group, as may security services, given the work the research program carries out for the Department of National Defence.

Research Sector interviewees tended to complain about the amount of paper-work required to make use of these services, as well as the size of the DGPA contingent at CRC (roughly 150 persons, which approaches in size that of the Research Sector's professional staff at CRC). They questioned whether the allocation of resources between R & D functions and administrative and technical functions was justifiable.[1]

The key consideration, however, is whether this arrangement contributes to the effectiveness of the R & D function at DOC. In our view, though it does guarantee that these services are provided in a fashion which is scrupulous in administrative and Treasury Board terms, it places significant contraints upon the effective performance of R & D.

For example, the potential for "micro-management" is enormous when an organization such as DGPA is providing technical and other services which are integral to the performance of the R & D function.

More important, given that R & D is unpredictable and yet must be conducted in light of a long-term perspective, rational long-term planning of R & D is both essential and very difficult. Such planning must be able to take into account not just the direction of the R & D and the capabilities of researchers, but also the changing needs for technical and other services integral to the R & D function. This task is significantly complicated when R&D managers must win approval for such plans from another responsibility centre whose scope of concern is primarily administrative.

Finally, given the unpredictable and changing requirements of the R&D endeavour, it may be necessary to shift the allocation of resources between programs or professional salaries and the technical and other services which are integral to the R & D function. Such decisions are significantly more difficult when the R & D program and the technical and other services supporting it report to different responsibility centres.

Certainly, these arguments are consistent with the views of the Wright Task Force[2] and the U.S. Federal Laboratory Review Panel,[3] both of which argued that, within the appropriate accountability framework, R & D managers should be given as much authority as possible to carry out their responsibilities. For example, at most federal agricultural and defence laboratory centres -- with the possible exception of those located at

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1 Interviews with Research Sector personnel, Summer and Fall 1984.

2 Wright Task Force, op. cit., p. 32.

3 Federal Laboratory Review Panel, op. cit., pp. 9, 10.

Shirley's Bay -- virtually all services on site are the responsibility of the centre manager.

For all these reasons, we would argue that, whatever organizational option set out in Chapter 5.0 is chosen as a framework for the research program, those responsible for the research program should be given responsibilility for the provision of some of these essential services now provided on site by DGPA. The exact mix of services to be transferred will, of course, depend on the organizational option selected. Clearly, the case is strongest with respect to the technical services. The case is less clear-cut with respect to a number of site services and other support services. However, one central principle should shape decisions on these services: the more integral a service is to the conduct of an effective R & D program, the stronger the case for its transfer.

4.1.3 Conclusion

Flexible management and long-term planning are vital to an activity as unpredictable and long-term in impact as R & D. The corporate culture of the Research Sector and its managerial style reflects a desire for increased flexibility, but existing bureaucratic constraints -- which in many instances amount to what the Packard and Wright reports would describe as "micro-management" -- have built significant rigidities into the operation of the Sector. These must be reduced if the effectiveness of the research program is to be enhanced, and Chapter 5 enunciates a number of organizational options for the research program, with this objective in view..

DGPA's responsibility for the provision to the Sector of technical and other support services also limit the flexibility of the Sector's management, as well as its capability for long-term planning. Responsibility for many of these services should be shifted to the management of the research program.

In our view, judicious implementation of these changes will in no way reduce the accountability of the research program. In a very real sense, the excessive and narrow financial and administrative accountability which now exists has not contributed to a more meaningful accountability based on an understanding of the over-all thrust and direction of the research program. Indeed, in our view, clear-cut responsibility for the tools needed to carry out a program is a necessary precondition of such accountability. It is, however, only a precondition, and the accountability question is crucial. Subsequent sections of this chapter will address the issue from a number of perspectives, and the question will be central to the discussion of organizational options in Chapter 5.0.

4.2 OPTIMAL UNIVERSITY LINKS REQUIRE COMMITMENT TO FUNDAMENTAL RESEARCH

Close links between universities and government-sponsored research programs are central to the effective husbanding of a country's research resources, especially in a relatively small country such as Canada. For such links to be optimized, government sponsored research programs must have some commitment to fundamental research and such a program should be developed and up-dated in conjunction with universities. Such an approach would have important benefits for both government sponsored R & D and the universities.

As noted in Chapter 2.0, the literature is virtually unanimous on the importance of government labs having close links with both university researchers and industry. These are regarded as vital to ensuring a coherent and co-ordinated national research program, a necessity for most countries -- especially relatively small countries -- in an era of growing international competition which is increasingly driven by technological change.

4.2.1 Fundamental research and the Research Sector

As noted in Chapter 2.0, fundamental research represents the first stage of the R & D cycle. It focuses on searching for and understanding the causal mechanisms or linkages involved in phenomena or events. It is the basic knowledge gained through fundamental research which provides the foundation, though in ways which are often unanticipated, for more applied research and development work. It is universities, of course, which devote by far the largest proportion of their R & D resources to fundamental research, and indeed the conduct of such research and education can be said to represent their two most important functions. It follows that, to the degree a government lab is involved in fundamental research, its links with the universities will be strengthened.

As noted in Chapter 3.0, the organizational unit which now constitutes the Research Sector committed from 15 to 20 per cent of its resources to fundamental research before 1969 when it was part of the Department of National Defence. In the early 1970s, after the move to the Department of Communications, the resources allocated to fundamental research declined sharply -- until, by 1975/76, less than one per cent of the total R & D effort was estimated to be fundamental research.[1] In the view of Research Sector managers,[2] they still do only a negligible amount of fundamental research,[3] even though the R & D activities of the Sector have shifted back somewhat from the developmental end of the spectrum which absorbed considerable resources during the late 1970s.[4]

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1 Research Sector, Budget Augmentation Five-Year Plan, p. 2.

2 Interviews with Research Sector Personnel, Summer and Fall 1984.

3 Loc. cit.

4 Loc. cit.

The bulk of the work now carried out by the Sector is characterized by its senior managers as applied research, which in their view is an intermediate stage between basic or fundamental research and development work.[1]

In the five-year plan prepared by the Research Sector, the argument was made that the earlier commitment to fundamental research had lain the basis for many of the significant achievements of CRC in the areas of space and informatics which were subsequently transferred to industry. The concern was then expressed that the present negligible commitment to fundamental research might reduce the future level of innovation.[2]

It can be argued, of course, that government labs should look to university researchers for the fundamental research which must lie at the basis of the more applied work of government labs. This argument assumes a solid, working relationship with university researchers and thus raises another question. Does the absence of a commitment to fundamental research by the Research Sector significantly constrain its ability to have an optimal relationship with university researchers working in related areas?

4.2.2 Present links with universities

As already noted, there is a small but growing trend towards more applied work in Canadian universities. One might hypothesize, therefore, that the predominantly applied concerns of the Research Sector would not be an obstacle to effective links with the university research community. Indeed, one might argue that interaction between the Sector and the university research community would present a very useful means of persuading the latter, as well as students, to conduct more applied research and therefore of playing a more central role in the entire Canadian research effort.

At present, roughly eight per cent of the Sector's entire resources are spent in one or another form of interaction with the university research community.[3] This interaction occurs through two specific university research programs, university contracts by the different branches of the Sector, a small contributions program in support of symposia at universities, a range of formal and informal contacts, and the special arrangements governing the Laval laboratory.

<u>University research programs</u>: The Sector administers a university research and a centre of excellence program intended to build up expertise in Canadian universities in the areas of interest to the Department. Under these programs, the Department dispenses $1,150,000 a year in university contracts.

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1 Interviews with Research Sector Managers, Fall-Winter 1984.

2 <u>Budget Augmentation 5-Year Plan</u>, pp. 12. 13.

3 R. E. Barrington, <u>Matrix of Sub-Activities related to Objectives</u> (Memorandum to ADMR, August 17, 1984).

Most of the contracts let under this program have tended to be for applied projects.[1] In this way, the program has tended to encourage university researchers to move into more applied areas -- not necessarily an undesirable objective, as already noted.

The program, however, is not structured so as to encourage a flood of new ideas and concepts, whether applied or otherwise, into the Department from the university community. Its administration, in fact, tends to discourage initiation and definition of projects by the university community. Proposals are formulated by all Sectors of the Department, and then considered by a number of selection sub-committees. Only after a number of the selected proposals are approved by Senior Management Committee is formal contact made with recommended universities to obtain research contract proposals.[2]

The program itself has not been evaluated since its establishment in 1972 (a design for such an evaluation is close to completion) and the administrators of the program lack the capability to evaluate, either prospectively or retrospectively, the capabilities of universities to carry out projects.[3] As a Director-General from another sector commented, "Historically, the response (to a request for research proposals from other sectors) has been a 'hodge-podge' of funding proposals often developed in haste within the Department, many of which have had little relevance to the Department's strategic research priorities."[4]

Clearly, there is a need for a thorough review of the university research program. Such a review should take into account the importance of of effective links between the DOC research program and the university community, as well as the various approaches and mechanisms for that purpose discussed below.

<u>Contracts with universities</u>: Every Research Sector branch and nearly every directorate contracts out work to university researchers. Research Sector directors-general state that they spend more of their resources on such contracts than are spent on the contracts put forward by their branches under the university research programs.[5] Most such contracts involve applied work.

Such contracts are useful to the individual branches and directorates which propose and administer them, but they by no means constitute part of a sustained and systematic process of consultation by the Sector as a whole with the university research community. In addition, the contract mechanism is not particularly suited to ensuring that the university community exercises any influence over the direction of the research program.

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1 Interviews with Research Sector personnel, Summer and Fall 1984.

2 <u>Loc. cit.</u>

3 <u>Loc. cit.</u>

4 DGBP, "Priorities for University Research/Centres d'excellence Contracts," Memorandum to SADM, October 11, 1984.

5 Interviews with Research Sector managers, Fall and Winter 1984.

Support for symposiums and colloquiums: The Sector administers a small contributions program -- $25,000 a year -- which is intended to support symposiums and colloquiums in Canadian universities on communications-related matters. Senior management in the Sector regard these events as a source of very useful exchanges with the university community. In fact, the Queen's University symposium, held every other year, attracts a large number of people from other universities and from industry.[1]

The small size of the budget for this activity, however, severely limits this very effective means of establishing links with the university community.

Other forms of interaction: There are a wide range of other forms of interaction with the university community. In terms of influencing the direction of university research in the communications area, perhaps the most important of these is the participation by senior Sector managers in the various committees -- especially the Strategic Grants committee -- of the Natural Sciences and Engineering Research Council, the largest dispenser of university research grants in the country.[2] It would be desirable if the research program adopted a conscious strategy with respect to such participation, aimed at ensuring better complementarity among the research thrusts of university, government and industry in the strategic technological areas of communications, informatics, space and office automation.

In addition, each branch and directorate maintains a network of contacts among university researchers working in related areas. There are also generally some post-doctoral fellowship students on site at CRC, and occasionally a professor on a paid sabbatical from a university faculty. The Co-operative Educational Program has also recently brought a number of university students into individual branches and directorates. In addition, loans of equipment are sometimes made to university researchers.[3]

While these are useful in providing support to the research programs of individual branches and directorates, these again do not together add up to a systematic program of establishing links with university researchers. Nor is the single position in the Research Policy and Programs Branch to co-ordinate university research programs sufficient for this purpose. In addition, according to Research Sector managers, these have not represented a useful means for university researchers to exercise any influence over the research program.[4]

Special arrangements at CWARC: The plans for the new Canadian Workplace Automation Research Centre at Laval call for a number of innovative arrangements which would place links with universities on a more systematic footing. For example, the Centre has an advisory board, with significant university representation, which is to play a key role in the planning and

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1 Loc. cit.

2 Loc. cit.

3 Loc. cit.

4 Loc. cit.

revision of research priorities. In addition, the Centre will draw half its research staff from universities and industry. These arrangements are promising, but until they are fully implemented and tested it is difficult to assess their ultimate effectiveness.

Perspectives on existing arrangements: Though the Sector has a wide variety of mechanisms for remaining in contact with the university research, community, these mainly serve the purposes of individual branches and directorates. These crucial links to universities have not been placed on a systematic basis, nor do they represent a useful means of communicating to the university research community what the Research Sector as a whole is doing. In addition, it is generally acknowledged within the Research Sector that these links do not, for the most part, represent a means for the university research community to exercise any influence on the over-all direction of the Sector's research program.[1]

4.2.3 The case for a commitment to directed fundamental research

In many ways, it is not surprising there have been definite limits to the effectiveness of the Sector's links with universities and to the degree to which university researchers have had an impact on the direction of the Sector's research program. Most Research Sector interviewees emphasized that applied research was generally a somewhat peripheral interest of most university researchers, especially outside engineering faculties, and that the expertise in this area — as well as the facilities for its conduct — mainly resided within the Research Sector itself. For this reason, it was felt that the university research community, with a few exceptions, generally lacked the expertise to provide useful input on the direction of the Sector's program of predominantly applied research.[2]

The converse also follows. The applied research focus of the Sector means that it has only a limited impact with respect to ensuring that the fundamental research — which is the main concern of university researchers — carried out at universities complements the applied concerns of the Sector.

It can be argued, of course, that, in comparison to agencies such as NRC and NSERC, the DOC research program has so few resources to devote to links to universities that its impact will be minimal and that it should not bother with universities. However, the importance to a small country such as Canada of ensuring that, in a strategic area such as communications, there is a certain complementarity in the deployment of the nation's research resources cannot be understated.

For this reason, <u>it is incumbent upon the DOC research program to use its relatively slender resources as effectively as possible to optimize</u>

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1 Interviews with Research Sector personnel, Summer and Fall 1984.

2 Loc. cit.

its interaction with Canadian university researchers in communications-related disciplines. In our view, this can only be achieved if the DOC research program employs a certain proportion of its resources for directed fundamental research -- that is, research which is relevant to its more applied concerns and which is at the same time close to the centre of the more fundamental scientific interests of the university research community. The customary level of directed fundamental research taking place in many government labs -- as well as large industrial R & D establishments such as Bell Labs,[1] Xerox[2] and IBM[3] -- is from 10 to 20 per cent.

The following benefits would flow from such a change in emphasis:

- a qualitative improvement in the range and depth of the interaction between the DOC research program and university researchers working in related areas;

- a concomitant increase in the complementarity between the DOC research program and those of university researchers, with the result that Canada's chances of having research activities of sufficient critical mass to be of world class in a greater number of strategic technological areas would be significantly improved;

- a significant rise in the prestige of DOC's research activities, given that much of such prestige derives from academic recognition;

- a consequent increased capacity to attract top university graduates -- an important consideration, given that the average age of professional researchers in the DOC research program is increasing; and

- an enhanced capacity within the DOC research program to innovate in the long term, given that a strong case can be made that the wave of important innovations produced by the Sector in the 1970s had its ultimate basis in the significant emphasis upon directed fundamental research within the organization during the 1960s and and early 1970s.

4.2.4 The need for systematic links with universities

Most of the benefits to be derived from a directed fundamental research program within the DOC research program cannot be achieved without more systematic and effective links with the university research community. Indeed, the main purpose of such a fundamental research program should be to ensure that there is real complementarity between DOC research and that of the university research community, with a view to ensuring that there is a critical mass of researchers working within the country in a larger number of strategic technological areas.

To this end and as a means of maximizing the benefits flowing from its involvement in directed fundamental research, managers of the DOC research program should ensure that:

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1 Stursberg, *op. cit.*, pp. 7, 8.

2 *Ibid.*, p. 8.

3 John Walsh, "Bell Labs on the Brink," *Science*, Vol. 221, p. 1269.

- the DOC program of directed fundamental research is developed and updated in formal consultation with the university research community, through mechanisms such as advisory committees, peer reviews, etc.

- the over-all DOC research program places increased emphasis, perhaps by employing the CWARC model, on bringing university researchers and post-doctoral fellowship students into government labs for periods of one to three years, as well as having DOC researchers spend time in university labs.

- it increases its budget for exchanges of information with the university research community through symposiums, colloquiums, etc.

- the DOC research program take a much more systematic approach to recruiting at universities, including the setting aside of a pool of person/years to be filled by top graduates in the appropriate fields.

- DOC should substantially restructure its university research program to provide more continuity in funding support for university research, to support fundamental as well as applied research in universities and to permit a much greater role in the definition of projects by university researchers, perhaps by replacing the contract mechanism with a grants or contribution mechanism.

- DOC participants on NSERC strategic grants committee should adopt a conscious strategy intended to assure complementarity in the research thrusts of government, industry and universities within the strategic technological areas of space, communications, informatics and office automation.

4.3 FUNDAMENTAL RESEARCH VS. APPLIED RESEARCH AND DEVELOPMENT

Organizationally and in relation to the environment in which they are conducted, fundamental research and applied research, including development, are different activities, drawing on different sources of information, driven by different concerns and priorities and possessing quite different clients.

If the Department, as part of its R & D activities, does undertake a program of directed fundamental research, it is important to emphasize that this will be different in its concerns, priorities and even organization from the applied research which is the Department's major R & D focus. While such a program much be relevant to the applied research areas in which the Departmental activity is greatest, it must be recognized that a major purpose of such a program is to heighten interaction with the university research community. In other words, though relevant to the more applied research interests, such a program must also reflect the concerns with advancement of knowledge and a relatively unstructured research program that are typical of the university research community. Indeed, as Chapter 2.0 showed, these concerns are even typical of fundamental research when conducted in major industrial labs.

The literature was also emphatic that more applied research should be conducted in a more structured environment, and its orientation must be towards the carefully scheduled production of results and satisfaction of clients.[1] In short, the orientation must be very much towards final application of the research and its ultimate client -- the government user, the manufacturer, the market and the consumer. The next two sections of this chapter will discuss the Department's applied research and development program in considerable depth.

At this juncture, however, it is important only to underscore the differences between fundamental research and more applied research in their priorities, concerns, organizational structures and client orientations. Because of these differences and the need to preserve the integrity of both fundamental research programs and more applied programs, most major industrial R & D establishments are careful to maintain an organizational and budgetary separation between the two activities.[2]

In our view, this industrial model is relevant to DOC R & D activities. However, it must be recognized that the DOC program is significantly smaller than Bell labs or IBM laboratories. Unthinking application of this general principle could lead to a fragmentation of the R&D effort in some areas of research. In short, it will be necessary to apply the general principle of separation carefully and pragmatically. For this reason, if the Department initiates a program of directed fundamental research, such a program must be separate in budgetary terms from its applied research and development programs, but organizational separation should take into account the unique circumstances in the different branches of the research program.

4.4 THE PRIMARY FOCUS OF GOVERNMENT LABS -- APPLIED RESEARCH OR LONG-TERM DEVELOPMENT TO MEET GOVERNMENT NEEDS

The primary focus of government labs should be long-term development or applied research conducted to meet government needs.

What are the needs of government for R & D in the broad area of communications, informatics and space?

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[1] See, for example, Lane, et al., op. cit., p. 154.

[2] See Section 2.3.3 of Chapter 2.0.

In many ways, the answer to this question cuts to the heart of the role of the Department of Communications (DOC) and involves an understanding of the some of the basic support mechanisms needed to assure efficient government and the achievement of the missions of other Departments.

It should be noted too that the discussion of needs here revolves very much around an analysis of the research program's present and potential government clients and their requirements. The reason is that the notion of need is often too diffuse to provide a real focus for a research program. For example, the government "needs" to ensure that the Canadian telecommunications system operates in as efficient a manner as possible and evolves in an orderly fashion in light of new technological developments. These "needs", though enshrined in statute, are too diffuse to provide a focus for a research program. They must be refined in light of specific policy contexts which can be translated into concrete R & D requirements and can provide criteria against which to measure the success of the program in meeting those requirements. A strong case can be made that one of the basic difficulties confronting the DOC research program has been the absence of such specific policy contexts and accountability mechanisms.

4.4.1 The evolving role of the Department of Communications

A country's communications network -- comprised of its telecommunications networks, its range of radiocommunications services, its broadcasting system -- is in many ways the nervous system of its nationality in economic, political, social and cultural terms. This is particularly true for a country such as Canada with a very diverse population scattered across a large and often harsh terrain, generally in close proximity to a dynamic and more populous neighbour with the most extensive and far-reaching communications system in the world.

It was because communications was so crucial that Canadian governments, as well as governments in virtually every country in the world, have regulated private telecommunications monopolies and even operated elements of the national communications system. Extension of communication service in response to public demand was an urgent national priority. National development -- in economic, political, social and cultural terms -- demanded an efficient communications system which was universally available to all at reasonable cost and responsive to the national interest. International commitments also became important, given the fact that spectrum is a scarce resource and radio waves do not respect national boundaries.

In the 1950s and 1960s, the pace of technological advance in the communications area raised sufficiently complex policy issues with respect to this vital part of the national infrastructure that the government decided in 1969 to create a single policy focus for its deliberations on these matters -- the Department of Communications. The Department was also responsible for regulation of the spectrum, and a newly established CRTC -- which reported to Parliament through the Minister of Communications -- would regulate broadcasting and eventually telecommunications monopolies.

In the early 1970s, the Department's emphasis was very much on developing the technology, the policy and regulatory framework and the appropriate instruments to extend basic telecommunications and broadcasting services into remote and rural parts of Canada. The Department's researchers were the major players in the development of this technology and the result was the creation of a Canadian space industry, as well as the establishment of a new public-private agency -- Telesat Canada -- to carry these basic services.

Another thread in the tapestry of Departmental policy concerns was the need to ensure that the Canadian communications system was responsive to the Canadian national interest in the cultural area. This concern lay at the foundation of the establishment of the CBC in the 1930s, the introduction of television in the 1950s, the Canadian content quotas of the CRTC, the Commissions's regulation of cable and the establishment of Canadian pay television and the CANCOM decision in the early 1980s. These developments can in many ways be viewed as a direct response to specific technological and industrial developments in the United States in the context of a belief that it was in the national interest for the state to intervene for the purpose of preserving a Canadian cultural fabric in the face of overwhelming competition from a much larger neighbour.

Throughout the 1970s and early 1980s, the pace of technological advance in communications-related areas has quickened enormously, intensifying the sense of cultural challenge and setting in motion forces which will in the long run transform the Canadian communications system. These technological changes, and the massive industrial realignments which flow from them, have raised fundamental questions about the traditional role of the state in the communications and cultural areas.

By radically increasing the bandwidth available for information or assuring more efficient use of the spectrum and reducing the importance of distance in communications, the new technology has opened up a fundamental challenge to the traditional monopolistic position of carriers and providers of communications services, as well as significantly increasing the range of possible communications services. This trend has been intensified by the merger of communications and computing in both technological and industrial terms as potentially the most important factor in the enhancement of productivity and economic efficiency within industrialized countries around the world. These technological and industrial developments represent a global phenomenon which -- especially but not only because of our proximity to the United States where these trends are resulting in major industrial realigments with important implications for Canada -- poses a fundamental competitive challenge to this country, especially its communication system, as well as presenting important new opportunities.

If nothing else, these developments have enhanced the strategic importance of the Canadian communications system as a vital component of the infrastructure of our nationality in economic, political, social and cultural terms. There has, however, been an important shift in the role of government vis a vis that system.

This shift is apparent along four dimensions:

- a shift from a policy focus on the regulation and management of communications monopolies in the public interest to an emphasis upon defining the boundaries between monopoly and competitive services, as well as the rules needed to govern a competitive environment in the public interest;

- a radically increased emphasis on creating an environment which favours the technological enhancement of the Canadian communications system -- not just in response to a perceived public need -- but to preserve that system from erosion because of increasing competition from the United States;

- a increased emphasis on strategies to strengthen Canadian industries in fields increasingly intertwined with communications -- for example, computer, software and cultural industries -- both as strategic sectors in their own right and as factors in the long-term health and technological enhancement of the Canadian communications system; and

- in light of all of these concerns and the growing recognition that the diffusion of these technologies is vital to Canada's productivity and international competitiveness, a new emphasis on strategies to encourage the use of these emerging communications-information services and products.

DOC has formulated a strategic plan which reflects these changes and calls for an extensive review of many of its policies and the various instruments -- regulatory agencies, spectrum management (including regulation), standards, application programs and R & D -- it deploys in the public interest. This activity still reflects the government's traditional concern to ensure that the vital communications infrastructure remains responsive to the national interest, efficient and available to Canadians at reasonable cost. But, as already noted, in the face of an increasingly competitive North American environment, there is a heightened emphasis on creating a climate favouring the long-term health of the system through its technological enhancement, as well as the development of the associated Canadian industries as strategically important in their own right and as a means of enhancing the productivity and international competitiveness of the Canadian economy.

The challenge for the Department of Communications is to adapt its policies and policy instruments to this new technological and industrial environment and to deploy these instruments in a co-ordinated fashion. This challenge is complicated by the fact that the pace of technological change has not slowed and the environment is still evolving rapidly and in some ways unpredictably.

4.4.2 Research in support of the DOC role

Given the rapid pace of technological advance and its profound impact across the range of DOC concerns and responsibilities, it is vital that the Department have access to technical expertise, advice and up-to-date information on the present state of the technology, the present and potential technical capabilities of Canadian firms and anticipated technological developments both here and around the world. In the main, it has been the responsibility of the Research Sector to provide this advice and information, though it has not been the only source.

The Wright Task Force,[1] the U.S. Federal Laboratory Review Panel[2] and the literature generally tend to agree that the provision of such advice is a legitimate role of goverment labs and indeed that this is the kind of activity that government labs can carry out quite effectively. Technical input from the private sector is necessary, but exclusive reliance on such input has its disadvantages in an environment which is increasingly competitive. Indeed, **for the government to set policy, regulations or standards in light of a broad national interest, it is vital that it have access to a range of impartial and objective technical information which is not coloured by the particular interests of any individual competitors. In the communications area, a government-sponsored research program, because of its relative insulation from an increasingly competitive marketplace, should be uniquely positioned to provide such advice.**

Below, we will examine the degree to which DOC labs in the Research Sector and other sectors carry out this role, as well as the implications of its performance in this area for both its other activities and the policy development, standards and spectrum management activities of the Department.

<u>Broad communications and cultural policy</u>: The Department advises the Minister of Communications on telecommunications, broadcasting and cultural policy and undertakes policy development in these areas on his behalf. Given the pace of technological change and its wide ranging impact, technological developments play a significant part in creating the need for new policies, in shaping the substance of those policies and determining the duration of their usefulness.

At present, the Research Sector is not a key player in the development of these policies.[3] There is a certain amount of informal consultation between Sector personnel and those developing the policy.[4] However, for the most part, the policy development takes place in isolation from the Research Sector. For example, the Broadcasting Strategy for Canada, the 1983 CBC policy, the National Film and Video Policy and the present telecommunications policy were developed without formal consultation with the Research Sector.[5]

This situation can have negative implications for Research Sector activities and the policy development process. For example, the Research Sector may develop a technology and transfer it to industry, on the assumption that there will be a significant domestic market for the product. However, deployment of the product in Canada may in fact not contribute to some policy objectives. In the late 1970s and early 1980s, this actually happened with small earth stations, a technology largely developed by the

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1 Wright Task Force, <u>op. cit.</u>, pp. 27, 28.

2 Federal Laboratory Review Panel, <u>op. cit.</u>, p. 2.

3 Interviews with Research Sector managers and managers from other DOC Sectors, December 1984-February 1985.

4 Interviews with Research Sector personnel, Summer and Fall 1984.

5 Interviews with managers from other DOC Sectors, December 1984-February 1985

Sector in co-operation with industry; the deployment of such earth stations in Canada could have frustrated statutory objectives in the Broadcasting Act and could well have had a negative impact on the Canadian cable industry, now regarded in policy terms as crucial to the health of the Canadian broadcasting system. Fortunately, the Canadian company to which the technology was transferred has found an export market for its products.[1]

That particular situation can be viewed, of course, as an instance when the research program, because of its technology transfer concerns, essentially took a fairly proactive policy stance vis à vis the rest of the Department. The development of that policy, however, occurred in isolation for the most part from the broadcasting policy development activity elsewhere in the Department. A conscious policy of involving the Research Sector in policy deliberations would certainly have rendered unnecessary the considerable amount of last-minute manoeuvring required to deal with this embarrassing contradiction in Departmental direction. It is also conceivable that such involvement might have resulted in a Departmental policy which would have permitted the use of these small earth stations in the Canadian market.

Given the impact of technological developments on these key policy areas, there can be little doubt that many policies would be strengthened by making greater use of the technical resource which is the DOC research program. For example, the technical correctness of assumptions about key technological developments could be checked.

More important, these policies could be informed by a greater awareness of future technological developments which are pertinent to the policy area.

At present, policy analysts rely on their contacts with affected industries and their reading of a range of business literature and reports for this information. Such sources will generally provide a picture of the technology-based applications, services and products already in the marketplace and some insight into what may soon enter the marketplace, either here or in other countries.[2] Certainly, this information represents one of the basic realities with which a policy in such a technology-intensive area must deal.

However, a more proactive policy development stance in these technology-intensive areas demands a greater awareness of technological developments which are further away from entering the marketplace. The scientific literature in many cases provides a more accurate and solidly based perspective on future technological developments, usually well in advance of the usual sources relied on by policy analysts. However, even the information there frequently lags up to two ore more years behind the first reporting of such developments at scientific conferences.[3]

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1 Interviews with managers from other DOC Sectors, September-October 1984.

2 Interviews with Managers in other DOC Sectors, December 1984-January 1985.

3 McBride, op. cit., p. 27.

The means by which a DOC-sponsored research program could be encouraged in its efforts to gather and disseminate such information are discussed in greater depth in Section 4.6 of this chapter. However, it should be noted that you must give information to get information; in other words, you must have some sort of applied research program in the related areas. In addition, for such information to be relevant to the policy needs of the Department, the gatherers of such information must be aware of those policy-related information needs.

At present, such awareness only emerges on an informal, almost accidental basis.

A more proactive policy stance on the part of the Department could also have important positive implications for the research program. To the degree the policy centres of the Department could identify with some precision the future communications needs of Canadians and enshrine these as precise and compelling policy objectives, they would be providing a precise policy basis for a focussed program of development, applied research and perhaps even fundamental research to meet those needs. With a few important exceptions, the Department has in the past been unable to provide such a precise and compelling policy focus for Research Sector activities.[1]

Cultural policy objectives might also provide fruitful opportunities for the DOC research program. Both the CBC and the National Museums have been involved in Telidon trials. The problems of large-scale information retrieval, electronic storage, automated cataloguing are, for example, of interest to cutural agencies such as the National Library and the Public Archives. However, the identification of such needs, and an understanding of policy priorities, requires closer liaison with the relevant policy development centre within the Department, as well as good relations with the ultimate users of the technology.[2]

For this reason, whatever organizational option is selected as a framework for DOC R & D activities, there must be significantly more effective formal links and consultative mechanisms between the Department's research program and its policy development centres. The managers of the research program should consult with the policy development centres in a long-term planning context to develop the kinds of applied research and technical information activities which would permit a significantly more proactive policy stance by the Department. This in turn might in the future result in the creation of precise and compelling public policy focuses for research activities which cannot be carried out by the private sector.

Industry policy: The above observations apply with equal force to the formulation of industrial development policies and programs by the Department, though it should be noted that there is considerably more interaction, both formal and informal, between the Research Sector and the Technology and Industry Sector than between the Research Sector and other major policy development centres within the Department. The nature of this

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1 See Section 3.4.3 of Chapter 3.0.

2 For a discussion of how the research program might better serve cultural objectives, see DOC Communications Technologies and Cultural Objectives: Final Report, an unpublished draft report submitted by CPER Management Consulting Inc. to the DOC Cultural Affairs Sector in May 1985.

interaction will be discussed in considerably more depth in Section 4.5 of this chapter in the context of the links between industry and the DOC research program.

Standards: Since the earliest establishment of radio and telecommunications systems in Canada and around the world, it was widely recognized that consultation and agreement on technical standards were crucial to ensuring that messages sent from one territory could be received in another. With the multiplication of communications systems and networks, issues of standardization and compatibility became even more central to the efficient and effective functioning of communications services. National standards-setting bodies proliferated, as did international standard-setting bodies whose decisions -- usually based on consensus -- took on the force of international agreements under multilateral treaty arrangements. National governments were and are expected to enforce these decisions on standards.[1]

The Department of Communications plays the lead role for Canada in the standards area, both nationally and internationally. However, it should be noted that most national standards are voluntary and all are developed in forums outside the Department through a process which is consensual and consultative in the fullest meaning of those words. Standards development occurs in private-public sector working groups and committees under the broad rubric of the Standards Council of Canada, which was established as an independent body by legislation in 1970 and is funded by Parliament. This body does have the power to recommend that national standards be enshrined in regulation and, of course, the Department can do this itself in the radiocommunications area. The Department also leads the Canadian delegation to international standards meeting.[2]

As a result of these responsibilities, the Department is an active participant in standards meetings at both the national and international levels. The Research Sector plays a crucial role in these standards activities -- especially in the area of communications protocols -- essentially because standards are highly technical formulations which can only be understood by someone with "state of the art" technical expertise in the particular area to which they apply.[3]

The Sector operates one research program which is in part devoted to standards issues in the area of communications protocols. It has also carried out a number of projects intended to resolve standards questions. In addition, researchers from all branches of the Sector assess standards proposals from industry and other countries, participate in standards meetings, both national and international, when these are focussing on technological areas in which they have expertise. The reason for their participation is that, though national and industrial interests may underly

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1 R.M. Bennett, Director, Network Development, DOC, "Technical Aspects of Telecommunications," (Unpublished note prepared October 28, 1980), p. 1.

2 Ibid., pp. 1-3.

3 Interviews with Research Sector personnel and managers from other DOC Sectors, Fall and Winter 1984

standards discussions, the substance of those discussions is highly technical.[1]

At present, the policy context for the Department's involvement in standards issues is provided by the Policy and Spectrum Management Sectors.

The lead role with respect to telecommunications standards is assumed by the Policy Sector, which approaches these discussions with a view to achieving compatibility and maximum common usage of standards to assure an orderly and efficient communications system. While the Policy Sector may occasionally ask the Research Sector to initiate a project -- usually with respect to communications protocols -- to resolve a standards question, the Policy Sector makes no effort, either formally or informally, to ensure that the Research Sector's program provides the kinds of expertise required to support Departmental activities on priority standards issues on a co-ordinated and continuing basis.[2] At the same time, it should be noted that Policy Sector interviewees had no criticisms to make of the advice and representation provided by the Research Sector in the standards area.[3]

The Spectrum Management Sector focuses, of course, only on radiocommunications, but in many ways from the same kind of perspective as the Policy Sector -- that is, the importance of achieving compatibility and maximum common usage of standards to assure an orderly and efficient communications system. The Policy Sector also plays a role here especially with respect to the policy implications of international standards. As was the case with communications protocols, the Research Sector often provides representation at the highly technical discussions which take place at international standards meeting.[4]

Informal consultations between the Research and Spectrum Management Sectors take place every year on the operational plans of the Research Sector, particularly in the areas of spectrum and environmental research. Spectrum Management Sector interviewees expressed general satisfaction with the technical support on regulatory issues they received from the Research Sector.[5]

An important role in standards development is also played by the Spectrum Management Sector's Clyde Avenue Laboratory. It develops standards for use of the spectrum, for the immunity of equipment from interference and

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1 Loc. cit.

2 Interviews with Research Sector Personnel, Summer and Fall 1984.

3 Interviews with Managers from other DOC Sectors, December 1984-February 1985.

4 Interviews with Research Sector Personnel, Summer and Fall 1984.

5 Interviews with Managers from other DOC Sectors, December 1984-February 1985.

for terminal equipment to be attached to Canadian telecommunications systems under the Terminal Attachment Program.[1]

A secondary concern in the standards area of the Policy Sector is to ensure that Canadian industrial interests are reconciled at the national level and vigorously defended at the international level. However, this concern is secondary to that of ensuring widely used, compatible standards in Canada that are compatible with international standards.[2]

It is not clear that Canadian industrial interests are best served by such an approach. Standards issues are becoming increasingly crucial to Canadian industries in the communications and computer areas where the technology is evolving so rapidly. Major industrial interests, both in Canada and abroad, can be seriously affected by standards decisions on the new information technology and terminal devices which are increasingly being connected to communications systems. As a result of the break-up of AT & T and the deregulation of long distance and specialized communications services, there is and will be increasing competition among carriers, computer companies, cable companies and others. Standards issues loom larger and larger in this ever more competitive environment. Beyond this, the question of standardization is of growing importance to users, who are increasingly faced with an electronic tower of Babel as computer and communications systems proliferate.[3]

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1 Loc. cit.

2 Loc. cit.

3 The DOC Communications Research Advisory Board, in its 1980-81 annual report stated: "With the world about to add significantly to the capabilities of its telecommunications networks, standards are about to become a much more important issue than they have been in the past. Decisions have will have to be made more quickly that has been the case in the past and many more factors will have to be taken into consideration. Since DOC is the focal point for telecommunications standards activities in Canada, CRAB recommends that many more resources should be applied to this activity in a planned fashion over the next few years to enable a faster pace of setting standards. Care should be taken to attract sufficient talent to this activity to be able to contribute technically as well as in a business sense." A concern about standards is also shared by governments around the world. See, for example, Long-Term Concept Committee, Telecommunications Council, Long-Term Concept of Telecommunications for the 21st Century (Report submitted to Japanese Ministry of Posts and Telecommunications in January 1984), pp. 34-36. In the view of the authors, standardization was the first component with respect to "laying the foundation of the sophisticated information-oriented society."

The relationship between standards issues and industrial development concerns is not always straightforward. In some instances, widely accepted standards can provide a firm foundation for innovation and industrial development. In others, such standards can benefit one company or group of companies at the expense of innovation and over-all industrial development.

Clearly, the implications of standards for users and other industrial sectors deserves greater attention within DOC. Under the Departmental reorganization of 1983, the Technology and Industry Sector was also to focus on this area. As yet, however, the Sector has not developed the capability to participate meaningfully in standards deliberations. At the same time, while the Policy Sector focuses on telecommunications standards and the Spectrum Management Sector focuses on radiocommunications standards, less attention is paid to the increasingly important area of informatics.[1]

The lack of a comprehensive strategy on standards by the Department has important implications for the Research Sector. There is a tendency for the Policy and Spectrum Management Sectors to consider standards desirable as a rule, with the result that there is no policy basis for determining the level of the Research Sector's commitment in the area. Standards work, while important, takes research personnel away from actual R & D work to assess proposed standards and to participate in national and international standards meetings.[2] This contributes to the diffusion and incoherence of the research program.

Indeed, because there are insufficient policy-based criteria for deciding what standards work is relevant, Research Sector managers claim that they could devote all their resources to standards work -- especially in the informatics area -- because such activity is increasing rapidly as a result of developments in information technology and the more competitive communications environment. Instead, because standards activity competes with work to meet the needs of other clients, they arbitrarily set levels for their commitments to standards work.[3] In other words, there is no firm and comprehensive policy basis for determining the level of the Research Sector's commitment to standards work.

Clearly, there is a serious need for the Department to develop a comprehensive and integrated strategy for dealing with standards issues as they affect the integrity of the communications system, the public and Canadian industry. Responsibility to develop such a strategy should rest with the Policy Sector, the Technology and Industry Sector, the Spectrum Management Sector and the Department's research program, whatever organizational option set out in Chapter 5.0 is selected as a framework for the program. Clearly, the Technology and Industry Sector will have to develop its capability in this area if industrial considerations are to be fully taken into account.

Such a strategy should also be shaped so as to provide the DOC research program a solid and rational basis for determining its level of commitment in the standards area. Formal links should be established between the DOC research program and the other sectors to plan how the research program could be shaped to meet the Department's needs in the context of such

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1 Interviews with Managers in other DOC Sectors, December 1984-January 1985.

2 Interviews with Research Sector Personnel, Summer and Fall 1984.

3 Interviews with Research Sector Personnel, Winter 1984.

a strategy. The organizational options put forward in Chapter 5.0 suggest various alternatives for what these links might be.

Spectrum management: Under the Radio Act, the Minister of Communications is responsible for the optimal and efficient management of the radio frequency spectrum. He also has the power to regulate use of the spectrum.

The purpose of DOC's Spectrum Management Sector is to carry out this responsibility on behalf of the Minister. It is no easy task. Technical characteristics vary at different frequencies. New technology is continually opening up new uses and new regions of the spectrum, while certain bands -- especially in urban areas -- are becoming increasingly congested. At the same time, because radio waves do not respect national boundaries, Canada's use of the spectrum is subject to international treaties and range of multilateral agreements.[1]

In order to manage effectively use of the spectrum, it is necessary to plan present and future uses of the spectrum, regulate it use through licensing, and enforce obedience to the regulations through inspections and other activities.[2]

The activity which draws most heavily on the technical expertise of an organization such as the Research Sector is that of planning future uses of the spectrum. According to Spectrum Management officials, the time frame for such plans is from 10 to 15 years. For this reason, it is important that the Sector receive continually updated information on anticipated new technologies -- an information-gathering function which can only be carried out by the possessors of technical expertise, as Section 4.6 of this chapter demonstrates.[3]

In addition, there is a continuing need for information on the characteristics of radio propagation at different frequencies and under different conditions. The growing number of radiocommunications systems and amount of electric and electronic equipment in homes, offices and the outside raises complex and increasingly important questions about the sources and conditions of interference. The Research Sector's program of applied spectrum and environmental research provides answers to a number of these questions or at least the means to find such answers through information exchanges, publications, etc.[4]

Finally, the Research Sector undertakes specific research projects for the Spectrum Management Sector. For example, in 1979, the Research

1 Interviews with Managers from other DOC Sectors, December 1984-February 1985.

2 Loc.cit.

3 Loc. cit.

4 Loc. cit.

Sector measured radio propagation characteristics over the Great Lakes to provide a factual basis for discussions between Canada and the United States on a change in the utilization of a certain portion of the spectrum.[1]

The Spectrum Management Sector also receives technical support and services from its own laboratory on Clyde Avenue in Ottawa. This laboratory develops methodology for test measurements of the spectrum; evaluates test procedures for new equipment; calibrates, repairs and sometimes designs equipment used by the Sector in monitoring and controlling spectrum use; provides a range of technical and engineering analysis -- including laboratory and field measurements -- to resolve problems in spectrum use which cannot be solved through normal operational procedures; and tests and approves radio equipment by type. Generally, the lab provides a technical or engineering service to the Sector and does not carry out the kinds of applied research which is so central to the work of the Research Sector in the spectrum area.[2]

In our interviews, Spectrum Management officials expressed general satisfaction with the support they received from the Research Sector and pointed out that the necessary expertise did not exist elsewhere in the country, though it could of course de developed.[3] Every year, Spectrum Management officials receive on an informal basis a copy of the operational plan for the spectrum and environmental research program of the Research Sector. They also consult with the director of the program and state that he will modify the plan in response to their requests.[4] However, the Research Sector is in no sense accountable to the Spectrum Management Sector and Research Sector officials now feel they should be doing more to sensitize their counterparts in the Spectrum Management Sector to the potential benefits of applied spectrum and environment research.[5]

In our view, the interaction between the DOC research program and Spectrum Management Sectors would be even more productive if the consultation was formal and occurred in the context of a consensus on the long-range needs of both the research program and the sector. In the long run, such an approach could give the planning and policy activities of the Spectrum Management Sector a more proactive stance vis a vis the development of new technologies. Supplemented by formal mechanisms to assure the accountability of the research program in this area to the Spectrum Management Sector, such an approach would also provide a clearer, more client-oriented long-range focus for the work of the research program.

<u>Conclusion</u>: The Department of Communications faces a rapidly and fundamentally changing environment which is largely shaped by technological

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1 Interviews with Research Sector Personnel, Summer and Fall 1984.

2 Interviews with Managers of other DOC Sectors, December 1984-January 1985.

3 <u>Loc. cit.</u>

4 <u>Loc. cit.</u>

5 R.E. Barrington, "Comments of ADMSM vs Strategic Review of Research Sector," (Memorandum to B.C. Blevis, June 20, 1985).

developments. In order to meet the challenge of such an environment, it must increasingly be able to develop its policies and deploy its policy instruments in a co-ordinated fashion which is responsive and proactive in relation to present and future technological developments.

The DOC research program is in many ways the Department's window on the future. In order to take full advantage of this important resource, the other sectors of DOC must have significantly more formal and effective links with the DOC research program in the context of continually revised long-term planning framework and formal accountability mechanisms. Such a framework, beyond clarifying the needs of Departmental users of the research program, would be a powerful lens to assist in the focussing of that now diffuse program. Chapter 5.0 presents a number of organizational options which in varying degrees would create such a framework.

4.4.3 Procurement -- GTA and common services to the government

The literature generally agrees that government labs do their most effective R & D when they focus on long-range development or applied research in areas where the government itself is a user-demander -- a purchaser -- of the technology. In such circumstances, the government lab can be in a better position than industrial labs to understand government needs. Equally important, the concreteness of those needs can give a clear applications and client orientation to the work of the lab.

GTA: In the context of deficit reduction and government restraint, there is no more pressing government need than enhanced efficiency and productivity within the public sector.[1] As already noted, applications of the new information technology represent an increasingly important means for both government and business to enhance their productivity, especially in the services sector.[2] Much of this technology is communications-related, and the Department of Communications through the Government Telecommunications Agency (GTA) is in a unique position to contribute to improvements in productivity in this area.

GTA operates as a common services agency providing telecommunications services to the entire Government of Canada. It should be noted that, in terms of financial outlay, the federal government is one of the largest single users of telecommunications services in the country.[3] The basic rationale for having a common services agency such as GTA is to ensure that the government can take advantage of economies of scale in its purchases of telecommunications services Definition by GTA of the evolving needs of a large homogeneous market can be an important input to Canadian industry. Government procurement of telecommunications products and services, either coordinated or carried out directy by GTA, is a key instrument of industrial development in the high technology area.

1 For example, the Ministerial Task Force on Program Review "has as its major objectives better service to the public and sound, prudent management of taxpayer's monies." See, for example, the budget paper on New Management Initiatives: Initial Results from the Ministerial Task Force on Program Review, May 1985.

2 OTA, op. cit., p. 4.

3 Government Telecommunications Agency (GTA), Government Telecommunications Planning Document (Ottawa: Department of Communications, January 1984), p. 1.

At present, GTA leases these services from the private sector, mainly the telecommunications carriers. However, in January 1984, the agency published a planning document which will in all likelihood involve it in creating a government telecommunications system which is at the leading edge of the technology.

In the planning document, the agency states: "The backbone of the future public (user) telecommunications networks will be based on the concept of Integrated Services Digital Network which is currently evolving from the existing telephone network under the guidance of the major telecommunications administrations.... Unlike the existing telephone network, which is analog based and designed for the interconnection of voice and voiceband data signals, the ISDN will be a fully interconnected digital network with the capability of carrying digitally encoded speech, text, graphics and video signals on the same facilities.... The intent of the government is to meet its future telecommunications requirements through the use of ISDN-compatible networks."[1]

The GTA document also notes: "A major influence in telecommunications is the rapid evolution of what may be broadly described as Information Technology and Office Communications Systems. These are in support of office automation initiatives to increase office productivity, and to cope with the anticipated significant increase in volume of information that the office has to handle. Terminals designed for speech, electronic messaging, EDP communications and graphics services are a potential means by which the integration of different services in an automated office will be achieved. In addition, a requirement exists for communications compatible information processing systems and databases, which will permit sharing of these resources through the interconnection of the databases with the offices. This will be achieved through the development of standardised communications protocols."[2]

GTA is also developing a satellite-based digital network to provide the infrastructure for integrating a wide range of user department's communications requirements.[3]

Full and successful implementation of all of these enhanced telecommunications services will require applied research and long-range development work in the pertinent technological areas, as well as actual product development and service development by GTA.[4] As is the case with other carriers, GTA should be prepared to put a certain proportion of its gross revenues into needed long-range development and applied research in the relevant areas. Bell Canada, for example, now puts two per cent of its gross revenues into research and development.[5]

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1 Ibid., p. 2.

2 Loc. cit.

3 Ibid., p. 14.

4 Interviews with Managers from other DOC Sectors, December 1984-February 1985.

5 Interview with Bell Canada officials, January 1985.

GTA operates under a revolving fund and recovers all its expenditures from user departments, and the common service policy governing GTA's operations makes to no provision for the funding of research and development. For this reason, the degree to which GTA has the authority to direct a certain portion of its expenditures to applied research and long-range development is at present unclear.[1] However, it is a strategy which is based squarely on the direction in which both communications and computer technologies are evolving. Potentially, it would also have important benefits in terms of government efficiency and Canadian industrial development, as shall be seen below. Clarification of GTA's role should be an urgent priority both for these reasons and because of the unique advantages in carrying out such a strategy for an agency located in DOC where much of the necessary technical support is available.

The Research Sector has specialized expertise in many of the new technologies which are vital to implementation of the enhanced telecommunications system envisaged by GTA. For example, the Workplace Automation Research Centre in Laval and the Information Technology and Systems Branch in Ottawa are both doing work in areas which are central to the development and effective implementation of an Integrated Services Digital Network and office automation and communications systems. The Space Branch has already done work for GTA to support some of the components of the envisaged Government Integrated Services Satellite Network.[2]

However, for the most part, this convergence of interest between GTA and the Research Sector has been unexploited. According to rough Research Sector estimates, only four per cent of the Sector's resources are spent in support of government services, of which GTA is only one component. There are a few informal consultations, most recently involving WARC.[3] The Research Sector has also undertaken specific projects for GTA, such as work on time division multiple access in satellite applications, which will be one of the two major components of GTA's envisaged Government Integrated Services Satellite Network.[4]

The over-all picture, though, is one of a rather haphazard collaboration. According to a GTA official, the agency has no opportunity to see Research Sector operational plans before they are approved, nor is any interaction between the the agency and the Sector in a formal planning context. As a result, according to this same official, GTA only learns be chance about Research Sector activities in relevant areas.[5]

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1 Interviews with Managers from other DOC Sectors, December 1984-February 1985.

2 <u>Loc. cit.</u>

3 R. E. Barrington, <u>Matric of Sub-Activities related to Objectives.</u>

4 Interviews with Managers from other DOC Sectors, December 1984-February 1985.

5 <u>Loc. cit.</u>

This situation clearly works to the disadvantage of GTA in its efforts to develop enhanced government telecommunications services in a continually changing technological environment. It also works to the disadvantage of the research program, which in effect is ignoring what should be a major market for its services. Indeed, if government labs are most effective in conducting R & D to meet government needs when the government itself is the user-demander of the technology, neither the DOC research program nor GTA are exploiting an increasingly important synergy between their two spheres of activity, especially given that the agency and the research program are both part of the same department. In our view, work conducted on behalf of GTA could also well be a major source of coherence and focus in the Sector's research program around a clear sense of applications based on concrete needs.

Clearly, it is vitally important that GTA clarify its authority with respect to putting a portion of expenditures into applied research and long-range development. Equally urgent is the development of a more effective interaction between GTA and the DOC research program. This will require a much more formal and systematic approach to collaboration, including perhaps specific accountability mechanisms. The management of both the agency and the program should together develop a program of applied research and long-range development which will meet the agency's needs over the next five to 15 years. This strategic framework should be revised regularly in light of changes in the technology and user needs. Within this context, GTA should be prepared to devote at least two per cent of its gross revenues to such a research program, as well as to procurement-related near-term and product development activity by industry. Chapter 5.0 outlines a number of organizational options which could provide a framework within which such formal collaboration could took place.

Other common services and DSS: The Wright Task Force saw government procurement as one of the most powerful tools the federal governnment has to encourage technology development in Canada.[1] The Task Force was also very critical of the failure of the government to use this tool more effectively in the context of long-term procurement planning linked to R & D by Canadian industry to ensure that industry is in a postion to meet the high technology procurement needs of the government.[2]

In light of the task force report and its own studies, the Department of Supply and Services (DSS) is trying to position itself so that it can carry out long-term procurement planning, especially in the high technology area, with a view to ensuring that Canadian industry can meet government needs. For the past two years, DSS has brought out an Annual Procurement Plan and Strategy[3] which is based on extensive consultations with industry and with government users and is designed to find effective ways to use

1 Wright Task Force, op. cit., p. 13.

2 Ibid., pp. 14-17.

3 See, for example, Supply and Services Canada, An Annual Procurement Plan and Strategy: 1984-85 (Ottawa: July 1984).

procurement to promote the government's economic and regional development objectives. The Department also now administers two procurement support programs -- the Unsolicited Proposals Program and the Source Development Fund -- which fund R&D by industry with a view to developing products which would meet government requirements.[1]

DOC's Research Sector provides scientific authorities or technical expertise for about $2.5 million a year in contracts under the Unsolicited Proposals Program[2] and also has some involvement with the smaller Source Development Fund. On occasion, the Sector encourages companies to seek contracts under these programs, usually in support of its own research and technology transfer objectives. However, such activity is by no means systematic and is often no more than a reaction to company proposals or DSS requests for assistance. This is not surprising, given that essentially only one person in the Sector's Research Policy and Planning Branch is responsible for handling the interface with these programs and all other government programs.[3]

Given the Wright Task Force's recommendations relating to procurement and the present policy ferment at DSS, both DOC and its research program should take a more systematic and proactive approach to its dealings with DSS.

As already noted, new information technology and office automation systems -- which interface with telecommunications systems -- are at the heart of the debate about enhanced productivity in both government and the private sector; a strong Canadian industrial presence in these areas is also deemed vital. DSS policy-makers recognize this reality.

More important, it is no easy task to carry out an effective program of supporting industrial R & D intended to meet government's long-term procurement needs. The reality is that industry is for the most part mainly interested only in carrying out near-term and product development work in house.[4] The reason is the rapid pace of technological change and the fact that longer-term R & D is generally much riskier both for the company undertaking it and for government purchasers who are held strictly accountable for their expenditures, both by Parliament and by users who may be suspicious of the new technology.[5]

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1 Interviews with senior official from Department of Supply and Services, March and May 1985.

2 R. E. Barrington, "Contracting out in Research Sector," (Memorandum to A/ADMR, February 5, 1984), p. 3.

3 Interviews with Research Sector Personnel, Summer and Fall, 1984.

4 "Northern Telecom, for instance, conducts almost 100 percent of its applied research using base technology derived from government, industrial and university labs around the world." (Northern Telecom, Forum: A newsletter for Northern Telecom managers (February 1985).

5 Wright Task Force, op. cit., p. 14.

Consequently, in order to reduce the risks to both the private sector and government procurement officers, it makes more sense for both applied research and long-range development work -- the basis for near-term and product development work -- to be carried out by government labs such as the CRC and WARC, especially in the areas of office automation, informatics, space and communications. This would lay the basis for procurement-related transfers of technology to industry, thereby meeting government objectives in this area.

Formal collaboration with DSS in the context of long-term planning to meet government procurement needs would pay important dividends to the DOC research program. In particular, it would help DOC to acquire an overview of the government's long-term procurement needs in areas of DOC expertise and target departments with such needs. Formal collaboration with those target departments would given DOC a systematic and in-depth understanding of government's procurement needs in relevant technological areas -- an understanding which is only sporadically present now. Awareness of those needs in concrete terms would help provide the basis for a coherent, results and client-oriented research program, founded on requirements of unassailable legitimacy. In order to ensure that such a program remained responsive to the requirements of client departments, it would be ideal if the resulting projects were carried out on a cost recovery basis.

Conclusion: The DOC research program must make a much more systematic effort, in formal collaboration with government service and procurement agencies, to identify long-term government procurement needs and develop appropriate programs of applied research and long-range development in response to those needs.

Such an approach is particularly important in relation to the activities of the Government Telecommunications Agency, which is also a part of the Department. Within a long-term planning context, GTA and the research program should formally collaborate to develop a program of applied research and long-range development in support of GTA's expanded role, once its authority to perform that role has been clarified. Chapter 5 contains a number of organizational options which could provide a framework for such collaboration.

In addition, both the Department as a whole and its research program in particular must take a much more proactive stance vis à vis the procurement activites of DSS. In light of government objectives for technology development, DSS is trying to set in motion a process of long-term procurement planning -- especially in the high technology area -- to ensure that Canadian industry can play a role in meeting government procurement needs. Industry would then be able to carry out R & D to meet future procurement needs. Given industry's interest in R & D towards the product development end of the spectrum, government supported labs, such as WARC and CRC, clearly have a role in carrying out the applied research and long-range development which will provide the technological basis for a productive industry involvement. An active involvement with DSS as it is trying to implement these policies would lay the basis for future formal collaboration, on a cost recovery basis, with other federal departments which have long-term procurement requirements in areas of DOC technological expertise.

4.4.4 The DND relationship

The Department of National Defence is the largest single client of the Research Sector aside from DOC itself. The literature is generally in agreement that, the more legitimate the government need, the more effective is the R & D by a government lab trying to meet that need. In the literature, defence needs are viewed as having a very high order of legitimacy and as being a very appropriate focus for R & D by a government lab.[1]

A description of the interaction: Under the 1969 agreement between the then Ministers of Communication and National Defence, the Sector is required to carry out a series of R & D tasks for DND. All branches of the Sector are involved in DND work. The tasking mechanism under the agreement has been formal, and has involved individual task sheets for projects and periodic progress reports. In the past, projects have generally involved applied research and been defined in sufficiently broad terms that it was possible to build a research program around them which was consonant with both DOC concerns and DND requirements.[2]

In 1984-85, the Sector will spend about $4.2 million in DND funds -- roughly 60 per cent on contracts to industry, 30 per cent on equipment and 10 per cent for travel and miscellaneous items; all of this money is spent through DOC procurement channels. In addition, DOC scientists act as scientific authorities on about $1.7 million in contracts let and administered through the Defence Research Establishment Ottawa. None of these funds appear in DOC budgets.

In 1984-85, DOC budgeted 54 person/years (33 professional and 21 technical staff) to carry out these activities. In return, DOC will recover from DND an amount equal to the cost of their salaries, as well as an overhead equal to 76 per cent of salary costs to cover indirect expenses. In 1984-85, this will amount to about $3.9 million.

Under the agreement, DOC is also expected to provide the infrastructure needed to carry out this R & D activity. To this end, DOC has budgeted some $120K in goods and services and $284K in capital expenditures. In addition, DOC also provides site services to the defence research establishments on the CRC site.[3]

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1 See, for example, Nelson and Langlois, op. cit., p. 816.

2 Interviews with Research Sector Personnel, Summer and Fall 1984.

3 Jacques Marcotte, "Military R & D Programs at CRC" (Memorandum to John Sifton, October 10, 1984.

Problems with the arrangement: Since the inception of the agreement, DND had expressed doubts about the level of resources DOC would commit to support this infrastructure.[1] In the past year, this complaint has intensified and DND has also raised questions about the security implications of having such work carried out by a non-military agency. However, this criticism is usually accompanied by expressions of satisfaction about the technical quality of the work carried out by DOC;[2] indeed, DOC researchers recently received a DND award for their work on the Search and Rescue Satellite (Sarsat) project. In addition, Research Sector managers say they have detected no dissatisfaction among most of the DND technical personnel with whom they routinely deal on projects. They state that the restiveness with the relationship would seem to stem from the senior levels of DND.[3]

This restiveness is reflected by DND steps to establish their own research sections in house to deal with areas where the Research Sector has expertise.[4]

Perhaps as a result of this dissatisfaction, DND has tended in recent years to require the Sector to conduct a larger number of small projects which tend to be much closer to the near-term end of the development spectrum than has been the case in the past.[5] Indeed, according to Price Waterhouse, 67 per cent of the person/years devoted to military projects are involved in "experimental development", while only 21 per cent are engaged in "applied research" and nine percent in "fundamental research"; in all other areas areas, the proportion devoted to "experimental development" is much lower.[6] This recent tendency of DND to support under tight controls small projects towards the near-term end of the development spectrum tends to diffuse the focus of the Sector's research program.

Clearly, DOC also has some grounds for dissatisfaction with the way the agreement is now working. However, the issue is not whether DOC or DND has failed or not failed to live up to the 1969 agreement. Rather, it is whether that agreement provides an effective basis for DOC/DND co-operation in an environment which has changed profoundly in the last 15 years. In many ways, the present malaise may be explained not just by DND's enduring dissatisfaction with the arrangement but by the fact that the agreement no longer provides a framework for a co-operative approach to defence-related research in the broad radar and communications area.

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1 "Scientific Operations," p. 1, in Appendix A of letter from Leo Cadieux,Minister of National Defence, to Eric Kierans, Postmaster-General (January 9, 1969).

2 In April 1984, the Department received a letter on this subject from D.B. Dewar, Deputy Minister of National Defence, and from J.R. Killick, Assistant Deputy Minister (Materiel). More recently, the matter has been raised by the deputy ministers of both Communications and National Defence with the Clerk of the Privy Council.

3 Interviews with Research Sector Managers, Winter and Fall 1984.

4 Loc. cit.

5 Loc. cit.

6 Price Waterhouse, op. cit., Exhibit 2.

An outmoded agreement?: An examination of the agreement indicates why.

A careful reading indicates that it was not intended to provide a clear mandate for defence-related research at DOC. For the most part, it deals with the disposition of 1969 projects and specific arrangements pertinent to the transfer of the research establishment. Its provisions for updating those activities deal with process rather than substance. Clearly, the procedures in question are not working very effectively now. In addition, in the absence of a review of the over-all direction of defence-related research in the context of the larger focus of the program, changes in the defence-related aspects of the program are inevitably incremental and to some degree ad hoc -- and not a positive force in assuring a clear focus of the program.

In the last 15 years, the importance of defence research in the areas of radar, communications, informatics and space has grown enormously. The rapid pace of technological advance in these areas has enormous implications in the defence area and has spawned a range of important new applications.[1] The government is also committed to enhancing Canada's outmoded defence capabilities. It should also not be forgotten that the commercial spin-offs for Canadian industry from defence-related research in the communications and radar areas can be very sizeable, especially in terms of exports. In the United States, for example, projected defence expenditures in the communications area will likely represent 37 per cent of the total U.S. market for communications equipment.[2]

There is in fact a strong case for expanding the program of defence-related applied research and long-range development at CRC, both to meet DND requirements and to provide the technological basis for Canadian companies to take advantage of the sizeable commercial opportunities.

However, it is very unlikely that such an expansion would occur in the context of the present agreement, given DND's uneasiness with the arrangement.

Another consideration is the degree to which DOC research expertise should be militarized. While there are important synergies between military and civilian research, specialized military applications are for the most less generalizable to the commercial marketplace than civilian government requirements. As the U. S. Congress Office of Technology Assessment (OTA) pointed out, "Science policy experts interviewed by OTA were almost universally concerned about this resurgence of DOD (Department of Defense) funding for R & D, and for information technology R & D in particular. Comparing the current situation to the post-War era when DOD research funding was also dominant, they point out that current research is generally much more mission-oriented and, consequently, less productive for non-military

1 Research Sector, The Sectoral Environment for Research and Development in Telecommunications, Space and Informatics, "Military Communications," (Unpublished draft, July 13, 1984).

2 Loc. cit.

uses. Some argue that we are endangering our international competitiveness in the long term by monopolizing the information technology R & D community with defense-related projects. Others point out that it is unwise to have a monolithic source of funding for any area -- e.g., certain technical approaches may tend to be ignored -- and argue that the current situation desperately calls for a civilian balance to DOD's funding."[1]

Clearly, it is important to strike an appropriate balance between civlian and military research in the information technology area. It is equally clear that a small country such as Canada cannot afford to divide its resources and reduce its critical mass in these key technological areas.

Conclusion: The 1969 agreement with DND is clearly outmoded and never in fact provided a clear strategic focus for defence-related research by DOC. Fundamental questions can also be asked about the nature of the over-all relationship in the context of the changed environment and the growing importance of such research. For all of these reasons, there is a clear need to undertake a comprehensive review of the relationship, with a view to either terminating it or placing it on a significantly firmer footing.

4.4.5 Other government clients

The Research Sector carries out work for a number of other departments and agencies. At present, the largest proportion of such work is carried out by the Space Technology and Applications Branch.

Other government clients for space R & D: As a result of the large DOC administered programs such as Hermes and Anik B, the Department's old Space Sector built up a formidable expertise which the present Research Sector took over in 1983. This expertise is being increasingly called upon by other federal departments and agencies[2] to help them carry out their missions in the space area through work on spacecraft systems and a wide variety of applications and systems.

As a result, the Branch has become the de facto centre for expertise in space technology and the design and implementation of spacecraft systems.[3] The clients of the branch include DND, Energy Mines and Resources, the National Research Council and a number of other federal departments and agencies. In addition, both the Canadian space industry and other federal departments and agencies makes extensive use of the David Florida Laboratory, which is the only Canadian facility offering the facilities for integration and environmental testing of complete large spacecraft, as well as their systems and sub-systems.

In addition to providing advice and expertise, the Branch carries out long and near-term development in house for these departments and agencies.

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1 OTA, op. cit., p. 296.

2 In addition to suporting other departments, the Sector continues to carry out and sponsor R & D designed to sustain Canada's successes in the satellite communications area -- particularly through the development of new technology for 14/12 GHz and 6/4 GHz satellites of the 1990s and new mobile and EHF satellite comunications systems.

3 Interviews with Research Sector managers, Summer and Fall 1984.

The Branch also provides advice and scientific authorities for contracts let by government clients.[1]

Most of this work is carried out in the context of formal arrangements and agreements with the user agency. Often the work is carried out on a cost recovery or shared basis.[2]

The major difficulty with these arrangements is their ad hoc quality. They emerge in response to specific user department requirements, and that department's decision -- not always predictable -- to draw on the expertise of DOC. This situation renders quite difficult long-term planning by the Research Sector in the space area.[3]

It should be noted that these requirements are defined in the context of the government's five-year Space Plan, which is developed by an interdepartmental committee on space. But this plan is less a clear statement of government priorities than a loose framework for permitting each department to pursue its own interests.[4] In passing, it is worth noting that it is the Assistant Deputy Minister Technology and Industry (ADMTI) rather than the Assistant Deputy Minister Research (ADMR) which represents the Department on this committee. Given that DOC is still the largest single government player in the space area and that satellite communications remains the only truly commercial application of space technology,[5] a strong case can be made that ADMR should have been on the Committee as well.

Such a change, though it might have made the committee more responsive to Research Sector concerns, would not eliminate the fundamental problem -- that of providing what is almost a common service function without any formal recognition of that role. Since in these circumstances other government departments can always look elsewhere, long-term planning in light of anticipated requirements is a very problematical exercise.

For this reason, it is recommended that recognition be sought ~~from Cabinet~~ for the common services role of the Department's space R & D program as the centre of expertise within the government on space technology R & D and the design and implementation of spacecraft systems. Once such recognition is gained, the space R & D program should provide all its services to other federal departments and agencies on a cost-recovery basis.

Non-space work for other federal departments and agencies: In the past, the Research Sector has carried out applied research and long-range development in the informatics, telecommunications and broadcasting areas for a number of other federal agencies, including:

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1 Loc. cit.

2 Loc. cit.

3 Loc. cit.

4 Loc. cit.

5 Research Sector, The Sectoral Environment, "Space Branch Input to Strategic Overview."

-- the RCMP in the area of mobile data communications,

-- the Department of Indian and Northern Affairs to extend communications services in the North,

-- the CBC, in the context of Project Iris,

-- the Department of Transport, in the areas of radar and mobile communications.

The new communications and informatics technology represents a powerful tool for improving the efficiency and effectiveness with which these federal departments and agencies, not to mention others, carry out their mandates. **For this reason, whatever organizational option set out in Chapter 5 is selected as a framework for the DOC research program, the program should operate in a considerably more proactive, even entrepreneurial, manner in identifying the needs of other federal departments and agencies and in opening formal discussions on how these needs might be met by the program. To the degree possible, whatever DOC R & D activities flow from the resulting formal arrangements should be conducted on a cost recovery basis.**

Conclusion: The DOC research program now operates as a *de facto* common services agency with respect to the support it provides other federal departments and agencies in the design and implementation of spacecraft systems. Cabinet recognition of this role should be sought so that it can be carried out with maximum efficiency on a cost recovery basis.

The DOC research program should also be considerably more proactive in identifying the needs of other federal departments and agencies in the other technological areas where the Department has expertise. If such needs can be met by CWARC and CRC in a manner which strengthens the internal synergy and coherence of the over-all research program, then the managers of the DOC-sponsored research program should conclude formal arrangements with the user department to meet those needs on a cost recovery basis to the degree possible.

4.4.6 Conclusion

As Figure 4-2 shows, roughly one-third of Research Sector resources are employed in meeting governmental objectives (excluding industrial development objectives, which will be addressed in the next section). This amount is split roughly in half between work in support of DOC and that in support of other federal departments and agencies. No formal strategy or conscious decision has determined this level of activity to meet government needs. Rather, this level of support has evolved in an ad hoc, program-specific, often project-specific fashion over the last 15 years.

The strategic basis for making such a decision does not exist at present. Certainly, applied research and long-range development work to meet government needs is what government labs can do most effectively, and such needs clearly exist in the strategic technological areas of communications, informatics and space. It has been the burden of this section of the chapter to describe the process which could provide a firm strategic basis for determining the level of DOC's commitment to meeting government needs through R & D in these strategic technological areas.

More specifically, we have called for:

-- extensive, formal collaboration between the DOC research program and other DOC sectors to identify their long-term needs in concrete terms (both as users of research results and as officials concerned with the definition and fulfillment of policy objectives) and to develop formal, regularly updated research plans and programs to meet those needs, with adequate provision for accountability;

-- a clarification of the authority for GTA's expanded role, a greater commitment of resources to applied research and long-range development by GTA, and formal collaboration with GTA to develop a research program to meet its long-term procurement needs, with provision for adequate accountability;

-- formal consultations with DSS to define the government's long-term procurement needs in these strategic technological areas and to target potential client departments, with a view to supporting the procurement activities of these departments with a program of applied research and long-range development;

-- a comprehensive review of the DND relationship;

-- Cabinet recognition of the role of DOC's program of space R & D as the federal government's centre of expertise in the design and implementation of spacecraft systems; and a more proactive approach to identifying the needs of other departments in other areas of technological expertise, with a view to concluding formal arrangements to provide support on a cost-recovery basis.

In our view, these steps would help realign the DOC R & D program in relation to concrete government needs and build into it a much clearer results discipline and client orientation into the program. But these represent only one dimension of possible need with this goal in mind. Chapter 5.0 sets out a range of options for reorganizing the program and some of these will also contribute to the program's responsiveness to government needs.

An R & D program which is responsive to government needs is also one which can have important industrial benefits. Indeed, as shall be seen in the next section of this chapter, a clear perception of government R & D needs is one of the basic preconditions for an effective government R & D program intended to support the government's industrial development objectives in these strategic technological areas.

4.5 ROLE VIS-À-VIS INDUSTRY

Government sponsored R & D programs should only carry out work on behalf of industry if, as the Wright Task Force pointed out, "it is in the national interest and if:"

- "the risks or expenditures involved are too high, or the potential payoff too small or too far down the road, to attract private industry;
- "the industry is too fragmented to conduct the necessary R&D."[1]

Within this context, the most effective focus for goverment sponsored R & D will be on projects intended to meet government needs, but with potent commercial implications. Government R & D programs should conduct only long-range development or applied research in house, and contract out to industry near-term development. Such programs could also involve the management of technical services and large multi-user facilities for industry when industry is unable to provide these itself. In all cases, the direction of such work on behalf of industry should be driven by a clear sense of industry's needs.

The literature and the Wright Task Force have, of course, raised fundamental questions about the effectiveness of government labs as tools of industrial development. These questions cut to the core of the interaction between industry, the Research Sector and DOC's Technology and Industry Sector. They revolve around:

- the nature of the industry to be served,
- the insulation of government labs from market forces and the respective R & D roles of industry and government,
- the quality of the interaction between the government lab and the industry.

4.5.1 The nature of the industry

In the view of the Wright Task Force, government labs should support fragmented industries -- that is, industries characterized by small companies with presumably a negligible capacity to conduct their own R & D. Canada's communication equipment industry is, of course, dominated by the Bell Canada - Nortel - BNR complex. The aerospace industry is more fragmented, as is the office equipment industry.

However, all of these industries are very R & D intensive. Bell Northern Research is, of course, the single most important R & D player in

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1 Wright Task Force, *op. cit.*, p. 26.

Canada, conducting 7 per cent of all the R & D in the country.[1] Figure 1-5 illustrates BNR's overwhelming dominance in the area of communications R & D.

As already noted, the technology in all of these area is evolving very rapidly and often in fundamental ways. For firms to remain competitive, they must stay abreast of this technology. Large firms such as BNR have the resources to have a fighting chance to keep up, though -- as noted in Chapter 1.0 -- they are not always as innovative as smaller companies. However, these smaller companies often do not have the necessary resources either to keep abreast or to do much other than near-term and product development work. Government support, in one form or another, is therefore crucial.

As a consequence, **the Research Sector largely focuses its work in areas where BNR is not working and aims its R & D support at small and medium-sized firms. This seems a defensible posture.**

4.5.2 In house R & D

As the Wright Task Force emphasized,[2] the in-house activities of government R & D programs should focus on work which is sufficiently long-term and/or high-risk that industry would not be able to carry it out.

As noted just above, in communications equipment, satellites and informatics, the technology is evolving very rapidly and it is often difficult for small and medium-sized firms to keep abreast. Because of their limited resources, the focus of these companies is generally on development work which is rarely more than two years from fruition in a product. Indeed, according to the Canada Consulting Group in a recent report to DOC, even Northern Telecom does not operate on a large enough scale to stay on the leading edge of the technology with its in-house effort alone[3] -- a necessity if it is to retain its position in foreign and domestic markets. Indeed, Northern Telecom has acknowledged in its publications that it looks to government labs, universities and industry labs around the world for the research base on which it founds its more applied efforts.[4]

It would seem, then, that the DOC R & D program does have an industrial development role, serving in particular small and medium-sized firms. **Given, however, that the industry in question is highly R & D intensive, with a strong orientation towards product development work, the role of any DOC-sponsored program would seem to lie in conducting applied research or long-range development in house which benefits the industry.**

As already noted, after a decade of moving ever further into the product development area, the Research Sector has now begun to place much greater emphasis on applied research. This new emphasis is appropriate. Clearly, **any DOC sponsored R & D program should continue to move away from**

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1 CCG, Research: Strategic Situation, p. 21.

2 Wright Task Force, op.cit., p. 26.

3 CCG, Research: Strategic Situation, p. 7.

4 Northern Telecom, op. cit.

the product development end of the spectrum -- emphasizing the development of new ideas and concepts which industry will then take over.

A program driven by government needs: As noted in Chapter 2.0, government labs, because of their relative insulation from market realities, are generally not terribly effective when doing research for industry. They are effective, however, when government itself is the "user-demander" of the technology. For this reason, if government sponsored R & D programs are to contribute to industrial development, their priority focus in house must be on applied research and long-range development in areas which respond to precise government needs and have significant commercial potential.

The significance of this intersection can be seen by comparing the successes of Telidon and the space program during the 1970s. Both involved technologies largely developed inside the Department and both involved extensive transfers of technology to industry. The space program, however, was driven by a powerful public policy need -- to extend basic communications services to Canadians in remote and rural areas -- and the government and Telesat Canada (which is half owned by the government) were the major domestic procurers of the technology.[1] In contrast, the goals of the Telidon program were very much oriented towards industrial development; and, though there was a serious effort to find, test and implement government applications for the technology, these efforts were essentially intended to contribute to the industrial development objectives.[2]

It is instructive to note that the space program has resulted in the establishment of a strong Canadian space industry with significant export potential. In contrast, Telidon, though it has been accepted as a North American and international standard and penetrated a number of specialized business markets, has never won the widespread consumer acceptance which had been predicted, though there are now some indications it may achieve some success because of the growing market for personal computers.

In our interviews, Research Sector personnel stated that at present most Research Sector projects are driven by a combination of government need and industrial development objectives.[3]

However, **as Section 4.4 of this chapter demonstrated, there is a clear need for a more formal and collaborative process to identify long-range government needs more precisely -- especially in the procurement area -- and shape the research program to meet those needs. Such a process will provide the foundation for an effective program to meet industrial objectives. For it is in areas where government needs intersects with commercial potential that projects are most likely to contribute to industrial objectives.** Chapter 5.0 suggests a range of organizational options which could contribute to the effectiveness of such a process.

Links with industry and the Technology and Industry Sector: Though in-house research programs must be clearly and compellingly tied to government needs, they must also be informed by an awareness of the capabilities of Canadian

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1 Interviews with Research Sector Managers, Fall and Winter 1984.

2 *Loc. cit.*

3 Interviews with Research Sector Personnel, Summer and Fall 1984.

industry and external market realities if they are to serve industrial development objectives effectively. In order to achieve this awareness, the DOC R & D program should have extensive formal links with industry and take full advantage of the expertise of the Technology and Industry Sector. In addition, the earlier the involvement of a company in the development of a technology or application, the greater are the chances of a successful transfer of the technology or application to the company.

The Research Sector does have a goods and services budget to support such contracting out. In our interviews, all Research Sector managers stated that they had a policy of contracting out applied research and long-range development work to industry for this reason, though they also emphasized that many companies lack the capabilities or simply are not interested in becoming involved this early in the R & D process.[1] In the absence of a management information system and a survey of relevant companies, it is difficult to determine the effectiveness of such contracting out activities. However, the value of all contracts managed by Sector personnel -- including those managed on behalf of other Departments -- represented in 1983/84 31 per cent of the Sector's entire budget.[2] Certainly, whatever organizational option set out in Chapter 5.0 is selected as a framework for the research program, the practice of **contracting out applied research and long-range development work to industry, with a view to easing the ultimate transfer of the technology, should be continued and used more frequently when a company has the interest and capability to do the work.**

It should not be forgotten, though, that such arrangements can give a firm a clear advantage in developing the technology. For this reason, to the to the degree possible, **open tendering should be the rule.** For the same reason, assessment of possible contract recipients should include a consideration of not just their technical capacity but also their financial strength and marketing capabilities to ensure that they will be able ultimately to take advantage of the transferred technology.

While personnel in the DOC R & D program should be in a position to assess technical capabilities, the Technology and Industry Sector has a legitimate role in assessing financial and marketing strengths. However, this role will have to be carefully thought out. Speed, flexibility and timeliness are crucial in the area of technology transfer,[3] as is a willingness to take risks. A second layer of bureaucracy could result in delays and risk-averse behaviour, as the Wright Task Force has pointed out.[4] In this context, it should not forgotten that the people who became the very successful SED Systems, in part because of DOC support in the form of contracts, would not have won those initial contracts if financial and marketing criteria had been strictly applied. In short, increased awareness of risks should not provide an excuse for their elimination.

While interaction between the two sectors on particular projects will be important, it should also take place on a more general level. The

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1 Interviews with Research Sector Managers, Fall and Winter 1984.

2 R. E. Barrington, "Contracting out in Research Sector," (Unpublished memorandum to A/ADMR, February 5, 1985), p. 4.

3 MOSST, <u>Technology Transfer by Department of Communications</u>, pp. 8, 9.

4 Wright Task Force, <u>op. cit.</u>, p. 5.

Technology and Industry Sector is developing a capability for assessing technology trends in the context of commercial potential.[1] Linkages between the two sectors should ensure that technology assessments have some impact on the the general thrust and direction of the research program. However, in this context, it should be noted that identification of a technological possibility by the research program will likely precede a technology assessment by the Technology and Industry Sector.

Links with industry are also important to ensure that the direction and thrust of applied research and long-range development activities to meet government needs is fully responsive to industrial capabilities, interests and market realities. At present, the Sector has a wide range of informal links with industry and -- according to Sector managers -- these do provide important input into the program.[2] As already noted, the plans for CWARC specify that half of the research staff should come in on a two or three-year terms from industry. Greater use of such mechanisms should be made by the rest of the DOC R & D program.

More important, there should be formal mechanisms which would permit industry to advise on and review the relevance of the applied research and long-range development program in the context of government needs, as well as to assure greater accountability to industry.

The Communications Research Advisory Board, which was suspended at the time of the CCIS initiative, does not provide an appropriate model. It was large and unwieldy and was not structured so as to provide a very meaningful review of DOC's highly specialized and very diverse research program.

The WARC advisory committee, which focusses on a single subject area, may well provide a useful model, given that we are told by WARC managers that this committee is expected to exercise an effective influence over the direction of the program.[3] It is possible to go even further. Chapter 5.0 outlines a number of organizational options which would permit a more intensive look by industry at each major subject area concentrated on by the Department, thereby permitting more focussed advice. These options range from a system of advisory committees, to actual managerial responsibilities by industry representatives, to varying degrees of privatization.

In this respect, it should be noted that the lack of effective formal mechanisms for assuring industry input on the in-house program of the Sector has meant that industry has very little understanding of what the Sector does. Though industry representatives tended to praise individual projects and programs administered by the Sector, they have expressed ignorance or criticism about the over-all direction of the in-house program.[4] For this

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1 Interviews with Managers of other DOC Sectors, December 1984-February 1985.

2 Interviews with Research Sector Managers, Fall and Winter 1984.

3 Interviews with Research Sector Managers, Fall and Winter 1984.

4 Price Waterhouse, <u>op. cit.</u>, p. 4.

reason, it is of vital importance that the Sector hold formal consultations in the next year with the industries to which its work relates, with a view to establishing a consensus on the direction of its entire program. Such formal consultations, which could be institutionalized through the various organizational options put forward in Chapter 5.0, would lay the basis for a strategic consensus among public and private sectors on the R & D emphases which should be pursued -- the first step towards assuring that a small country such as Canada can develop, through the co-ordination, sufficient critical mass in strategic technological areas to compete in an increasingly globalized marketplace.

The Department's Technology and Industry Sector also has a role in ensuring that the broad direction of the in-house applied research and long-range development program is responsive to industry. One of the Sector's most important responsibilities are technology assessment and the development of industrial strategies in these key technological areas; it also has program responsibilities in the technology transfer area. The Sector's sense of industrial and market realities, domestic and international, must inform the DOC research program, both to strengthen the program and to ensure that is in harmony with the application programs of the Technology and Industry Sector.

Steps have already been taken to begin formal collaboration between the Research and Technology and Industry Sectors in a long-range planning context. Initial meetings were held last year at operational planning time, and a more elaborate series of meetings are being held this year.[1] This collaborative process must be intensified and be supported by formal mechanisms. Various options in this respect are outlined in Chapter 5.0.

Conclusion: The in-house program R & D of the Department must focus on applied research and long-range development -- that is, work which is too long-term or too risky for industry to want to undertake. The greatest industrial benefit will result if the Sector focusses on work of commercial potential which meets government needs. This intersection of government need and commercial potential can provide important leverage for the company to which the technology is transferred, as shall be seen below.

However, these industrial benefits can only be achieved if the research program is informed in an ongoing way by a more realistic sense of commercial potential. In our view, the present mechanisms for assuring this are not insufficient. They should be supplemented by initiation in the next year of a formal process of consultation on the direction of the program, with a view to achieving a strategic consensus on the direction of the program and how it can complement industry R & D activities. Also important is an intensification of the formal collaboration with the Technology and Industry Sector in a long-range planning context.

Enhancement of these two activities would increase the accountability and responsiveness of the DOC R & D program to both industry and the Technology and Industry Sector. A number of organizational options are put forward in Chapter 5.0, and some of these would have the effect of improving even further the responsiveness and accountability of the program to both the Sector and industry.

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[1] Interviews with Managers of other DOC Sectors, December 1984-February 1985.

4.5.3 Near-term development and the transfer of technology

As the literature tells us, the further work progresses towards the product development end of the R & D spectrum, the more crucial manufacturing and marketing considerations become. Even in the case of research to meet government needs, government labs encounter serious difficulties in dealing with these manufacturing and marketing considerations. Industry labs far excel them in this near-term development work and there is no reason why they should not benefit from such work in any case. For this reason, once a project has progressed to the near-term development end of the R & D spectrum, it should be transferred to industry.

The transfer of technology is, of course, a delicate and complex process. It must be timely and not subject to long delays during which the potential commercial opportunity might disappear. It must be fair, and not involve giving one company an inordinate advantage over another. It involves a calculated risk, which revolves around the realism of the market projections for an uncreated product and around the technical, financial and marketing capabilities of the firm to which the product has been transferred, as well as perhaps the genuineness of the firm's interest in seeing the technology transformed into a marketable product.

In many ways, the complexity of the technology transfer process raises fundamental questions about the respective roles of the Research Sector and the Technology and Industry Sector and their mutual interaction within DOC.

Description of Research Sector activities: All Research Sector interviewees agreed that, once an application progresses to the near-term development end of the spectrum, it becomes a candidate for transfer to industry and usually is transferred if there is a taker.[1]

There was some debate as to the precise stage at which the actual transfer should take place. Some Sector managers argued that it should occur once a "breadboard" has been created -- that is, once the basic concept for the application had been demonstrated. Others stated that it should occur once a "prototype" has been built -- a rough outline of what a potential product might be like. The prevailing view was that the stage to be reached would depend very much on the technical capabilities and orientation of the potential companies to which the technology would be transferred.[2]

All technology developed in the Research Sector belongs to the Crown, and, if patentable, becomes a Crown patent. Thus, technology transfer often involves the licensing of the technology to a company through Canadian Patents and Development Ltd. if there are takers. The royalty and license fees are usually small to maximize the industrial benefit. The in-house researcher who developed the technology receives a portion of the license fees.

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1 Interviews with Research Sector Personnel, Summer and Fall 1984.

2 Interviews with Research Sector Managers, Fall and Winter 1984.

In order to limit the risks and strengthen small and medium-sized firms in these strategic technological areas and to ensure that government needs for the technology are met, the contract mechanism is employed to subsidize the near-term development and sometimes product development work of the company to which the technology is transferred.[1]

In our interviews with Research Sector managers, we were told this was exactly what they did[2]. A number of different programs and mechanisms are used to this end.

Nearly every project in the Sector has a **goods and services budget** which is used for both contracting in and contracting out. However, the amount of money available per researcher is not large. We were told, for example, that in the Space Branch, only about $25,000 were available per professional researcher to support contracting out and in -- a level significantly lower than that of other comparable laboratories.[3]

There are also a number of programs, operated by both DOC and other Departments which support contracting out.

The **Technology and Industry Sector** operates several programs -- space applications, M-Sat, Telidon and Office Communications Systems, to mention only a few -- which involve extensive contracting out of technology development to industry. The Research Sector provides technical support and sometimes the scientific authorities for these contracts.[4]

The Research Sector itself administers a **Program for the Development of Space Sub-Systems and Components** (DSSC), which has a budget of about $3 million a year. Established in 1976, the program supports contracts to Canadian industry for the purpose of developing specific space subsystems and components which have a high probability of being required in future Canadian and foreign satellite systems, and which are required by DOC to fulfill its mission.

DOC -- and, in particular, the Research Sector -- is involved in about $3 million a year in contributions under the NRC's **PILP** program. Though the program generally supports the further development of concepts originated in industrial labs, it also represents a means by which knowledge or support needed by the industry for its projects can be transferred from the Research Sector.[5] Under one component of the program, however,

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1 MOSST, Technology Transfer by Department of Communications, p. 48.

2 Interviews with Research Sector Managers, Fall and Winter 1984.

3 Loc. cit. and Research Sector, The Sectorial Environment, "Space Branch input to Strategic Overview.

4 Interviews with Research Sector Personnel, Summer and Fall 1984.

5 Interviews with Research Sector Personnel, Summer and Fall 1984.

technical teams from industry are encouraged to work in government labs.

The Research Sector is also involved in about $2.5 million in contracts under the **Unsolicited Proposals Program** of the Department of Supply and Services. Again, though there are exceptions, the program generally supports the further development of ideas originated in industrial labs which may meet government procurement needs.[1]

DOC researchers also act as scientific authorities on about $3 million in DND contracts.

There are a number of other programs administered by other federal departments and agencies in which the Sector provides scientific authorities and technical support.

In 1983-84, DOC funded $5.8 million in research contracts and provided scientific authorities for another $6 million in research contracts let by other federal departments and agencies. The value of these contracts represented 31 per cent of the total cost of operating the Research Sector.[2] There are no comparable figures for other government research establishments, though it is improbable any other establishment -- with the possible exception of NRC -- would act as scientific authorities on so many contracts for other federal departments and agencies.

The contract mechanism is not, of course, the only one used by the the Research Sector to transfer technology to industry. It also employs publications and the conveyance of information through its range of informal contacts within the industries with which it has dealings, as well as the mechanisms described in the previous section.[3]

A good record for a government lab: There are fairly solid indications that the Research Sector has a better record than most other government labs in the area of technology transfer and contracting out.

For example, one of the most important beneficiaries of government research contracts in the space area during the late 1970s and early 1980s was SED Systems Inc., which grew over the last decade from a research unit of the University of Saskatchewan to a major exporter of satellite communications equipment with annual sales of $34 million in 1982. These are projected to rise to from $60 to $70 million by 1987.[4]

According to an analysis prepared by the company, between 1977 and 1982, government contracts valued at $15 million resulted in spin-off commercial contracts valued at $52 million, not to mention additional benefits in terms of spin-off companies and products. The ratio of value of government contract to that of commercial spin-off contracts was by far the highest with DOC contracts. The ratios ranged from 1 to 3 in the case of NRC

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1 Loc. cit.

2 Barrington, "Contracting out in Research Sector," pp. 3, 4.

3 See also MOSST, Technology Transfer by Department of Communications p. 48.

4 SED Systems Inc., SED Systems Inc. (Prospectus published in 1984).

contracts, to 1 to 20 in the case of DOC contracts.[1] It is worth noting in this context that the Wright Task Force, in a report which was generally critical of the government's role in technology development and of government labs in particular, concluded that those early procurement-related R & D contracts to SED Systems represented the kind of innovative forward planning, and willingess to take risks to the benefit of industry, which should be a model for the government as a whole.[2]

There are other indications that the Sector's private sector clients tend to feel positive about its contracting out activities -- at least on the evidence of the interviews with industry conducted in conjunction with the evaluation, by the DSS Bureau of Management of Consulting, of the Research Sector Program for the Development of Space Subsystems and Components (DSSC). Indeed, the evaluators reported favourable industry comments "on the good relationships between industry and project teams."[3] For example, R. E. Mooney, vice-president of Sparton of Canada Limited pointed out, "the elapsed time between submission of our Unsolicited Proposal and contract award is very short, which is in sharp contrast to our experience with other programs. The result of comparing notes with friends in other companies is that DOC CRC has a very good track record in contracting-out to industry."[4] The evaluators concluded that the program was effective and should be continued.[5]

A number of other reports by other federal agencies have singled out the DOC research program as uniquely effective for a government lab in the area of technology transfer.

For example, according to the Economic Council in its 1983 report, <u>The Bottom Line: Technology, Trade and Income Growth</u>, "in the case of the Department of Communications, the (federal government's 'make-or-buy') policy seems to have been redundant, the department's contracting out activities having reached the saturation point by 1972."[6]

The Science Council of Canada, in a 1976 background study on <u>The Role and Function of Government Laboratories and the Transfer of Technology to the Manufacturing Sector</u>, pointed out that "The Department of Communications' research arm is one of the best examples of an organization which employs technology transfer to manufacturing as an intermediate step in the

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1 <u>Loc. cit.</u>

2 Wright Task Force, <u>op. cit.</u>, p. 14.

3 BMC, <u>op. cit.</u>, p. 34.

4 <u>Ibid.</u>, frontispiece.

5 <u>Ibid.</u>, pp, 41-43.

6 Economic Council of Canada, <u>op. cit.</u>, p. 46.

completion of its missions and therefore a fulfillment of its functions."[1]

In addition, in 1980, the federal Ministry of State for Science and Technology (MOSST) published a background paper, containing the case studies of eight innovations originally developed at CRC. These case-studies focussed on innovations originating in all the research-oriented branches of the Department. According to MOSST, the study "illustrates the role government laboratories can play in influencing the 'innovation process' to foster the development of the communications sector in Canada. The study shows clearly that, under the right conditions, opportunities exist for government and industrial laboratories to work together, and that work in government laboratories can supplement the development work being done in the private sector."[2] In other words, the CRC innovations were selected for study because they might provide a model for other government labs.

Clearly, a fairly strong case can be made that, in comparison to most other government labs, DOC's Research Sector has a relatively solid record in the areas of technology transfer and contracting out. However, given the Wright Task Force's observations on the serious ineffectiveness of government labs in this area,[3] such a comparison cannot be the source of very much comfort. Indeed, the Task Force provides a clear *prima facie* case that there is room for considerable improvement.

Indications of a need for improvement: There are also indications that there could be improvements.

For example, there would seem to be a lack of organizational focus to work conducted to benefit the private sector. Responsibility for co-ordinating the Department's involvement with other federal technology development programs, such as PILP, rests with the Research Policy and Programs Branch, but the resources available for this purpose are minimal.[4] Together, these programs represent very large sums of money which could have a significant impact on the industries with which the Sector deals. **Greater resources should be available for co-ordinating the Department's involvement with other federal technology development programs, and a systematic strategy should be worked out to clarify the Department's objectives in this area and to maximize the beneficial impact on Canadian industry.**

The actual management of other technology transfer activities is, for the most part, diffused throughout the Research Sector. Indeed, even though the Research Policy and Programs Branch provides administrative support for the Development of Space Subsystems and Components Program, the basic thrust

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1 Arthur Cordell and James Gilmour, The Role and Function of Government Laboratories and the Transfer of Technology to the Manufacturing Sector (Science Council of Canada Background Study No. 35, April 1976), p. 227.

2 MOSST, Technology Transfer by Department of Communications, p. i.

3 Wright Task Force, op. cit., p. 27.

4 Interviews with Research Sector Personnel, Summer and Fall 1984.

of the program is determined by the Space Technology and Applications Branch.[1]

This decentralized approach would seem to be appropriate, given that the expertise on different technologies is scattered throughout the Sector. However, even though considerable expertise in technology transfer has been developed within the Sector, it has never been codified or systematized in any formal way, nor has there been any systematic effort to draw lessons from past failures.[2] **There is a clear need to examine systematically the over-all experience -- including both successes and failures -- in technology transfer and see what lessons can be learned.**

For the most part, there has also been been no formal and systematic evaluation of the impact of the Sector's technology transfers on industry, either prospectively or retrospectively. As a result, it is difficult to be certain whether the very real achievements of the Sector in this area typify its over-all effort.

The only exception is the largely positive evaluation of the Program for the Development of Space Subsystems and Components (DSSC) conducted by the Bureau of Management Consultants. However, as the authors of the evaluation commented, "A number of problems were encountered which impose limits on the amount and usefulness of data collected during this study."[3] They went on to point out:

> "Within DOC, the difficulties can be traced mainly to the historic lack of a central record keeping system. This factor and the absence of standards for maintenance of detailed project files made it a rare occurence for a complete set of documentation to be available for any given project. This limited the ability of the evaluators to fully determine the rationale and justification for projects and to understand problems encountered during the course of the projects...."
>
> "The records which were available (including financial data) also often differed from one source to the next. Further, the older the project (and the more long term information available on impacts and effects), the poorer was the quality of historical information available. Most financial records have been archived and retrieval of this data from the central financial records on a project basis would demanded a prohibitive amount of effort....
>
> "Similar problems were encountered in the companies contacted. Most firms were either unable to supply the requested data on sales resulting from each DSSC project or heavily qualified the information submitted....

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1 _Loc. cit._

2 _Loc. cit._

3 BMC, _op. cit._, p. 31.

"Further complications are added by the inevitable unevenness between companies in their administrative and financial systems. The level of detail and degree of confidence in estimates of past sales, for example, was highly variable across the spectrum of companies contacted....

"Forecasts of future sales are even more unreliable....

"As with any evaluation study, the problem of determining incrementality (that the impacts and effects measured took place because of the program and not become of some other set of conditions or factors) is significant in this case. It has been noted that many projects enjoyed joint funding. Similarly, many of the companies involved were receiving money from other programs to assist with research on product development, areas not covered by the DSSC but obviously critical to the successful introduction of the subject product or technology to the marketplace. In most cases, company representatives were understandably reluctant to hypothesize about whether their firms would have underaken the project in the absence of government funding. In at least two instances, however, the companies were clear that they would have proceeded without assistance from DSSC. They did indicate that compromises would have been necessary...."[1]

The problem is not just a lack of the information needed to conduct a complete evaluation. In the absence of a sector-wide management information system (to be implemented in the coming year), it is even difficult (for both Sector managers and outsiders) to acquire a systematic understanding of the scope and nature of the technology transfer activities carried out by the Sector. The recently implemented process of periodic review of projects by Sector directors, directors-general and ADMR represents an important step in the right direction.[2]

Once the new management information system is implemented, middle and senior management in the DOC research program should be in a somewhat better position to track and evaluate their technology transfer activities. **This tracking and evaluation process should be combined, however, with a genuine examination of the ultimate industrial impacts of past and present technology transfer activities, with a view to developing a systematic and continually updated strategy for technology transfers. At present, the program lacks the capacity to learn in a systematic way from its mistakes and it must develop this capacity.**

Boundary with Technology and Industry Sector: Also crucial to successful technology transfer is the capacity to assess the technical, financial and marketing capabilities of the firm to which the technology is to be transferred, not to mention the commercial potential of the technology in the first place. While the research program can assess the technical capabilities of a firm, financial and market issues are beyond its purview. For this reason, it is vital that the research program formally collaborate

1 Ibid., pp. 31, 32.

2 Interviews with Research Sector Managers, Fall and Winter 1984.

with industry and the Technology and Industry Sector in the technology transfer area.

Though important steps have been taken to establish such a relationship with the Technology and Industry Sector, there are obstacles, mainly revolving around the raggedness of the boundaries between the two Sectors' areas of responsibilities.

The Research Sector now provides R & D support to the Technology and Industry Sector in its administration of the David Florida Laboratory,[1] a facility which industry uses on a cost-recovery basis. According to the Price Waterhouse study on the viability of CCIS, industry is generally supportive of Departmental policy in this area.[2] However, it is felt by some in the Research Sector that the technical project management of the lab should rest with the research program, while over-all program management should rest with the Technology and Industry Sector.[3] In the view of the Technology and Industry Sector, the service provided is a form of industrial support and the role of the research program is the conduct of research.[4]

The Technology and Industry Sector also manages a range of applications programs -- Telidon, M-SAT and space applications -- which demand a fairly high level of technical expertise as well as knowledge of marketing considerations, etc. In order to gain access to the required technical expertise, the sector employs formal tasking mechanisms in its relationship with the Research Sector. In the view of Research Sector managers, the formal tasking mechanisms which the Technology and Industry Sector does employ are not always conducive to either a coherent research program or stategy. While Research Sector managers generally accept that program responsibilities for technology-related industrial development activity rests with the Technology and Industry Sector, they argue that the Technology and Industry Sector usurps their technical responsibilities by lodging project management functions in technical areas with its own staff. In addition, the tasking mechanisms tend to involve Research Sector professional in small, peripheral activities on such projects, with the result that Sector resources become diffused and the development of an over-all research strategy complementary to an industrial development strategy becomes difficult.[5]

Technology and Industry Sector personnel respond that the proper role of the Research Sector is research and that financial and marketing factors are crucial to successful technology transfers and all programs intended to stimulate technology development in industry. On this basis, they argue that management of the Development of Space Systems and Sub-Systems Program, a number of proposed WARC activities and responsibility for co-ordinating

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1 F. Vigneron, "Inter-relationships between DFL and DSM," (Memorandum to A/DGSTA, June 3, 1985).

2 Price Waterhouse, op. cit., p. 5.

3 Interviews with Research Sector Personnel, Summer and Fall 1984.

4 Interviews with Managers from other DOC Sector, December 1984-February 1985.

5 Interviews with Research Sector Managers, Fall and Winter 1984.

Departmental involvement in other industry support programs should rest with the Technology and Industry Sector.[1]

The arguments are persuasive on both sides. However, the precise placing of the boundary is less important than the establishment of formal collaboration and a solid working relationship between the Technology and Industry Sector and the research program. However, there can be little doubt that resolution of the confusion over the boundary would contribute to a more effective interaction between the two.

In our view, a number of principles are relevant to the resolution of this boundary issue:

- questions of technical feasibility should be resolved through the research program; questions of commercial feasibility of a technology should be resolved through Technology and Industry activities and programs;

- where questions of commercial feasibility predominate but there are still important outstanding technical questions, the Technology and Industry Sector should have program management responsibilities while the research program should have technical project management responsibilties;

- where questions of technical feasibility predominate but there are important commercial feasibility issues, there must be effective formal collaboration between the research program and the Technology and Industry Sector.

Chapter 5.0 provides a number of options for how the relationship between the research program and the Technology and Industry Sector could be organized. Some of these options involve giving an organizational manifestation to these principles; others, in contrast, provide a more direct role for industry in determining the direction of research program activities in the area of technology transfer.

<u>Formal collaboration with the Technology and Industry Sector</u>: As already noted, important first steps have been taken to initiate a formal process of collaboration between the Research Sector and the Technology and Industry Sector. Whatever organizational option put forward in Chapter 5.0 is selected as a framework for the research program, plans to extend this collaboration must be acted upon so that a solid working relationship, both formal and informal, is established. Such a relationship is necessary to ensure that the Department, in its technology transfer and technology development activities, takes into account the full range of pertinent technical, commercial, financial and marketing factors.

It is worth emphasizing that the Government Telecommunications Agency in the Technology and Industry Sector should play a crucial role in this collaboration, given that the priority focus of the research program should be on meeting government needs and GTA will be an important vehicle to identify those needs in the broad telecommunications, informatics and

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[1] Interviews with Managers from other DOC Sectors, December 1984 - February 1985.

workplace automation areas. This focus on government needs has important advantages. Government sponsored research programs are most effective when they conduct research to meet government needs and in this respect have a distinct advantage over the private sector. Indeed, the involvement of a government lab in the early stages of R & D is one means of protecting the integrity of the procurement function, given that R & D is a risky endeavour at the best of times. At the same time, there can be important industrial benefits when the technology has commercial potential. If the company is brought into the R & D process quite early and encouraged to develop and sell the resulting product to the government, the company's competitive position can be significantly improved. More precisely, it can have access to government test-beds to refine the product, as well as some guarantee of a sizeable initial market -- both of which are fundamental considerations to any firm introducing a new technology into the marketplace.

The importance of GTA in this context only enhances the need for effective interaction between the labs and the Technology and Industry Sector. The nature of this interaction and the respective roles of the labs and the Sector can be modelled as follows:

- early identification of promising technologies and technological areas by the labs, as well as assessment of technical capabilities of Canadian firms,

- ongoing technology assessment resulting in definitions of commercial potential, government need and formulation of industry strategies by the Technology and Industry Sector, taking into account financial and marketing capabilities and potentials of Canadian firms,

- in light of the above information, the formulation and undertaking of applied research and long-range development projects by the labs, combined with ongoing assessment of technical capabilities of Canadian firms to which the technology might be transferred,

- intensive assessment by Technology and Industry Sector of financial and marketing capabilities of firms to which technology might be transferred,

- transfer of technology to a Canadian firm in light of assessment of technical capability by labs and assessment of financial and marketing capability by Technology and Industry Sector,

- technical support for firm from labs, including sometimes field-tests of technical feasibility,

- marketing support for firm from Technology and Industry Sector, including sometimes field trials to assess commercial feasibility and marketing strategies.

The process of interaction is, of course, simultaneously dynamic and cumulative, with feedback loops back to earlier stages, especially with a view to revising technology and industrial strategies.

Clearly, the formal collaboration between the labs and the Technology and Industry Sector will likely have a significant impact on all their activities, including all phases of the R & D cycle as carried out in the labs. A number of organizational options intended to assure effective collaboration will be outlined in the next chapter.

However, there are two important criteria which such collaboration must meet.

- it should result in the increased accountability of the research program, but not increased micro-management;

- it should not result in delays or risk-averse behaviour on the part of the Department in the area of technology transfer; the strength of the current research program has been its willingness to take risks -- collaboration must result in a clearer understanding of those risks, not their elimination.

Formal links to industry: As already noted, the Research Sector has a range of informal links with industry, as well as the formal links provided through contractual relationships. However, there is at present no formal mechanism which would allow industry to have systematic, ongoing input into R & D priorities and the direction of the program, or into the procedures and mechanisms employed in the technology transfer area.

The Wright Task Force, of course, argued "that the managers of each laboratory should be held accountable to their clientele."[1] This is especially important in near-term development work and technology transfer activity which can have such a direct impact on industry. It is also a view with which the Bureau of Management Consulting agreed in its evaluation of the DSSC contract program. In fact, the Bureau argued that the program would benefit significantly from more effective industry input into its operations.[2]

Chapter 5.0 suggests a number of organizational options which would have the effect of increasing the accountability of the program to industry, and even giving the private sector considerable influence over the direction of the DOC research program.

Conclusion: As a general principle, the DOC research program should contract out near-term development work to industry, with a view to ultimately transferring the technology to industry. In order to render explicit and improve the procedures it employs for technology transfer, the managers of the program should undertake an ongoing review of its technology transfer activities.

In order to assure the full consideration of the marketing and financial factors crucial to the translation of a transferred technology into

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1 Wright Task Force, op. cit., p. 29.

2 BMC, op. cit., p. 62.

a marketable product, the research program and the Technology and Industry Sector should extend and intensify the process of formal collaboration which already initiated. In order to ease this process, the present overlap in the roles of the research program and the Technology and Industry Sector should be clarified. In implementing this process of collaboration, the two should also be careful to avoid any increase in the micro-management of research activities and risk-averse behaviour in the area of technology transfer. Chapter 5.0 puts forward a number of organizational options which would clarify the boundary issues and provide a framework for collaboration.

In order to ensure that industry needs are being effectively met in the areas of near-term development and technology, the private sector must have formal input into the direction of the research program, especially in the areas of near-term development and technology transfer. The options outlined in Chapter 5.0 directly address this issue.

4.5.4 Conclusion

The DOC research program has a key role to play in assisting small and medium-sized Canadian industries in the strategic technological areas of space, informatics and communications. In carrying out this role, it should restrict itself in house to carrying out applied research and long-range development, with a priority focus on work intended to meet government needs in areas of commercial potential -- the only area where government labs would seem to have an advantage over industrial labs. Near-term development should be contracted out to industry, as should more applied research and long-range development.

In order to reposition itself vis a vis industry and identify commercially relevant approaches where appropriate, the DOC research program must:

- undertake extensive formal consultations with industry in the coming year,
- acquire mechanisms which will permit ongoing input by industry on a formal basis into deliberations on the direction and priorities of the program,
- intensify and extend significantly its formal collaboration with the Technology and Industry Sector.

A number of organizational options are put forward in the next chapter which would serve to improve the accountability and relevance of the research program to industry and to encourage a more productive working relationship with the Technology and Industry Sector -- especially the Government Telecommunications Agency.

4.6 AN INTERNATIONAL MONITORING AND DOMESTIC DISSEMINATION ROLE

Government labs have an important role in monitoring technology developments in other countries and disseminating the resulting information to public policy-makers and to industry.

As noted in Chapter 2.0, total Canadian expenditures on R&D in communications, both by government and the private sector, represent only two per cent of the world total.

4.6.1 Industrial Need

The Economic Council of Canada has recommended that the federal government put greater emphasis on the adaption of new ideas, products and processes already in use abroad and not in Canada.[1]

This need is particularly evident in the communications, space and informatics area where the technology is evolving so rapidly. Even Canada's largest communications-equipment firm, Northern Telecom, is dependent on R & D being conducted elsewhere in the world. As the Canada Consulting Group observed, "Northern Telecom has become big enough that it can no longer rely on existing technology for its product development. Northern Telecom's scale is not great enough to support the research necessary for leading edge development."[2] Northern Telecom and BNR have, of course, the resources to gather research intelligence from around the world. The same is not true for the many small and medium-sized companies working in this broad area.

4.6.2 Government Need

There is an equally pressing need within DOC. As noted in section 4.4 of this chapter, if DOC policy is to be relevant and effective, DOC policy-makers must have up-to-date knowledge of present and future development on the frontiers of communications, space and informatics technology around the world because of the globalization of the market for products and system in these areas. Every Sector of the Department saw this as a crucial need and some managers stated that, in the absence of such an information base, they would be doomed to taking a reactive rather than a proactive stance vis a vis the new technological developments which can have such a sweeping impact in their areas of responsibility.[3]

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1 Economic Council of Canada, op. cit., p. 80.

2 CCG, Research: Strategic Situation, p. 7.

3 Interviews with Managers from other DOC Sectors, December 1984 - February 1985.

4.6.3 Role of the research program

Such research intelligence can only be effectively gathered and analyzed by specialists, such as those in the DOC R & D program.

Their involvement in co-operative international research ventures is usually central because these are highly technical and usually negotiated on a government-to-government basis. In December 1984, the Department signed an agreement with NTT of Japan, calling for co-operation in the area of videotex standardization. The Department also exchanges scientists with NTT under a consultation agreement signed several years ago. Such arrangements can be an important source of research intelligence.

Attendance at major international scientific conferences is the most mechanism for gathering information on international developments. Such conferences are vitally important because it is often up to 30 months before the presentations made at such conferences are published.[1]

It should be noted that the most up-to-date and often most useful technical information is frequently not contained in formal presentations. Rather, such information is gained informally, and only if the person gathering the information has technical information to exchange in return.[2] The research activities of Research Sector scientists and engineers means that they have the necessary access to such information and thus makes them uniquely effective in conducting such a research intelligence function at international conferences.

However, in interviews, Research Sector personnel expressed the view that their unique intelligence needs were poorly appreciated in the framework provided by the Department for processing requests to attend international conferences.[3]

The various mechanisms employed for technology transfer now provide the means for information gathered in this way to be passed on to industry. However, it should be noted that there is no strategic and systematic focus to either the gathering or the dissemination of such information. Indeed, according to Research Sector scientists, present arrangements have posed severe obstacles to the quick and timely publication of the results of the Sector's own research.[4]

The International Collaboration Assistance Fund for Research on New Information Technologies, which is administered by the Sector, also provides a vehicle for exposing Canadian industry to new international developments. The Fund is intended to enable Canadian organizations, both public and private, to participate in international co-operative research projects on new information technologies. However, the Fund is too small to assist more than a few organizations a year.

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1 McBride, op. cit., p. 27.

2 Interviews with Research Sector Managers, Fall and Winter 1984.

3 Interviews with Research Sector Personnel, Summer and Fall 1984.

4 Loc. cit.

4.6.4 Conclusion

Whatever organizational option put forward forward in Chapter 5.0 is selected as a framework for the DOC research program, it should assume the role of gathering, analyzing and disseminating research intelligence from around the world for the use of Canadian industry and the other Sectors of DOC. In order to carry out this role, there is clearly a need to provide an organizational focus for research intelligence functions within the Research Sector, as well as a significantly less restrictive approach to approvals for attendance at scientific conferences, both here and abroad, by research program scientists. Mechanisms for the timely dissemination of such information within the Department and to industry should be jointly explored by managers of the research program, DGIS, DGPA and managers of other Sectors.

4.7 THE QUALITY OF VISION AND THE NOTION OF CRITICAL MASS

Research and development is most successful when it is driven by a clear, realistic and compelling vision of its ultimate importance to its users -- a vision which to the degree possible is shared by those users. For the vision to be credible, however, sufficient resources -- enough critical mass -- must be available to make the vision at least appear achievable. The vision itself may help in this respect -- by focussing a research program so that there are enough resources concentrated in crticial areas.

The formulation of such a vision is vital for a number of reasons.

It is central to the internal health and coherence of a research program. If provided in the context of active and energetic leadership, it can be a key force in motivating personnel, a fundamental consideration in an area such as R & D which is so dependent on the morale and creativity of its human resources. More important, such a vision, when married to a precise strategy, should provide the focus for a research program -- a coherent view of what it is about, and thus a shield against the multiplication of small and irrelevant projects which seems to afflict so many government labs. In other words, the vision itself can help ensure that an R & D program has sufficient critical mass.

Such a vision, when fleshed out as a strategy and as a range of specific research programs in light of public need and specific requirements, should serve as the basis for the accountability of a research program to the government as a whole, to industry and to the university research community. Indeed, if sufficiently compelling, it can serve as the basis for a more co-ordinated approach to strategic technological areas by government, industry and university establishments. Such co-ordination can, of course, increase the critical mass in those areas.

This section explores the quality of vision and the question of critical mass in the DOC research program.

4.7.1 Past visions

In the 1970s, two compelling visions of potential applications held sway in much of the Research Sector of DOC and provided the basic rationale for a significant growth in its resources.

Space: The first of these focussed on space and flowed from the clear and compelling need, identified in public policy terms, to extend telecommunications and broadcasting services to Canadians in rural and remote areas. Repeated studies and representations had demonstrated that the need was real and that the market for such services existed.

This vision of important applications, combined with a perception of clear public need, helped ensure that in 1972 Canada was the first country in the world to have its own domestic commercial satellite communications system operated by a special instrument created for that purpose -- Telesat Canada, a corporation jointly owned by the public and private sectors. The vision also encompassed the future, as can be seen in the Department's annual report of 1974-75: "Looking to the future, the Department is engaged in a number of projects designed to meet projected requirements for communications satellite systems in the 1980s and beyond."[1] The most important of these projects were, of course, Hermes and Anik B, and these resulted in a very sizeable increase in research program resources and ultimately the spinning off of space R & D -- as well as a range of space-related technology and industrial development programs -- into a separate Space Sector within the Department.

It is worth emphasizing that the vision involved the translation of this legitimate public communications need into specific government requirements which would drive the R & D program. More important, this synthesizing vision of an R & D program driven by specific government requirements in light of a compelling public need was sufficient powerful that a key secondary objective could be attained -- that of creating a largely Canadian-owned space industry which in 1982 sold 65 per cent of its products abroad, with the Canadian value-added averaging 75 per cent of sales.[2] Indeed, government-industry partnership -- and presumably a shared vision -- in applications-oriented activity was a feature of the Canadian space program from the very beginning.[3]

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1 Department of Communications, 1974-75 Annual Report, p. 11.

2 Space Policy Group, Aerospace Industries Association of Canada, Space - An Opportunity for Canada (Proposal submitted to Hon. Thomas Siddon, Minister of State for Science and Technology, on October 26, 1984), p. 9.

3 Ibid., pp. 1, 2.

There was also a strong element of personal leadership in the development of this synthesizing vision. As the Space Policy Group of the Aerospace Industries Association of Canada observed in October 1984 with respect to the period of the program's birth, "The period up to 1976 could well be called the 'Chapman era', where, largely through the efforts, charisma and foresight of one man, an embryonic industry was created in Canada."[1]

In many ways, the vision created during the 'Chapman era' sustained a space-related research program at DOC until the late 1970s and perhaps -- some would argue -- into the early 1980s.

Telidon: The Telidon vision was quite different, though perhaps almost as powerful in the late 1970s.

In the mid-1970s, the CRC had been doing applied research and long-range development on a class of problems associated with the transmission of graphic images along a voice-grade telephone line. At the same time, the British and French governments were allocating considerable resources to the development and commercial testing of videotex systems, which were then regarded as potentially the first widespread application of the new information technology in homes and offices. In 1977, it was realized that the work done at CRC could result in a superior videotex system.[2] Thus was the Telidon vision born.

What was this vision? The manager of the Telidon program in its early years, John Madden, writing in 1979, captures some of it, "Videotex, Teletext and TELIDON: These three technical terms are worth understanding. They systems they represent could be the mainspring of some significant changes in our lives over the next decade. They are at the cutting edge of the changes that silicon chip technology is bringing to us, and as such are likely to be the focus for the hopes and fears with which the new electronics both tantalizes and taunts us."[3] In other words, Telidon was to be a strategic technology in the context of what was then known as the "information revolution".

But why these particular technologies? Again, Madden provides the answer: "The words videotex, teletext and TELIDON all describe information systems which are designed for mass market home and business use and which make use of an ordinary TV receiver as the primary (but not the only) output terminal. The systems are all adaptations of old, well-tried computer techniques to a mass market, a market which, for the time is acessible due to the precipitous drops in the cost of essential electronic components...."[4] In short, the reason for Telidon's strategic importance was that it felt to

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1 Ibid., p. 9.

2 Madden, Videotex in Canada, pp. 20, 21.

3 John Madden, "Simple Notes on a Complex Future," Gutenberg 2: The New Electronics and Social Change, ed. Dave Godfrey and Douglas Parkhill (Toronto: Press Procepic, 1979), p. 52.

4 Ibid., p. 53.

be a mass market application of the new information technology -- in many ways, the first significant mass-market application.

Indeed, in Madden's view, there was a genuine "market pull" drawing the technology out of the labs: "Some readers will have noticed that the fundamental question of whether or not videotex services should be developed at all has not been addressed. This was deliberate. I have assumed that since competitive market forces are causing videotex systems to be developed simultaneously in several different countries, only a deliberate renunication of a pluralist system and its substitution with highly centralized government control could prevent videotex development...."[1] In fact, Madden had it almost exactly backwards. The reason for so much activity in so many countries was the perception by a number of governments and large corporations that videotex could be -- not was -- the first mass-market application of the new information technology. In Britain, France, Germany Japan and Canada, videotex was a classic case of "technology push".

The perceived significance of Telidon as the first significant mass-market application of the new information technology can be seen in Madden's views on the policy objectives which should shape introduction of the technology: "I believe it is important that the industry structure that evolves for videotex be one where the gain of individuals from the new services is also society's gains, and where there is a minimum disruption and loss caused to those who are net losers from their introduction...."[2]

In the actual DOC Telidon program, these social concerns clearly took a second place. According to Madden, "Since the public announcement of Telidon in August 1978, the government program has altered from a purely R & D activity to an advance on a broader front which is endeavouring to see the Telidon concept widely accepted both at home and abroad. This activity has two primary objectives -- the establishment of the appropriate standards... and the maximization of the number of jobs available in both the services and manufacturing aspects of videotex."[3] The development of a strong indigenous Canadian Telidon industry so that Canada could take advantage of this apparent first mass-market application of the new information technology was the primary concern and lay at the heart of the Telidon strategy.

It was also shared by industry. Even Bell Canada became involved in Telidon trials and a number of formal consultative mechanisms with industry were established to co-ordinate government and private sector activities. Less clear was the relationship to concrete government needs. Though a number of Telidon applications were found in government, such as at the Task Force on Information to the Public, these were mainly driven and developed in response to the industrial development objectives.

By the end of 1985, the total Telidon budget of DOC will have reached almost $60 million. Until the departmental reorganization in 1983, all of the money was being spent by the Research Sector, and this meant an enormous

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1 Madden, Videotex in Canada, pp. 7, 8.

2 Ibid., p. 7.

3 Ibid., p. 24.

increase in the Sector's program activity, though on a sunset basis. The Sector was involved in a wide range of technology transfer, technology promotion, product development, field trial, standards and information-provider activity -- all, for the most part, in intimate co-operation with industry.

The Telidon vision was enormously energizing for the Sector, and the program did achieve many of its objectives. Telidon was accepted as part of the world and North American videotex standards. A somewhat uncertain Canadian Telidon industry with a specialized business market did emerge, though the expected mass market has yet to materialize. Videotex and Telidon were clearly not the first real mass-market application of the new information technology.

The personal computer was, however. Ironically, Telidon and videotex may yet find a mass market as an enhancement to the personal computers which are now penetrating so deeply into the business and home markets in industrialized countries. Because of DOC support, the Canadian Telidon industry may be in a position to take advantage of that commercial opportunity.

<u>Perspectives on past visions</u>: These visions were both very important to the DOC research program. They were sufficiently compelling to result in massive increases in the budget of the research program -- indeed, the largest increases which the program received in the 16 years since the establishment of the Department.

These visions were also powerful enough to win the support of the Department's senior management. This was crucial, as MOSST pointed out in its 1980 background paper on <u>Technology Transfer by the Department of Communications: A Study of Eight Innovations</u>: "The support of senior management (at the Director General, Assistant Deputy Minister and the Deputy Minister level) is critical to a speedy and smooth completion of the R & D project in all of the cases examined."[1] The paper notes that such support made the project a departmental priority and "also helped the research team in obtaining financial resources more easily, and acquiring relative flexibility in both allocation and control of those resources."[2]

In fact, both the space and Telidon programs were centrepieces in the Department's agenda during the 1970s and early 1980s. As noted in Chapter 3.0, a survey of Departmental annual reports and information materials provides clear evidence that, in the view of the Department, its own reputation depended significantly on the success or failure of these programs.

Both visions were also largely shared by industry and the programs unfolded in the context of close working relationships with the affected industries.

There were, of course, important differences between the two programs.

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1 MOSST, <u>Technology Transfer by Department of Communications</u>, p. 8.

2 <u>Loc. cit.</u>

The vision for the space program grew out of a compelling and widely acknowledged public policy need -- to extend communications to Canadians in rural and remote areas. People in those areas were clamouring for such services. Government procurement, or at least procurement by Telesat Canada, helped to provide a sharp applications focus for the program.

In contrast, the Telidon vision grew out of a sense of opportunity -- the feeling that here potentially was the first significant mass-market application of the new information technology and that the R & D efforts of CRC could give Canadian industry an edge in exploiting it. There was no great market demand for videotex, nor compelling public policy need associated with it -- except perhaps in the wish-fulfillment sense of giving Canada an edge in a little understood "information revolution". The program was also not driven by government procurement needs. Rather, it was felt that the "technology push" activities of other Western governments in the videotex area could be emulated more successfully in Canada because Telidon technology was superior.

4.7.2 The present hiatus

These visions no longer provide a compelling focus for the DOC research program. Telidon sunsets in March 1985, and since 1983 most of the Telidon application activity has been the responsibility of the Technology and Industry Sector. The Sector is also responsible for most of the high-profile space activity -- the prime contractor support activities, M-Sat, L-Sat and the operation of the David Florida Laboratory.

As a result, since the early 1980s, the DOC R & D program has in fact been looking for a new focus. The work on a five-year plan by the Research Sector in 1982 was in many ways an attempt to find a focus for the Sector's activities -- away from near-term development work and into long-range development and applied research supported from the Sector's A-Base. But, before it came to fruition, this effort was superseded by the Departmental reorganization and the CCIS feasibility study, another effort to find a new focus for the research program. Neither of these exercises resulted in the formulation of a new vision, though one may be struggling to emerge in the area of office communications as a result of the establishment of a new lab complex, the Canadian Workplace Automation Research Centre.

Personal leadership is another important constituent of vision. But with the retirement of one ADMR and with his replacement only in the position on an acting basis, the basis for strong personal leadership is not present.

Whatever the cause, there is a growing sense that the research program lacks vision and is too diffuse -- in other words, is engaged in too many small projects and activities which lack over-all significance and do not form a coherent whole.

4.7.3 The constituents and strategic basis of a new vision

This report does not purport to define a new vision for the Research Sector. In our view, such a vision can only emerge as a result of extensive and systematic consultations within the DOC research program and between it and its major clients in government and industry. The report does, however, try to define some of the necessary constituents of such a vision and the strategic basis upon which it must rest.

An applications orientation: Perhaps the most basic constituent of such a vision is its applications orientation -- its focus on some key application arising from the R & D.

In the case of even directed fundamental research, there must be some range of applications in mind, and these must be envisaged in as concrete terms as possible -- even though they may be anywhere from three to 15 years from realization. As noted earlier in this chapter, from 10 to 15 per cent of the resources for the program should be committed to directed fundamental resource.

In the case of applied research and long-range development, the application will generally be from two to eight years out. Such activity should be the major focus of in-house R & D.

In the case of near-term development, the applications will generally be no more than two years away from realization. All such work should be transferred and, if necessary, contracted out to the private sector.

Applications can, of course, take many forms. They can be a product, a service, a system or sometimes even technical advice or information. All share one thing in common, however. They are not terrible useful or meaningful unless there is a need -- the more precisely and concretely defined the better -- for them.

The strategic nexus -- a triple lens: In the case of government-sponsored R & D, the needs which define the resulting applications must be government needs.

As noted in Section 2.4, government R & D is most effective when it is driven by strongly legitimate government needs, when government itself is the user-demander of the technology. Such R & D is not only productive in meeting those government needs, but also has the best chance of generating significant commercial spin-offs.

As the space program of the 1970s demonstrated, government R & D can also be quite effective when it flows from public policy requirements. In this particular case, as already noted, the CRC's space program was perhaps the most significant factor in the creation of a Canadian space industry.

However, it should be noted that the R & D strategy chosen to meet the needs of government users and fulfill government policy objectives can determine whether the final applications or services have commercial potential or not. As already argued in Section 4.5 of this chapter, the strategy chosen must take full account of both commercial potential and Canadian industrial capabilities.

Indeed, in our view, government R & D has its largest positive impact when it is at the intersection of government user requirements, public policy priorities and commercial potential for Canadian industry, as illustrated in Figure 4-3. In our view, this triple lens represents the basic instrument to be used in focussing the DOC research program. The major in-house focus of the research program should be on applied research or long-range development work which simultaneously meets the requirements of government users, fulfills priority policy objectives and possesses significant commercial potential for Canadian industry.

In this context, the more important and concrete the government needs in terms of user needs and public policy context, the more effective and focussed the applied research and long-range development. However, since we are speaking of in-house applied research and long-range development, it should be emphasized that the government needs in question will not be fulfilled by an application for anywhere from two to eight years. For this reason, it will be vital for the research program to consult extensively to identify those needs and assume an entrepreneurial stance in suggesting how those needs could be met. Accountability to government clients for meeting those needs, or policy-makers who see R & D as a means of contributing to the fulfillment of policy objectives, will also be also be vital to assuring that applied research activity remains precisely focused on genuine needs.

Given that industrial development objectives are also central to this strategic nexus and near-term development is to be contracted out to industry, the selection of even applied research thrusts should be shaped by extensive consultations, even formal collaboration, with Canadian industry and realistic assessments of its technical capacity, as well as its financial and marketing strengths.

Even the 10 to 15 per cent of program resources devoted to directed fundamental research should be shaped by as concrete as possible an appreciation of future applications meeting present or anticipated government needs in areas of commercial potential where industry has the necessary capability.

The ingredients of a vision are, therefore, quite simple. It must revolve around applications flowing out of high-priority government needs and possessing a high commercial potential which Canadian industry can be placed in a position to take advantage of. It will be the synergy between such applications -- a fundamental criterion in their selections -- which provides over-all visions for the different labs composing the DOC research program.

Critical mass and the sharing of the vision: The question of critical mass is central. As noted in Chapter 1.0, the DOC research program represents a declining proportion of a national R & D effort in these strategic technological areas, which in turn may represent a declining proportion of the global R & D commitment in these areas. In other words, serious questions can be raised about the degree to which the DOC research program and the Canadian R & D effort as a whole has sufficient critical mass to remain competitive in these strategic technological areas.

In our view, the triple lens suggested in the previous section represents a modest attempt to address the question of critical mass. This triple lens, by permitting the research program to focus on those application areas at the strategic intersection of government user requirement, public policy priority and commercial potential and Canadian industrial capability, should significantly increase the resources available in those areas where government R & D can be most effective in partnership with industry. Indeed, the resulting projects may provide a basis for seeking additional funds.

It also goes without saying that the vision infusing the DOC research program must be a shared one -- shared with industry in the areas of applied research and development, and shared with universities in the area of directed fundamental research. The creation of such a strategic consensus around the DOC program is, in fact, vital to its success, as noted repeatedly in this chapter.

However, the creation of such a strategic consensus through formal consultations and perhaps the range of accountability mechanisms suggested in the next chapter will have another welcome side-effect. It should result in greater co-ordination among the R & D efforts of DOC, industry and the university research community, with the result that greater critical mass -- perhaps sufficient to create a national world-class commitment -- could emerge in a larger number of strategic technological areas.

FIGURE 4-1

RESEARCH SECTOR

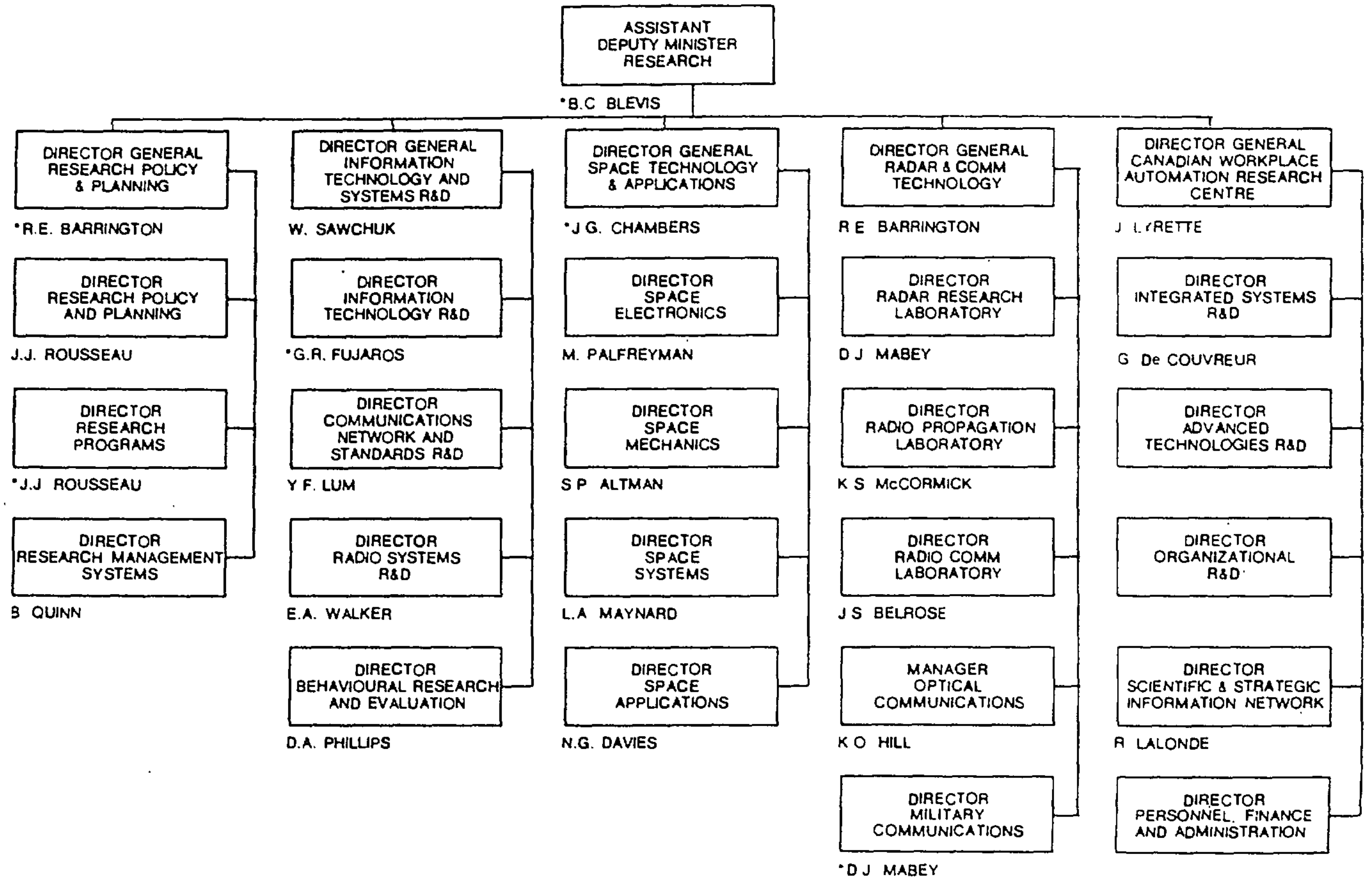


Figure 4-2

Percentage of Research Sector Resources by Client and Objective

TECHNOLOGY BASE AND UNIVERSITY SUPPORT

Objective or Client	% of Resources
curiosity-oriented research	3
technology base	23
universities	8
Total	34

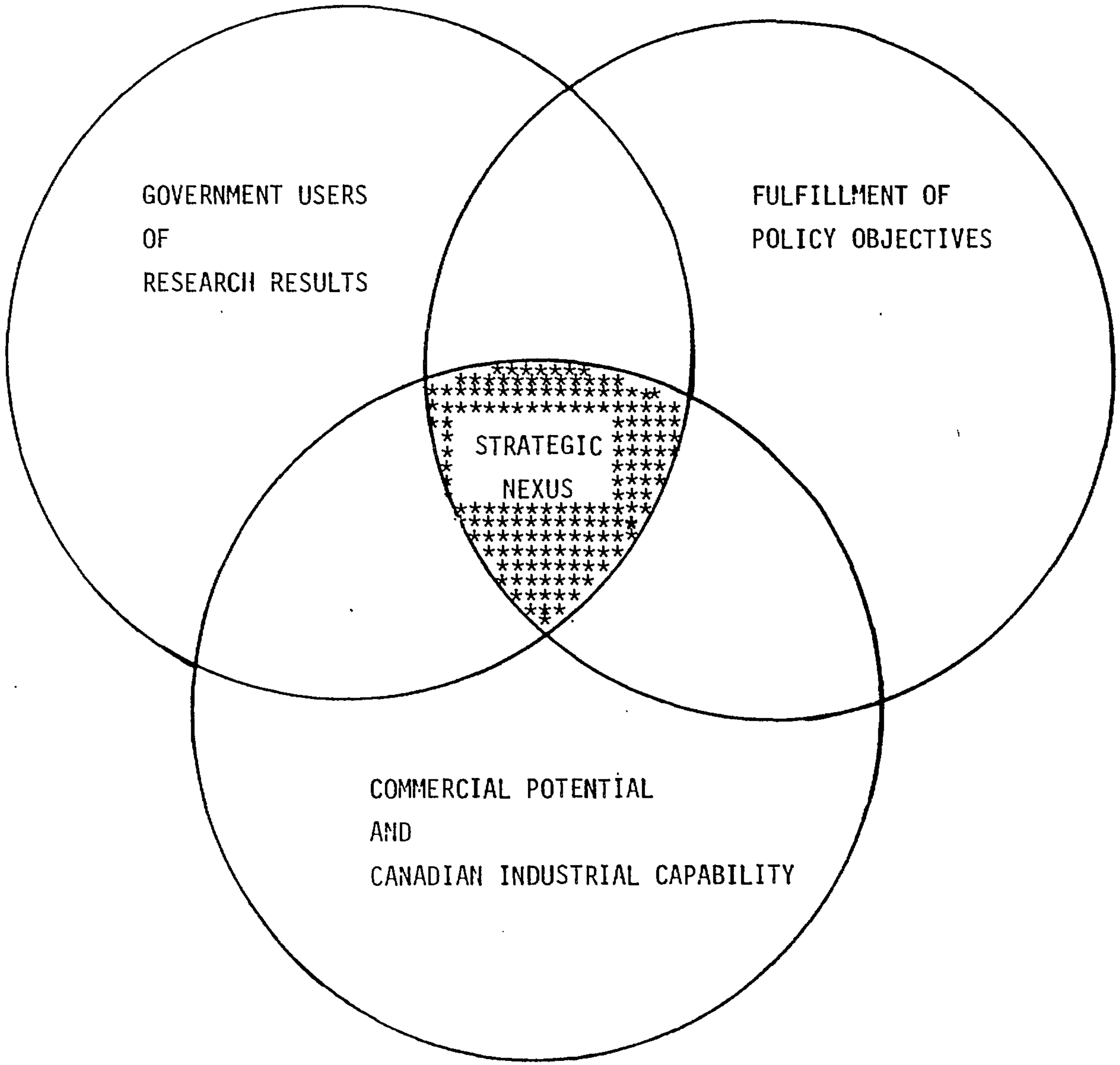
SUPPORT OF CLIENTS

Objective or client	% of Resources
PUBLIC SECTOR	
DOC: policy development	9
DOC: standards and regulations	6
GTA and other government services	4
Other departments and agencies	14
PUBLIC SECTOR TOTAL	33
PRIVATE SECTOR	
Manufacturing industry (hardware/software/design)	19
Service industry (carriers, broadcasters, cable)	6
Users (education, medicine, resource, financial)	8
PRIVATE SECTOR TOTAL	33
Total	66

SOURCE: Research Sector Estimates

FIGURE 4-3

THE STRATEGIC NEXUS



CONTENTS OF CHAPTER 5.0

Chapter 5.0

ORGANIZATIONAL OPTIONS

The purpose of this chapter is to delineate a number of organizational options for the conduct of R & D at DOC. These options fall into three major categories:

- remaining within DOC,
- the bestowal of different forms of quasi-independent status on the research program, and
- special options for the Canadian Workplace Automation Research Centre.

The logic of the options is a move from modifications of the status quo to progressively more radical options which would involve increased accountability to industry. All of these options have been developed in light of the conclusions and findings arising from the strategic assessment of R & D at DOC in the previous chapter.

5.0.1 Key principles applicable to all options

Whatever organizational option is approved, it is fundamentally important that the research program be carried out in a manner consistent with the key principles defined in Chapter 2.0 and applied in Chapter 4.0 to DOC research activities. In our view, these principles are basic to the effective conduct of government-sponsored R & D. These principles are as follows:

1. Micro-management of research should be reduced: An excess of micro-management handicaps the effectiveness of the research program and does not provide a meaningful basis for accountability. Recognition of this principle has important implications for the organizational options described below.[1]

2. About 15 per cent of R & D resources should be devoted to directed fundamental research in formal collaboration with university researchers: A commitment to directed fundamental research on the part of government labs, in conjunction with a number of other steps, represents the most effective means of assuring effective links with universities which provide the maximum benefit to both the government lab and the university research community.[2]

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1 See sections 2.1 and 4.1 above.

2 See section 4.2 above.

3. Fundamental and applied research (including development work) should be separate in budgetary terms and, where possible, in organizational terms: Such a separation is important to ensuring that fundamental research and applied research programs are to retain their integrity and responsivness to their respective clienteles.[1] The application of this principle should, however, be pragmatic. For example, it may make very little sense to break up or introduce artificial organizational barriers into the activities of a small productive directorate performing both fundamental research and applied R & D.[2]

4. The major focus should be on applied research and long-range development to meet government needs, especially in areas of maximum commercial potential where Canadian industry has the necessary capabilities: This emphasis -- and, in particular, an emphasis on government procurement needs -- must lie at the heart of the research program and represents the foundation for any discussion of how best to focus that program. Fundamentally important to such an emphasis are mechanisms to ensure that the applied research and long-range development is truly responsive to government needs and commercial realities.[3]

5. All near-term development should be contracted out to industry: Near-term and product development is what government labs do worst because of their insulation from the market and what industrial labs do best because of their responsiveness to market realities. However, if the contracting out of near-term development by government labs is to be effective, this activity must de driven by a clear sense of industry needs and future opportunities, as -- to a significant degree -- must the applied research and long-range development which lay the basis for near-term development work.[4]

6. Establishment of a research intelligence gathering and dissemination function is vital to both the Department and industry: New technology is diffused more slowly in Canada than in our trading partners; this failure reduces our international competitiveness in strategic but research-intensive areas such as communications and computers. The policy-making centres of the Department also require such information. Researchers with technical information to exchange are most effective in gathering such information.[5]

7. In collaboration with government clients, industry and the university research community, steps must be taken to encourage the development of a focussing strategic vision for the research program, with a view to ensuring that critical mass is created in strategic technological areas within the research program and Canada as a whole: The organizational options enumerated below will be assessed in light of the encouragement

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1 See section 2.3 above.

2 See section 4.3 above.

3 See sections 2.4 and 4.4 above.

4 See sections 2.5 and 4.5 above.

5 See sections 2.6 and 4.6 above.

they provide to the development of such an approach and the concentration of critical mass in strategic technological areas.[1]

These principles are relevant whatever organizational option is selected for the research program. Indeed, these options were developed with with a view to providing a framework in which these principles could receive a concrete manifestation. The options will also be assessed in light of their contribution to a realization of these principles.

5.0.2 Departmental relationships in the context of government need

The most important of these principles is, of course, that the major focus should be on applied research or long-range development intended to meet government needs. Within this context, one set of findings was particularly significant: the existence or desirability of certain dominant relationships between certain subject areas for R & D and the responsibilities and concerns of certain branches and sectors of DOC. These relationships are illustrated in Figure 5-1 at the end of this chapter. In our view, recognition of the importance of these relationships is vital to the development and assessment of organizational options for the DOC research and represent important building blocks in the creation of a vision for the program or its constituent parts.

Such strong relationships should exist with the Technology and Industry Sector, the Spectrum Management Sector and the Policy and Cultural Affairs Sectors of the Department:

1. Technology and Industry Sector: There are a number of dimensions to the relationship which should obtain between the research program and the Technology and Industry Sector. First and most important, the Government Telecommunications Agency should represent, though it does not now, a major focus of government needs which the research program is uniquely equipped to meet. Second, the Technology and Industry Sector is heavily involved in the area of space applications and the provision of technical services to the Canadian space industry. Third, the Sector is acquiring the capability to assess the commercial potential of new technologies and the financial and marketing capabilities of Canadian industries.

   (a) **GTA and workplace automation, informatics and telecommunications** R & D: At present, the relationship between the research program and the Government Telecommunications Agency (GTA) in the Technology and Industry Sector is very weak.

   A strengthening of the relationship between the two would have important benefits to the research program, GTA, the government as a whole and industry.

   The GTA strategy now envisions its increasing involvement in offering Enhanced Telecommunications Services (as defined by the CRTC) and ultimately a government-wide Integrated Systems Digital Network (ISDN). These enhanced telecommunications services will include office communication services and networking of government office communications systems. The work of the Canadian Workplace Automation Research Centre and the informatics and

[1] See sections 2.7 and 4.7 above.

telecommunications groups at CRC focuses on many of the technologies required to provide such services. Formal collaboration between GTA and these parts of the research program -- as well as the commitment of a proportion of GTA revenues to R & D -- would therefore result in an applied research program more focussed on concrete government procurement needs, as well as an improved capability on the part of GTA to meet its strategic objectives.[1]

Applications of this technology could also make an important contribution towards an enhancement of the government's over-all productivity.[2]

More important, a procurement-related R & D strategy in these key technological areas, which was called for by the Wright Task Force,[3] would have important industrial benefits, given that applications of these technologies have enormous commercial potential[4] and there is a significant Canadian industrial capability. Within such a framework, government R & D would, of course, focus on applied research and long-range development -- that is, pre-competitive, non-proprietary R & D -- while encouraging industry to undertake the necessary near-term and product development.

In short, a procurement-related R & D strategy, based on a formal collaboration between the research program and GTA in these strategic technological areas, would likely have more leverage in terms of meeting government needs and creating industrial benefits than almost any other strategy the research program could pursue. A key condition for success in this area is a clarification of GTA's authority to make a portion of its expenditures on R & D in this area.

(b) **The space connection:** The Technology and Industry Sector now administers space applications programs, as well as providing extensive technical services to the space industry through the David Florida Laboratory located on the CRC site. Both activities draw extensively on the technical expertise now located in the space R&D program within the Research Sector.

(c) **The industrial strategy link:** The Technology and Industry Sector is acquiring the capability to assess the long-term commercial potential of certain technologies, as well as the financial and marketing capabilities of individual companies.

The assessment of commercial potential should represent vital input into deliberations on priorities for applied research, long-range development and near-term development, which should be located at the strategic intersection of government need and commercial potential.

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1 See section 4.4.3 above.

2 See sections 1.1.5 and 4.4.3 above.

3 Wright Task Force, op. cit., pp. 13-17.

4 See section 1.1.3 above.

Similarly, if the DOC research program is to make wise decisions in the areas of technology transfer and the contracting out of near-term development, it must draw on the growing expertise of the Technology and Industry Sector in the assessment of the financial and marketing capabilities of potential beneficiary companies.[1]

As noted in the previous chapter, the relationship between the present Research Sector and the Technology and Industry Sector is uneasy. Only the first steps have been taken to initiate a productive process of formal collaboration between the two Sectors. Movement in this direction is hampered by the fact that there is a certain raggedness to the boundaries between the two sectors and this has led to a certain tension at the working level. It is however, vital, that the inter-related activities of the two sectors be concerted and some of the organizational options described below were developed with that objective in mind. A greater role for industry -- for which to some degree the Technology and Industry Sector acts as a surrogate -- was also a concern in developing these options.

2. Spectrum Management Sector: There is also a strong relationship between the activities of the Spectrum Management Sector and the research program in the area of spectrum and environmental research.

The Spectrum Management Sector is responsible, on behalf of the Minister, for management of the radio frequency spectrum to assure its optimal and most efficient use. This involves planning present and future uses of the spectrum, regulating its use and enforcing obedience to those regulations through inspections and other activities.

In carrying out these responsibilities, the Sector receives technical support and services from its own laboratory on Clyde Avenue in Ottawa. Among other activities, this laboratory develops methodology for test measurements of the spectrum; evaluates test procedures for new equipment; calibrates, repairs and sometimes designs equipment used by the Sector in monitoring and controlling spectrum use; and provides a range of technical and engineering analysis -- including laboratory and field measurements -- to resolve problems in spectrum use which cannot be solved through normal operational procedures, and tests and approves radio equipment by type.

The technical and engineering services provided by the Clyde Avenue Laboratory differ from the program of mainly applied spectrum and environmental research provided by the Research Sector. This research, which focuses mainly on larger propagation, interference and compatibility issues, provides important input into the Spectrum Management Sector's plans for future uses of the spectrum. The Research Sector also undertakes specific projects for the Spectrum Management Sector.

Managers in the Spectrum Management Sector regard as important this support role of the Research Sector and were the only DOC managers to express complete satisfaction with their capacity, on an informal basis, to influence the direction of the DOC research program.

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1 See sections 4.5.2 and 4.5.3 above.

3. Policy and Cultural Affairs Sectors: The linkages between the research program and the policy centres of the Department are very tenuous. This situation means that research activities are often carried out in a policy vacuum and occasionally in ignorance of policy concerns. It also means that policy can be developed in the absence of up-to-date information on technological trends and advances. Clearly, then, as noted in Chapter 4, there is a strong *prima facie* case for stronger links between the research program and the Department's policy development centres -- in particular the Policy Sector and the Cultural Affairs Sector.[1]

   (a) **Information gathering and dissemination role:** This argument takes on additional force, given the proposal above that the research program should take on the role of monitoring international technological developments and disseminating that information domestically -- including to the policy development centres of the Department.[2] Formal links with these centres are necessary to define on a continuing basis exactly what information would be valuable to them in their work.

   (b) **Standards:** At present, the Policy Sector has the lead role in the standards area, but depends very much on the research program for technical advice and the provision of technical experts at standard meetings. As noted in the previous chapter, there is a need for closer links between the Policy Sector and the research program to ensure that technical work in the standards area coincides with policy requirements. In addition, as already noted, the present policy framework for standards work does not take into sufficient account user and industrial strategy concerns and does not provide a basis for defining the degree to which the research program should be involved in standards work. These deficiencies should be rectified. In addition, it is important that the Technology and Industry Sector also play an active role to bring industrial and user considerations into clearer focus.[3]

   (c) **Policy-driven R & D:** The DOC research program is also involved in work intended to extend and improve communications services in Canada. However, the development of new services and the extension of existing services can have important policy implications. Beyond this, a more precise policy context for such work might provide a clearer and sharper focus for such R & D work. Indeed, it may well be that R & D in some circumstances can provide long-term solutions to problems which obstruct the fulfillment of policy objectives. In short, both policy and research work would benefit from closer links between the research program and the Policy Sector.

   Work on new communications services can also have important cultural policy implications, and there are also perhaps other areas of

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1 See section 4.4.2 above.

2 See section 4.6 above.

3 See section 4.4.2 above.

communications-related R & D which could contribute to the fulfillment of cultural objectives. For the most part, because the Cultural Affairs Sector only joined the Department of Communications a few years ago, cultural policy objectives have not had much impact on the direction of the research program, though Telidon, for example, has had some direct and indirect cultural impacts.[1] Closer, formal links between the research program and the Cultural Affairs Sector is essential to the identification and definition of R & D activities which might contribute to the fulfillment of cultural objectives.

As noted above,[2] the strategic focus of the research program should be in areas which meet government and public policy needs, but also where there is genuine commercial potential. The Technology and Industry Sector, therefore, has a role in examining policy-driven research to determine whether it has commercial potential.

It should be noted that policy-driven work undertaken by the research program -- whether this involves the gathering of information, standards-related work or policy-driven R & D -- could involve any of the broad subject areas addressed by the research program. In other words, it could include work in areas such as office communications, space or spectrum where the Technology and Industry Sector and the Spectrum Management Sector have a particular interest. This fact has important implications for the options considered below.

5.1 REMAIN WITHIN DEPARTMENT

If the present research program remains within the Department of Communications, three options would seem to be available:

- a modification of the status quo,
- an expanded program with enhanced accountability mechanisms, and
- elimination of the Research Sector.

These are clearly the most conservative options, though the last two suggested would entail significant changes in the structure and operations of the Department.

5.1.1 Modified Status Quo

Under this option, the Research Sector would remain essentially as it is now, though steps would be taken to correct in some degree some of the most glaring sources of deficiencies. The effectiveness of these steps is assessed below.

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[1] Interviews with Research Sector Managers, Fall-Winter 1984.

[2] See section 4.7.3.

The option: While the Research Sector would remain essentially intact, it would be subject to less micro-management and steps would be taken to enhance its accountability, its planning capabilities and its administrative efficiency:

Reduction in micro-management: Four steps could be taken to reduce the burden of micro-management upon the Research Sector:

- First, the Research Sector could assume responsibility for the provision of the technical services -- and some of the administrative services -- now provided on site at CRC and CWARC by DGPA. The emphasis should be on transferring responsibility to the the Research Sector for those services which are most integral to the R & D function.

- Second, approval should be sought from Treasury Board[1] and Cabinet to conduct a five-year personnel management demonstration project[2] within the Research Sector, with a view to trying out on an experimental basis, among other things, (i) a more flexible, manageable and understandable classification system which aggregates several classification levels into broad pay bands, (ii) a performance appraisal system that provides a stronger link between performance goals, compensation and organizational effectiveness, (iii) an expanded application of the merit pay concept to both supervisory and non-supervisory employees and (iv) an emphasis on performance as a primary criterion in employee promotion and retention, with due regard for tenure and length-of-service factors. One possible guide in developing the objectives and features of such a project might be the present classification system used for researchers and research managers at NRC, as well as the personnel management demonstration project now close to completion at the U.S. Navy's Naval Ocean Systems Centre and Naval Weapons Centre, as outlined in Appendix A. The 1983 report of the U.S. Federal Laboratory Review Panel strongly praised the scope and innovativeness of this experiment as a means of enhancing the productivity of U.S. government labs.

- Research Sector budgets for travel to scientific conferences should be increased, while the process of approving such travel

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1 Preliminary discussions with Treasury Board officials indicated that the Board might not regard such a project favourably. In their view, as long as Treasury Board remained the employer responsible for negotiations with employees' associations and unions, simple equity demanded that classification systems in the scientific and engineering areas remain the same right across the government. However, it should be noted that these same employees' associations and unions also represent researchers at NRC which work under the kind of simplified classification system which would likely be tested under a personnel demonstration project.

2 The conducting of such a project was strongly recommended for U.S. government laboratories by the U.S. Federal Laboratory Review Panel chaired by David Packard and reporting to the White House Science Counsel in 1983.

applications should be streamlined. Such a change would increase the capacity of the Sector's personnel to remain abreast of scientific and technological developments outside the country, where most of the significant advances are now occurring. It is also critical to the Sector's being able to fulfill a research intelligence monitoring and dissemmination role, as described in Section 4.6 above.

Improved accountability: A number of modest steps could be taken to increase the accountability of the Research Sector to the rest of the Department of Communications, to industry and to the university research community.

- There would be a formal requirement for the Research Sector to hold formal consultations with other DOC sectors each year on the direction of its applied research and development program in order to ensure that the direction of the program was in harmony with the R & D needs and technical requirements of the rest of the Department. In the case of the Technology and Industry Sector and the Spectrum Management Sector, the consultations would focus, not just on the operational plans of the Research Sector, but also on the operational plans of these key client sectors. Of particular importance in this respect would be technology assessment plans and results generated by the Technology and Industry Sector.

- Work for other federal departments would be conducted on a full cost-recovery basis except in special circumstances. Approval would be required of senior management in the Department for any joint projects conducted on a shared-cost basis, and these should be undertaken only if they would make an important contribution to the synergy of the research program and and are consistent with Departmental policy priorities.

- A formal mechanism would be established to assure industry input into the direction of the applied research and development programs. This would consist of an industry advisory committee, representative of the major industries working in areas related to the research program. This industry advisory committee would provide advice in light of industry's long-term R & D needs on the over-all direction of the entire Sector's applied research and development program. Feeding information and advice into the industry advisory committee would be industry advisory sub-committees, corresponding to each branch of the Sector and representative of the industries active in areas where each branch concentrates. Such a structure would permit a much more fine-grained examination of the program by industry than was possible with the now suspended Communications Research Advisory Board.

- Formal mechanisms would be established to assure input from university researchers on the direction of the directed fundamental research conducted by the Research Sector. First, a university advisory committee would be established to provide advice on the over-all direction of directed fundamental research activities in the Sector. In addition, directed fundamental research would be subjected to a peer review every four to five years.

- Approval should be sought from Cabinet and Treasury Board for taking steps to ensure that, at the end of five years, a significant proportion of research personnel would be brought in on a temporary (two to four years) basis from industry and the university research community. This would be achieved through a process of attrition and transfers of personnel, with the money saved being transferred from salaries to support for an exchange program modelled on that which is planned for CWARC.

Improved planning: A number of steps could be taken to improve the planning capabilities of the Sector.

- First, the strategic planning capability of the Research Sector could be significantly enhanced so it could take into account changes in its environment -- either governmental or non-governmental -- and respond to them. The strategic planning group would also provide the secretariat for the university and industry advisory committees and sub-committees.

- Second, this strategic planning group would be headed by a DG who would report directly to ADMR and it would be be located at Headquarters rather than at either of the laboratory centres. Its DG would be a full member of the senior management committee for the Sector, and his staff would provide secretarial support to the senior management committee. This would ensure that the corporate planning function served ADMR rather than any of the laboratory centres and give it the independence so necessary to the performance of such a function.

Administrative efficiency: A number of steps would be taken to improve the administrative efficiency of the Research Sector.

- First, a more unified management structure would be established to assure greater coherence within the two major laboratory centres of the Research Sector -- the CRC and CWARC. Each would have a senior manager who would report directly to ADMR and, along with ADMR and the DG for strategic planning, would form the senior management committee of the Research Sector. Managers of the branches at each laboratory centre would report to the senior manager of the centre.

- Second, each laboratory centre would have a corporate services and programs branch which would take over many of the program functions of the present Research Policy and Programs Branch -- such as interfaces with federal programs such as PILP and UPP, as well as university and industry exchanges and assuring the effective implementation of the planned management information system in such a fashion as to ensure that that middle managers, as well as senior managers, in the Sector are fully supported by the system.

- Third, in close conjunction with the strategic planning group reporting to ADMR, the corporate services and programs branches in each laboratory centre would be responsible for co-ordinating and providing support services for the range of activities associated with the performance of the international research intelligence gathering and domestic dissemination function by the Research Sector.

- Fourth, directed fundamental research activities would be separate in budgetary terms from applied research and development activities and would be achieved to the degree practicable in organizational terms. It should be noted that the relatively small size of the Research Sector makes such separation in organizational terms more difficult to achieve without sacrificing productivity and critical mass in strategic technological areas. For this reason, the degree of organizational separation should depend on the circumstances in each branch of the sector.

- Fifth, the procedures necessary to effective technology transfer would be codified in light of the lessons from past experience, and this codification would be continually updated in light of lessons from present and future experience.

Assessment: This option will be assessed in light of the seven principles defined in Chapter 2.0 and applied in Chapter 4.0 to the Research Sector:

1. **R & D is a unique endeavour requiring unique managerial practices:** The Research Sector's assumption of responsibility for the technical and some of the administrative services now provided by DGPA, as well as the proposed personnel management demonstration project and increased travel budget with a streamlined and more responsive travel approval process, would reduce significantly the burden of micro-management upon the Research Sector. However, it should be noted that, though in modified form, Treasury Board guidelines and Public Service Commission rules would still apply. Certainly, Research Sector management would not have the degree of responsibility or control over their program recommended by the Packard Panel -- a fixed budget with the capability to allocate it in light of priorities between salaries and program activities. Increased flexibility in this respect might, of course, result from the move over five years to a situation where the Sector had less resources tied to salaries for person/years and more resources to support an industrial and university exchange program and perhaps other program activities.

2. **Optimal university links require commitment to directed fundamental research:** The establishment of a university advisory committee to advise on directed fundamental research, in conjunction with regular peer reviews of such research, would clearly result in a significant improvement in the Sector's links with the university research community. These links would be further strengthened if a portion of the Sector's researchers came on an exchange basis from universities. However, it should be noted that, under such arrangements, university researchers could only advise on the direction of the research; they would have no actual power to determine the direction of the research.

3. **Fundamental research vs. applied research and development:** Directed fundamental research and applied research as well as development would be separate in budgetary terms under this option. Organizational separation would be carried out to the degree practicable, given the size of the R & D program and necessary interrelationships in the different branches of the Research Sector.

4. **The primary focus of government labs -- applied research or long-range development to meet government needs:** A strengthened strategic planning function and the requirement for annual formal consultations with the other sectors of the Department would strongly contribute to ensuring that the Research Sector's program was more responsive to government needs. However, it should be noted that such consultations would only serve to expose the Research Sector to other sector's advice and perceptions of government needs. The other sectors would have no direct influence on the actual decisions with respect to the Research Sector's program, though -- assuming goodwill on both sides -- a certain harmonization of their respective programs would no doubt occur. Such influence could only be exercised indirectly through the Deputy Minister and the Senior Management Committee.

   R & D for other federal departments and agencies is now conducted under a wide range of different arrangements, including cost recovery. If there was a formal requirement that such work be carried out on cost-recovery or shared-cost basis, accountability to those departments and agencies would certainly be strengthened.

5. **Role vis à vis industry:** Formal links with industry would be significantly strengthened by the establishment of an industry advisory committee and sub-committees, as well as the requirement that at the end of five years a significant proportion of the Sector's researchers come on a two to four-year basis from industry and the university community. Formal consultations between the Research Sector and the Technology and Industry Sector would also tend to make the Research Sector more responsive to industrial development considerations. However, it should be noted with respect to all of these arrangements both industry and the Technology and Industry Sector would only have an advisory role vis à vis the direction of the research program; they would not in short have any direct influence over the program.

6. **An international monitoring and domestic dissemination role:** Though the actual information would be gathered by researchers, it is clearly important that there be some central organizational focus for the co-ordination of all this activity. The performance of this role would also be enhanced by an increased travel budget and streamlined travel approval to enable DOC researchers to attend international conferences where such information can be gathered. It should be noted, however, that the effectiveness of such a service will depend to a large degree on the effectiveness of the provisions for links with other DOC sectors, other federal departments and agencies, industry and the university research community, enumerated in sections 2, 4 and 5 above.

7. **The quality of vision and the notion of critical mass:** A reduction in micro-management, improved formal links with government, industry and university clients, and a strengthened planning capability -- all of these should make it more possible to develop a strategic vision for the Sector which is shared by its clients. However, it should be noted that there would be a higher probability of that vision being truly shared if these various clients had a more direct influence, rather than an advisory role, with respect to the direction of the research program. In such a context, care would have to be taken to ensure that the exercise of direct influence over the program by these diverse groups did not set

in motion centrifugal forces which would render impossible the achievement of a coherent vision.

Success in developing such a vision, which would permit the focussing of resources in a few strategic technological areas, is of course a necessary condition for generating critical mass in those areas. If the resulting research program is co-ordinated with R & D in industry and universities, the potential for a greater critical mass in these areas nationally is also greatly increased.

With respect to both the development of a vision for the DOC research program and the creation of critical mass, special attention should of course be paid to the synergies across the different subject areas on which the Sector focuses. These in themselves may represent sources of vision and the basis for increasing the critical mass in strategic technological areas. If the Sector were broken up, it is certainly arguable that such synergies could be lost along with the possibility of increasing critical mass based on them.

5.1.2 Expanded program with strengthened accountability mechanisms

Under this option, the Department would have a Research Sector with an expanded research program, but with this expansion would come new mechanisms to assure the accountability of the Sector to the other sectors of DOC as well as a further reduction in micro-management. **This option would subsume all the features of the previous option outside these three areas.**

The option: This option varies from Option 5.1.1 in only three respects. First, the program of the Research Sector would be expanded so that greater critical mass would be available for the Department's research program. Second, with this expansion, which would occur at the expense of other DOC sectors, would come increased accountability to other DOC sectors for the conduct of applied research and development work, as well as in the provision of technical and other services. Third, specific steps would be taken to reduce further the burden of micro-management. The features of this option are described in more detail below.

Expansion of Program: In order to increase the resources available for the over-all research program and to take advantage of technical synergies at the managerial level, the research program would be expanded at the expense of the Technology and Industry Sector.

- The interrelationship between the Research Sector and the Technology and Industry Sector has already been noted, as has the raggedness of the boundary between the two sectors. Under this option,
  - the David Florida Laboratory would be transferred from the Technology and Industry Sector to the Research Sector.
  - responsibility for the technical aspects of the applications programs now administered by the Technology and Industry Sector would be transferred to the Research Sector.

This does not mean that the Technology and Industry Sector would not have responsibilities in these areas. Responsibility for targetting of strategically or commercially important applications and the commercial and industrial aspects of specific program activities would remain with the Technology and Industry Sector. Indeed, we would envisage parallel program structures in the two sectors on key applications.

New accountability mechanisms: Both Chapter 2.0 and Chapter 4.0 argue very strongly that the conventional methods of assuring accountability within government tend, when applied to a research and development program, to result in counter-productive micro-management without in fact providing genuine accountability. The need to eliminate micro-management does not, of course, remove the need to assure accountability. For this reason, both chapters also indicate that the basis for the traditional and necessary forms of vertical accountability to the Deputy Minister, the Minister, the government and Parliament lie in assuring the accountability of an R & D program to its clients and those whose objectives its research is intended to fulfill. In Option 1(a), a number of mechanisms were put forward to assure greater responsiveness to industry and university researchers, as well as government clients from DOC and other federal departments and agencies; these would be incorporated in this option too. In addition, two steps would be taken to increase the accountability of the Research Sector to other DOC sectors.

- First, a new joint planning structure would be established within the Department to oversee applied research, development and technical services. As illustrated in Figure 5-2 at the end of this chapter, this would involve the establishment of at least three inter-sectoral planning and control groups as a key interface between the Research Sector and the other sectors. On the interface between the Research Sector and the Technology and Industry Sector would be a joint planning group composed of DGs from the two sectors. A similar group would be established on the interface between the Research and Spectrum Management sectors. A final and similar group would be on the interface between the Research Sector and the Policy and Cultural Affairs Sectors. The DGs on these groups would report to their respective ADMs, who in turn would be members of a Research Committee composed of the Department's senior management.

  These planning groups would meet periodically to discuss the operational plans for the research program in light of the needs and priorities of the Sectors involved, including the Research Sector. Within their ambit would also be the allocation of person/years among projects. Reports on progress towards milestones would be reported to these groups, as would deviations from plans, though these reporting requirements would be limited to prevent micro-management. The object of these groups would be to establish an inter-sectoral consensus on Departmental research needs and how these needs would be met.

  It cannot be emphasized too much that the establishment of these groups would inaugurate a new managerial regime for R & D within DOC. In effect, the performance of Research Sector management would be measured in terms of the degree to which the R & D program met government needs as defined by the planning and control groups. Performance of management in other sectors on the interface with the Research Sector would be measured in terms of their capability to define government R & D needs in their respective areas and ensure, **without resorting to micro-management or incursions into technical areas where those with technical expertise must be paramount**, that the research program met those needs without losing its over-all coherence.

Though the establishment of such a joint planning structure should lead to greater harmony between the research program and the needs of other sectors, there will inevitably be disagreements. The priorities of a specific sector may, for example, not be entirely consistent with the emphases necessary to ensuring the over-all coherence of the research program or critical mass in a few strategic technological areas. If these disagreements could not be resolved at the joint planning group level, they would be aired and resolved at the level of the Research Committee composed of the Department's senior management and chaired by the Deputy Minister. The literature generally agrees that a research program is more effective when it has access to the highest level of management, and the existence of Research Committee -- and the potential for conflict in the new joint planning structure -- should both ensure that research issues have a higher profile for the Department's senior management and that senior management is fully involved in their resolution.

- Second, 14 per cent of the Research Sector's over-all budget, which represents roughly the proportion now used for contracting out development work, would be split in half between the sector and other DOC sectors working in related areas -- in particular, the Technology and Industry Sector and the Spectrum Management Sector. All of this money would be designated for use in R & D projects. Other DOC sectors could go outside the Department -- for example, to the private sector -- to get R & D done with their portion of this money. However, if they had the R & D done through the Research Sector, their funds would be matched by Research Sector funds. In other words, for a 50 cent expenditure, they could get a dollar's worth of R & D done through the Research Sector, but only 50 cents worth if they went anywhere else.

  This arrangement would strengthen the accountability of the Research Sector to other DOC sectors and give both the Research Sector and other sectors a clear incentive to harmonize their programs in the context of the joint planning and control structure outlined above.

Rolling multi-year budgetting: Approval would be sought from Treasury Board to introduce, as a five-year pilot project, rolling multi-year budgetting for all R & D budgets within the Department. As the Wright Task Force argues,[1] such funding would lend additional continuity and flexibility to the research program, as

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1 Wright Task Force, op. cit., p. 32.

well as strengthening its capability to undertake long-term planning. Whatever would be lost in the way of accountability because of such an arrangement would be gained as a consequence of the new horrizontal and vertical accountability mechanisms suggested above. In other words, there is an inextricable link between such a pilot project and the new accountability mechanisms suggested above.

Assessment: As was the case with Option 5.1.1, this option will be assessed in light of the principles defined in Chapter 2.0 and applied to the DOC research program in Chapter 4.0. Because this option incorporates many of the features of Option 5.1.1, the assessment in light of certain principles will simply refer back to the corresponding assessment for Option 5.1.1.

1. **R & D is a unique endeavour requiring unique managerial practices:** For the most part, the comments in this area, made on page 8 of this chapter, with respect to Option 5.1.1 are applicable here. However, there are two important differences.

   First, in comparison to the previous option, there is a danger that the new joint planning structure and the cash-splitting arrangements could result in more micro-management of the R & D program, though it should be noted that such a development would run counter to the spirit of this report and these arrangements as conceived here.

   Second, the move to rolling multi-year budgetting would represent a further reduction in the potential for micro-management and might in fact counterbalance any increase in micro-management as a result of the new accountability mechanisms.

2. **Optimal university links require commitment to directed fundamental research:** This option incorporates all the features of Option 5.1.1 which are relevant to this principle, and thus the assessment of Option 5.1.1 in this area is completely applicable.

3. **Fundamental research vs. applied research and development:** Again, this option incorporates all the features of Option 5.1.1 which are relevant to this principle, and thus the assessment of Option 5.1.1 in this area is completely applicable.

4. **The primary focus of government labs -- applied research or long-range development to meet government needs:** With respect to research undertaken for other federal departments and agencies, this option incorporates the cost-recovery or shared-cost requirement which formed part of Option 5.1.1 and thus the assessment in this area of Option 5.1.1 applies equally here.

   However, this option differs significantly from Option 5.1.1 with respect to the relationship between the Research Sector and other DOC sectors -- especially the Technology and Industry Sector and the Spectrum Management Sector.

   Under Option 5.1.1, the other sectors would have a formal consultative relationship with the Research Sector, and this would permit them to make the Research Sector aware of their needs, advise on how these needs might be met and become aware of the Research Sector's plans. Under this option, through the cash-splitting provision and the proposed joint planning structure, the Research Sector would in some ways be accountable to the other sectors for the conduct of R & D to meet their needs and there would be a real incentive for a harmonization of programs.

5. **Role vis à vis industry:** This option would incorporate all the features of Option 1(a) relevant to the industrial role of the Research Sector. For this reason, the assessment of Option 5.1.1 in this respect is equally applicable to this option.

   However, it should be noted that the expanded role of the Technology and Industry Sector vis à vis the research program would in theory ensure that industrial and commercial considerations received greater weight in determining the direction of that program.

6. **An international monitoring and domestic dissemination role:** This option would incorporate all the features of Option 5.1.1 relevant to this role. For this reason, the assessment of Option 5.1.1 in this respect is equally applicable to this option.

7. **The quality of vision and the notion of critical mass:** This option incorporates many of the features of Option 5.1.1 relevant to these concerns. For this reason, the assessment of Option 5.1.1 in this respect is also largely applicable to this option.

   However, there are important additional features, and these raise new considerations with respect to questions of vision and critical mass.

   For example, the significant expansion of the program envisaged under this option would significantly increase the resources available for the research program and thus in theory its critical mass. It can be argued too that the cash-splitting with other sectors and the joint planning structure would assure a more realistic vision, given that the research program would as a result of these measures be firmly based on a realistic appreciation of government needs.

   However, these same features raise the question as to whether there could be significant reallocations of these additional resources into strategic technological areas in order to develop critical mass in those areas. For instance, it is difficult to envisage agreement being reached in the joint planning groups on significant reallocations of resources from the Clyde Avenue Laboratory to support R & D in some strategic technological area. However, it may well be that such reallocations would be necessary to give the Research Sector a coherent program with critical mass in strategic technological areas.

   Under the joint planning structure, such disagreements would be raised at the Senior Management Research Committee and ultimately with the Deputy Minister and the Minister. In our view, it is appropriate that such disagreements be raised and resolved at the senior management level. Indeed, the strength of the joint planning structure is that it would ensure that such issues are considered in detail at the middle-management level in all sectors and then raised and resolved at the highest level. These issues are basic, involving as they do trade-offs between Sectoral needs, the coherence of the research program and the imperative of assuring critical mass in strategic technological areas. Senior management must have a full understanding of these trade-offs and must decide on the appropriate balance to be struck. All the literature agrees on the importance of senior management involvement in such basic decisions involving a research program.

5.1.3 Elimination of the Research Sector

Under this option, the Research Sector would be eliminated as an organizational unit and the different laboratories would become the responsibility of other DOC sectors. This option is described and assessed below.

The option: Under this option, the Research Sector would cease to exist as the organizational unit responsible for R & D within the Department. The various R & D programs would become the responsibility of those sectors with which R & D subject areas have their single most important intra-departmental relationship. With this change, the R & D programs would in fact become fully accountable to some, though not all, of their Departmental clients -- a significant difference from the previous two options.

The sectors which would assume new responsibilities under this arrangement would be the Technology and Industry Sector and the Spectrum Management Sector. Within this context, the option would incorporate many of the features of Options 5.1.1 and 5.1.2 intended to strengthen the formal links between the research programs and other federal departments and agencies, industry and universities, as well as all of the features of the previous options intended to reduce micro-management.

Technology and Industry Sector: As already noted, the Technology and Industry Sector is already responsible for administering the David Florida Laboratory, as well as a range of specific applications programs. The Sector is now developing a technology assessment capability and is developing a capacity to assess the financial and marketing capabilities of Canadian companies. The Sector also includes the Government Telecommunications Agency. Under this option, the sector would assume responsibility for the present research programs in the space, informatics, office automation, fibre-optics and radio technology areas.

The Government Telecommunications Agency, as the bulk purchaser of telecommunications services for the federal government, has developed strategic plans which envisage the development of a government-wide Integrated Systems Digital Network, which would involve considerable emphasis on the deployment of new transmission systems, office communications systems and information technology in general. It would therefore provide a sectoral focus for the identification of the procurement-related R & D needs of the government, especially in the areas of telecommunications, informatics, office automation and to a lesser degree space. Other branches of the sector would assist by providing technology assessments and evaluations of the financial and marketing capabilities of Canadian company to whom technology might be transferred.

There is a particularly strong logic to this option in the space area, given the raggedness of the boundary and the overlap of responsibilities between the present space R & D program and the

Technology and Industry Sector's space applications programs and the David Florida Laboratory.

Radio technology R & D focuses essentially on the development of new mobile radio technologies, sometimes in light of government needs, for ultimate transfer to industry. At present, the Technology and Industry Sector has no capability in this area and would clearly have to develop it if this research program was transferred.

It should be noted that, with the transfer of the R & D programs in the informatics, telecommunications, office automation and space areas, the Technology and Industry Sector would become the centre of technical expertise on standards within the Department. The marriage of this technical expertise with the industrial and user concerns of the sector would provide a useful counter-balance to the more carrier-oriented concerns of the Policy Sector in the standards area.

Spectrum Management Sector: Under this option, the Spectrum Management Sector would assume responsibility for the spectrum and environmental research program. The Sector already operates the Clyde Avenue Laboratory and the spectrum and environmental research program now provides important input into the Sector's ongoing efforts to plan future uses of the spectrum, with a view to developing appropriate licensing and regulatory policies.

Links to industry and university research community: With certain modifications to take into account structural changes specific to this option, it would incorporate the same mix of university advisory committees and industry advisory committees and sub-committees suggested in Options 5.1.1 and 5.1.2.

Reduction of micro-management: This option would incorporate all the features of Options 5.1.1 and 5.1.2 intended to reduce the burden of micro-management on the research program. There would, of course, be some differences in their implementation to take into account the unique features of this option.

For example, there would be a minor difference with respect to responsibility for the technical and some of the administrative services now provided by DGPA at the Department's laboratory complexes. At CRC and WARC, these would become the responsibility of the Technology and Industry Sector. At the Clyde Avenue Laboratory, these would be the responsibility of the Spectrum Management Sector.

Administrative efficiency: This option would incorporate with a few small variations, most of the features of Options 5.1.1 and 5.1.2 intended to improve the administrative efficiency of the R & D function.

For example, directed fundamental research would be separated in organizational and budgetary terms from applied research and development. Each Sector would develop its own management information system for its R & D program.

There would, however, be a few variations.

For instance, each laboratory complex would have its own senior manager who would report directly to the ADM of the Sector to which he belonged. This would be necessary to protect the integrity of the R & D function insofar as it could be protected under this option.

The Technology and Industry Sector would become responsible for assuring a more effective technology transfer function and for providing a strong organizational focus for the interface with PILP, UPP and other federal programs outside the department which the Research Sector now makes use of. The Technology and Industry Sector would also be expected to provide the new organizational focus for co-ordinating the research intelligence gathering and dissemination function.

Assessment: As was the case with the previous two options, this option will be assessed in light of the principles defined in Chapter 2.0 and applied to the DOC research program in Chapter 4.0.

1. **R & D is a unique endeavour requiring unique managerial practices:** As was the case with the previous options, this option would involve a significant reduction in micro-management, given that it incorporates the features of those options intended to reduce micro-management.

   However, it should be noted that, with the relocation of research programs in client sectors whose predominant concern has not been R & D, there would be a greater tendency -- even a temptation -- to subject those R & D programs to the same kinds of internal management and accountability requirements as other programs within those sectors. In short, the danger of micro-management would be significantly greater.

2. **Optimal university links require commitment to directed fundamental research:** As already noted, this option incorporates the features of Options 5.1.1 and 5.1.2 with respect to the establishment of university advisory committees and peer review. However, with the fragmentation of the research program, it would be much more difficult for university advisory committees to examine and give advice on the Department's over-all priorities and commitment in the area of directed fundamental research.

   It also seems very doubtful that in the long run there would be the same commitment to directed fundamental research within a Sector not oriented to research as there would be if the research programs formed a Sector wholly oriented to R & D. As a result, there is a very real possibility that links with universities would be weakened.

3. **Fundamental research vs. applied research and development:** As with Options 5.1.1 and 5.1.2, this option would entail the separation in budgetary and organizational terms of directed fundamental research from applied research and development. However, in the long run, there might well be pressure to make the fundamental research more applied if it was located in a Sector with a predominant concern other than research.

4. **The primary focus of government labs -- applied research or long-range development to meet government needs:** Under this option, the research programs of the department would be fully accountable to, and driven by government needs, but only as defined by those DOC sectors of which they would form a part. In short, the accountability of the research programs to the Technology and Industry Sector and the Spectrum Management Sector would be far greater than under Options 5.1.1 and 5.1.2. In contrast to what would obtain under the previous two options, the priorities of these Sectors would entirely drive the research programs.

   The difficulty with this option is that both the Policy Sector and the Cultural Affairs Sector should also have close links with the research program. Information gathered by the Research Sector is vital to successful policy development. The Policy Sector now has the lead role role in the standards area and relies heavily on technical support from the research program. R & D should also contribute to the achievement of Departmental policy objectives and priorities. If such R & D is to be effective, it must grow out of close links with the two main policy development centres of the Department -- the Policy Sector and the Cultural Affairs Sector. With the research programs forming part of the Technology and Industry Sector and the Spectrum Management Sector, it would be significantly more difficult than it is at present for the research programs to establish effective and formal links with the Policy and Cultural Affairs Sectors.

   In addition, it should be noted that the elimination of the Research Sector and the distribution of its research programs among other DOC sectors would have some negative impact on the sensitive DND relationship. One of the key arguments which DOC has used to resist DND proposals for a return of defence-related research to that Department has been that there is a strong synergy among the many DOC research programs and this enhances the quality of the results in any specific area. This argument would be weakened if the research programs were divided up among other DOC sectors.

5. **Role vis à vis industry:** Under this option, industry advisory committees and sub-committees would provide formal links with industry of about the same quality as for Options 5.1.1 and 5.1.2. However, the relocation inside the Technology and Industry Sector of those research programs with the most relevance to industry would clearly make industrial and commercial considerations much more influential in shaping those programs than would be case with the two previous options. On the other hand, there would exist a danger in the long run that, in a Sector dominated by industrial, commercial and marketing concerns, the emphasis of the research program might tend to shift towards near-term development work -- work which can be conducted much more effectively by industrial laboratories.

6. **An international monitoring and dissemination role:** With the organizational focus for the co-ordination of this activity inside the Technology and Industry Sector, it seems likely that this activity might be more responsive to industrial and commercial needs than would be the case with Options 5.1.1 and 5.1.2. However, if -- because of the industrial, commercial and marketing concerns of the Sector -- the emphasis of the research program shifted towards near-term development,

the ld lose a capacity to tap sources of information on
long- earch around the world.

More , it should be noted that one of the most important reasons
for research programs assume this information role was to
ens Department's policy development centres were abreast of
cur gical developments. As explained previously, this option
wou nificantly more tenuous the already tenuous links between
the gram and the Policy and Cultural Affairs Sectors, the
Depa ain policy development centres. In other words, this
opt less likely that the research programs would meet
the s of the policy development centres of the
Dep.

7\. The n and **the notion of critical mass:** Clearly, the
eli esearch Sector and the distribution of research
pro ology and Industry and Spectrum Management sectors
wou difficult to develop an over-all vision for the DOC
R&D ition, because research managers would no longer have
di e highest levels of the department, it would be more
di e the involvement of senior management in the
e ecution of such a vision -- an important precondition
fo implementation according to most of the literature.
Mo s already noted, this option would render more tenuous
th the research programs and the policy development
ce epartment, with the result that there would be less
li vision reflecting the policy priorities of the
De ally, if the predisposition to micro-management of
sec nted to research became a reality, there would be a real
pos any coherence of vision could be lost in the resulting
pro f small, overcontrolled projects.

On nd, those programs transferred to the Technology and
Ind would be clearly driven by that Sector's priorities, and
this ide the basis for a very focussed vision. The same might
wel or the spectrum and environmental research program inside
the nagement Sector.

In owever, the critical mass of the Department's research
prog e reduced. Neither the Spectrum Management Sector nor the
Tec Industry Sector by themselves would have as many R & D
res allocate into strategic technological areas as would the
Res under Options 5.1.1 or 5.1.2. It would also, for
exa e difficult to develop synergies -- say, between spectrum
res adio or space R & D -- across sectoral boundaries.

On d, it should be noted that the bulk of the R & D programs
and ould be going to the Technology and Industry Sector, and
this esent a fairly large pool of resources available for
rea light of strategic technological or industrial
cons . In addition, if it was felt that R & D in a certain
str ological area should be a priority, there is no reason, at
leas , why the ADM of a sector could not reallocate into R & D
res his non-research programs.

5.2 QUASI-INDEPENDENT STATUS

Full implementation of the recommendations of the Wright Task Force would involve the conversion of all government laboratory centres into crown corporations, departmental corporations or branches designated as departments under the Financial Administration Act. Under that legislation, a crown corporation -- or Schedule 'C' corporation, as it is sometimes called -- must to a significant degree operate in a marketplace environment rather than being dependent upon Parliamentary appropriations. In contrast, a departmental corporation or a branch designated as a department are essentially dependent on Parliamentary appropriations.

As noted in previous chapters, the Department hired a consortium of consultants led by Price Waterhouse to study the feasibility of setting up a not-for-profit corporation -- the Canadian Communications Informatics and Space R & D Institute (CCIS, for short) -- jointly sponsored by the public and private sectors and utilizing the CRC as its nucleus. Beyond investments from the private and public sectors and government contracts, it had been felt that CCIS would be able to support itself through contracts with provincial governments, domestic companies, foreign companies, foreign governments and international organizations. The consultants concluded that CCIS would not be viable, in part because there seemed to be little market for CCIS contractual services.[1]

It would seem, then, that if the Research Sector as a whole was to move outside the Department, it could not rely sufficiently upon the market to be classified as a crown or Schedule 'C' corporation. Rather, it would be classified as a departmental corporation or a branch designated as a department under the Financial Administration Act.

It is these two options which are explored in this section. Most of the features of the first three options intended to reduce micro-management could be incorporated under this option, though some might be less necessary because departmental corporations and branches designated as departments can be given separate employer status which frees them from many Public Service Commission and Treasury Board constraints. Most of the features of the previous options intended to improve the efficiency of the research program could also be incorporated in this option.

The significant differences between these two options and the previous ones would lie in the mechanisms for assuring accountability to industry, university and government clients. However, it should be noted that these options would provide an organizational context more conducive to accountability to industry and universities than was the case with the previous options. It would also not be incompatible with these options to take steps such as assuring that a portion of the research staff came on a two to four-year basis from industry or government labs or seeking Treasury

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1 It should be noted that the CCIS viability study did suggest as an alternative for consideration that a not-for-profit corporation might be set up around the Research Sector's R&D in the office automation and informatics area -- especially that taking place at the Canadian Workplace Automation Research Centre (CWARC); a number of specific options for CWARC are considered in the next section.

Board and Cabinet approval for such measures as the personnel demonstration project or multi-year budgetting with roll-overs.

5.2.1 The option

Under this option, the Research Sector would cease to be part of the Department of Communications and become a departmental corporation or a branch designated as a department under the Financial Adminstration Act and reporting to the Minister of Communications. These two sub-options would have essentially the same implications for the effectiveness of the research corporation, though it should be noted that that the former has a stronger corporate legal identity. Both sub-options are described and assessed below.

The National Research Council is perhaps the most important federal example of a research institute which operates as a departmental corporation. There are also a number of examples within the federal government of branches designated as departments -- the Defence Research Board, the National Film Board of Canada, the National Library of Canada, etc.

Both the departmental corporation and the branch differ significantly from the previous three options in that they would give representatives of industry and universities real decision-making power with respect to the research program. At the same time, such institutional arrangements could be made more responsive to DOC and other government requirements than would be the case with subsequent options.

Board: As a departmental corporation or a branch designated as a department, responsibility for running the research program would rest with a board representative of its industry, university and government clients.

- Sub-committees of the board would be responsible for determining priorities and budget allocations within each subject area addressed by the corporation's research program: workplace automation and informatics, telecommunications, radio technology, space, and spectrum and environmental research. A separate university sub-committee could be charged with the responsibility to oversee directed fundamental research.

- As recommended by the Wright Task Force, the board and its sub-committees would have actual decision-making responsibilities as opposed to the advisory powers for industry and university representatives contemplated under all the options under which the research program would remain within the Department.

- The Wright Task Force outlined in some detail the arguments for, and the nature of, such a board and sub-committee structure: "...it should not be a rubber-stamp. Its members should be long-term appointees, so that the board is thoroughly familiar with the laboratory's operations. It should be composed of representatives of the laboratory's main 'clientele', including private sector members and qualified regional representatives where appropriate. It should not be an 'advisory board'. Rather, it should have the power to define and review missions, set priorities, and ensure that these goals are reflected in budgetary allocations. In our view, the board's most important job would be mission definition: enhancing the legitimacy of a lab's activities by deciding what the lab should be doing, and on whose behalf. Finally, the manager must be held accountable for the quality, relevance and productivity of the lab. Therefore, the appointments of lab managers should be made for finite terms, and the board should have the authority to extend or abbreviate those terms."[1]

Reduction in micro-management: The act designating the research program as a departmental corporation or a branch with the status of a department would give the new body "separate employer status" under the Financial Administration Act.

- The legislation could provide that, as a result of such status, the new agency would not be subject to the legislation and rules administered by the Public Service Commission with respect to hiring, promotion and negotiations with unions.

- The legislation could also provide that Treasury Board rules and guidelines with respect to personnel classification would not have to apply to the agency. It could, if it so desired, devise its own classification system reflecting the unique requirements of the R&D environment.

Responsiveness and accountability to government: With a departmental corporation or a branch designated as a department, it would be possible in the normal course of events for the government to give the agency positive directions with respect to its activities, as well as to exercise the kind of prohibitory powers implicit in Treasury Board rules and guidelines.

- The legislation would contain provisions for the Minister -- and through him, the Department -- to assign work for the new agency. For example, the legislation establishing the Defence Research Board states: "There shall be a Defence Research Board, which shall carry out such duties in connection with research relating to the defence of Canada and development of or improvements in materiel as the Minister may assign to it, and shall advise the Minister on all matters relating to scientific, technical and other research and development that in its opion may affect national defence." In other words, the Minister -- and, through him, the Department would in the normal course of events be able to assign tasks to the new research agency and thus be able to give a positive direction to its activities.

- The new agency would be funded through the contractual mechanism. The terms and conditions of those contracts would constitute a powerful instrument for ensuring that the agency served Departmental needs, as well as the needs of other federal departments and agencies with which it had contracts.

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1 Wright Task Force, <u>op. cit.</u>, p. 29.

5.2.2 Assessment

This option will be assessed in light of the seven principles defined in Chapter 2 and applied in Chapter 4 to the DOC research program.

1. R & D is a unique endeavour requiring unique managerial practices: Under this option, there would likely be a considerably greater reduction in micro-management than if the research program remained within the Department. For example, if the new agency had separate employer status, the Public Service Commission rules and guidelines with respect to personnel hiring and promotion would not apply at all. Treasury Board classification rules would also not apply. Both regimes would apply to the research program if it remained inside the Department, unless some relief was provided by securing Cabinet and Treasury Board approval for the personnel demonstration project proposed above.

   As a result of this change, certain additional responsibilities would fall on the management of the new agency. For example, it would be responsible for all dealings with its own unions -- a task now undertaken by Treasury Board and to a lesser degree the Department.

   If the new agency was wholly funded through the contractual mechanism, it is unclear to what degree Treasury Board rules and guidelines with respect to financial management would still apply.

2. Optimal university links require commitment to directed fundamental research: In contrast to the previous options under which the research program would stay within the Department of Communications, this option would give representatives of the university research community a direct influence on the direction of the proposed research program. The board of the new agency, and its sub-committees -- which would contain university representatives -- would have clear decision-making responsibilities vis à vis the direction of the research program. If the program remained within the Department, the present system of delegations of authorities would prevent such boards or committees from having anything other than an advisory role.

3. Fundamental research vs. applied research and development: Within the new corporation, directed fundamental research would be separate in budgetary terms from applied research and development, as would be the case if the program remained within the Department.

4. The primary focus of government labs -- applied research or long-range development to meet government needs: The legislation establishing such an agency would would give the Minister -- and, on his behalf, the Department -- the power in the normal course of events to assign tasks to the new agency. Such provisions could provide a fairly flexible framework for ensuring that the research program of the new agency was responsive to government needs.

   In addition, the terms and conditions of the contracts through which the Department funded the new agency would enforce a clear-cut customer-client relationship between the Department and new agency.

R & D for other departments could be carried out on a cost-recovery basis, which would enforce a certain responsiveness to their needs.

5. Role vis à vis industry: This option would involve considerably stronger links with industry than would the previous three options. Indeed, under this option, with representatives on the new agency's board and its sub-committees, industry would have clear decision-making responsibilities with respect to research priorities and the means of attaining them. If the research program remained within the Department, industry would only have an advisory role vis à vis the program.

6. An international monitoring and domestic dissemination role: This option would include nearly all of the features of the previous three options intended to strengthen this role -- including expanded travel budgets and a clear organizational focus for the performance of this role. However, it should be noted that Treasury Board guidelines with respect to foreign travel do apply to a branch designated as a department, and approval would have to be sought from the Minister of Communications for travel outside the country to scientific and technical conferences. Still, there can be little doubt that the processing of such requests within an agency devoted to research would tend to be more responsive to the needs of researchers and the requirements of the role than if these requests were processed along with others within a Department with responsibilities outside the research area.

   Given the greater influence of industry and university representatives over the activities of departmental corporation or a branch designated as a department, one would expect that the performance of this role would be more responsive to the needs of these two groups than would be case if the program remained within the Department. At the same time, there is the possibility that, in carrying out this role, such an agency might be somewhat less responsive to Departmental information needs than if the research program remained within the Department.

7. The quality of vision and the notion of critical mass: The development of vision can be said to depend in part upon a relative lack of conflicting demands being placed on that program. It is certainly arguable that a research program located within a government department is subject to many such demands and that many of these can have little to do with the exigencies of developing a strong and coherent R & D program. In other words, it might be easier to develop such a vision in the context of a department corporation or branch designated as a department, both of which would be relatively more independent of the Department of Communications than one of its sectors would be.

   It should be noted that such a vision would tend to place greater emphasis on the needs of industry and universities and less on the needs of government, especially the Department of Communications, than would be the case if the research program remained within the department. However, this shift in emphasis might not cause difficulties, given that an important force shaping the vision would be the tasks assigned to the new agency on a regular basis by the Minister and, on his behalf, by the Department through the contractual mechanism. In some ways, such a shift in emphasis might constitute a clear-cut advantage. The board and chief executive officers of such an agency, with representation from industry, universities and government, might provide a focus for the development of a clear strategic vision which, because shared by all major R & D players, would result in a co-ordinated national research program in these strategic technological areas.

5.3 CWARC OPTIONS

All the options described above would apply to the entire research program -- including both the CRC and CWARC. However, as noted many times above, there are significant differences between the two laboratory centres. a case can be made, at least on theoretical grounds, that CWARC should be treated differently from the CRC.

For example, while the CCIS feasibility study concluded that a not-for-profit corporation utilizing the CRC as its nucleus could not be achieved at the present time, it suggested as an alternative for consideration that an Informatics Institute or Agency be established as a not-for-profit or departmental corporation.[1]

The consortium of consultants working on the CCIS feasibility study did not specify the precise mix of R & D which such an institute or agency would undertake. Clearly, however, the new workplace automation laboratory centre at Laval would be central to such an undertaking and would likely form its nucleus. It might also subsume some of the work carried out at CRC in the informatics area, as well as in the fibre-optics area. Whatever the precise mix, the program of such an institute would have to recognize the dominant client relationship which should obtain between R&D in these areas and the activities of the Department's Government Telecommunications Agency and Technology and Industry Sector.

Before considering the kinds of organizational frameworks available for such an institute, it should be noted that CWARC, as now constituted, represents a radical departure from traditional departmental practice in the R & D area. With its ambitious external relations program, its commitment to a strong role for industry-university advisory boards and its intention to have half of its research staff come from industry and universities through a contribution-based exchange program, it represents in many ways a bold experiment.[2] This experiment would become even more radical if any of the previous options described in this chapter were implemented.

The CWARC experiment is still in its initial stages, but there is evidence that it has made a promising beginning. It is therefore important to consider whether such an experiment should be cut off before any conclusions can be drawn as to its validity -- especially given that any of the options mentioned here would have the effect of making that experiment even more radical.

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1 Price Waterhouse, op. cit., pp. 12-18.

2 Ibid., p. 18.

The countervailing argument is, of course, that, because CWARC has no history, the same constraints which would apply to such an experiment at CRC are not relevant. In short, the embryonic state of CWARC -- which now has very few staff and not much equipment -- presents an opportunity for even bolder experimentation.

Whatever the merits of these arguments, there are alternative organizational frameworks which could be applied to CWARC, and these might make it even more relevant to industry and the university research community.

The most conservative of such options would be to take CWARC outside the Department and convert it by itself into a departmental -- or Schedule 'B' -- corporation. This was in fact one of the possibilities put forward as an alternative for consideration in the CCIS Feasibility Study.[1] The impact of such a change is discussed in general terms under the previous option.

At the most extreme would be sale of the facility to the private sector. It seems doubtful that such an option is realistic at the present time, given that most of the necessary scientific and technical equipment has not been installed and would have to be provided by the purchaser. In fact, any purchaser would in reality be buying not a laboratory -- but a building and a plot of land.

There is, however, a middle range of options which may be more feasible. These would involve: contracting out the CWARC research function to the private sector, or converting CWARC into a crown corporation under the Financial Administration Act or a not-for-profit corporation under the Canadian Business Corporations Act. All of these are discussed below.

5.3.1 Contracting out the function

Whether CWARC remained within the Department or was spun off into a departmental corporation, a crown corporation or a not-for-profit corporation, the management and functions of the laboratory centre could be contracted out to the private sector. More important, contracting out of the function by itself might constitute an attractive alternative to giving CWARC corporate status in some form, given that such a step would not require going to Parliament for a legislative authority. The features of such an option are described and assessed below.

The option: According to the Wright Task Force, "the logical extension of the 'contracting out' policy is to have a private contractor operate entire laboratories on behalf of their government owner. This is not as fanciful as it may sound; government-owned labs, operated by private contractors, are a permanent and well-regarded feature of the U.S. research establishment. One Canadian example is TRIUMF, the government-owned research facility on the University of B.C. campus, which is operated by a board representing four Canadian universities. Whether GOCO (government-owned, contractor-operated) laboratories are clearly superior to GOGO (government-owned, government-operated) labs is still a matter for lively debate in the U.S.

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[1] Price Waterhouse, op. cit., p. 18.

But we believe this model for managing federal laboratories should be used more widely in Canada, on a deliberately experimental basis."[1]

The advantages of such an arrangement would seem to be two-fold.

First, contracting out the function to the private sector might in itself well represent a means of gaining some of the advantages of corporate status for the lab -- in terms of heightened responsiveness to the needs of the private sector and universities -- without going through the time-consuming and complex process of having legislation passed by Parliament to create such a corporation.

Second, the contractor would not be subject to Treasury Board or Public Service Commission requirements with respect to financial, personnel or administrative matters.

Presumably, the contract would call for the performance of R & D which would simultaneously meet government needs and have important industrial benefits. The exact nature of the contract, and the required "deliverables", are difficult to specify at this time. These do, however, raise important issues. For example, joint arrangements with industry would clearly contribute to industrial development objectives; but would the government want the contractor itself to profit from such arrangements?

The basic question with respect to this option is who should be the contractor. It could be an individual engineering consulting firm -- with experience in managing R & D -- selected by open tender. It could be a consortium of such firms. It could be a consortium of Canadian manufacturing, software and systems firms in the office automation and informatics areas, as well as users. It could be a consortium which included both manufacturing, software and systems firms and university representatives in these areas.

In our view, the last option is preferable. The direct involvement of companies actually engaged in making and using products would introduce a powerful element of "market pull" into lab operations. More important, these companies would, in fact, be the primary targets of any government industrial development area aimed at these strategic technological areas. Their direct involvement in such a laboratory operation would provide a basis for co-operation among them in the areas of basic and applied research and thus encourage them to co-ordinate their activities, thereby permitting perhaps a focussing of resources in key areas.

The direct involvement of university representatives would ensure greater interaction and perhaps co-ordination among industry and university research programs. Such co-operation might lay the basis for a significant more coherent national R & D agenda in which the efforts of the major players complemented each other to the benefit of all.

Assessment: This option is assessed in light of the seven principles defined in Chapter 2.0 and applied in Chapter 4.0 to the DOC research program.

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[1] Wright Task Force, op. cit., p. 31. Underlining theirs.

1. **R & D is a unique endeavour requiring unique managerial practices:** As already noted, the actual operation of CWARC by the contractor need not be subject to either Treasury Board or Public Service Commission rules and guidelines. This would represent a considerably greater reduction in micro-management than would be possible if CWARC were directly administered by the Department or became a conventional departmental corporation. Of course, the degree of improvement would depend very much on the managerial approach of the contractor and the kinds of reporting requirements built into the contract.

2. **Optimal university links require commitment to directed fundamental research:** The direct involvement of university representatives in the consortium receiving the contract would assure strong formal links with the university research community. Indeed, as a result, university representatives would have some control over the direction of the research program -- subject, of course, to the provisions of the contract. The level of responsiveness to the university community would depend on the composition of the consortium and the nature of the contract.

   It should be noted that one of the most prominent examples of such an operation is the Lawrence/Livermore Laboratories in California. It is owned by the Department of Energy, but its management -- including the supplying of all personnel -- is contracted out to the University of California. It is involved essentially in the design of nuclear weapons and the development of non-nuclear energy resources.[1]

   However, it should not be forgotten that the mission of the Lawrence/Livermore Laboratories is very different from what is contemplated here. The California labs would seem to have a very narrow mission and be strongly driven by government -- especially defence -- requirements, which would provide a clear measure of performance. The mission of the new CWARC would be significantly less precise and as a result measures of the contractor's performance would be susbstantially less clear.

3. **Fundamental research vs. applied research and development:** An organizational and budgetary separation between directed fundamental research and applied research (including development) could be a requirement under the contract, or the matter could be left to the contractor.

4. **The primary focus of government labs -- applied research or long-range development to meet government needs:** The contractual mechanism itself would be the main means of ensuring that the R & D performed under the contractor's management met government needs.

   For example, the contract could be for a definite time period, at which time the relationship would be assessed to provide input into a decision on its renewal or termination. This arrangement in itself could create a climate which would be conducive to responsiveness to government needs on the part of the contractor.

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1 Price Waterhouse, _op. cit._, Appendix C, p. 24.

In addition, the contract could contain requirements for specific kinds of services or deliverables. However, there would be definite limits on the degree to which one could build into such a contract requirements to carry out applied research and long-range development in areas where future government needs might be met.

Also problematical would be how such a contract with DOC would enable the research program to meet the needs of other departments and agencies. It may be that other departments and agencies would also have to establish contractual relationships with the DOC contractor.

More important, there is the question of the degree to which the contractor's natural desire to make a profit from the arrangement would limit the quality of the R & D and its contribution to meeting government objectives. For example, if the contract was for a fixed price, it might be in the contractor's interest to skimp on the R & D.

5. **Role vis à vis industry:** If the contract were with a consortium of manufacturing, software and systems firms -- as well as users and university representatives -- in this area, there can be little doubt that the industry would exercise a strong influence over the research program. There would, of course, be some trade-off between their authority and the degree to which the contract specified in detail how the contractor should meet government needs. In our view, their influence would be far beyond what could be exercised by industry in an advisory role if CWARC was administered in accordance with the first three options in this chapter. Under this option, the consortium and its industry members would have clear-cut managerial authority over the program and thus probably greater authority than would be exercised by industry members of the board of a departmental corporation.

Clearly, CWARC would be expected to contribute to industrial development in these key technological areas. However, it is difficult to envisage how the meeting of such a requirement could be operationalized in the context of a contract. The question of who should benefit could also be a knotty question to government and the members of the consortium in two senses. First, the research program might benefit some members of the consortium more than others, setting in motion centrifugal forces within the consortium. Second, to what degree would the members of the consortium be interested in providing benefits to companies not part of the consortium? It may be that the members of the consortium would find themselves in a conflict of interest situation with respect to how the lab contributed to industrial development.

The key question, of course, is whether such a consortium could in fact be formed. The office automation and informatics fields are highly competitive, and it might be difficult to persuade Canadian companies in this field to co-operate together as fully as would be necessary if such a consortium were to be a success. Certainly, the degree of co-operation required would be greater than would be necessary if representatives of participating companies were members of the board of directors of a departmental or crown corporation.

In this context, it should be noted that, in Japan, the United States and Europe, there are many examples of such R & D consortia in this highly competitive field. Clearly, the participants in such consortia have felt that the long-term benefits of co-operation on a national scale outweigh any possible loss of a competitive edge vis à vis other domestic companies. Whether Canadian companies could attain such an enlightened perspective is, of course, an excellent question.

6. **An international monitoring and domestic dissemination role:** The performance of such a role would, of course, be required by the contract. If the contract was with a consortium, the lab in carrying out this role would likely be very responsive to the needs of industry and the university research community. The meeting of government information needs could be a requirement of the contract, though it might be more difficult for a consortium composed of people from outside government to put together an effective mechanism for identifying, let alone satisfying, such needs.

7. **The quality of vision and the notion of critical mass:** In many ways, the terms and conditions of the contract with the consortium would provide the foundation for such a vision. Indeed, the contract should be designed so that the consortium itself would be responsible for developing a scientific plan for the lab at the strategic nexus of government need, commercial potential and Canadian industrial capability. Given that such a consortium would ideally be representative of the major R & D players in both industry and universities, it may well be that the scientific plan would lay the basis for a co-ordinated national program of R & D in these strategic technological areas.

5.3.2 Parent Crown Corporation

The conversion of CWARC into a parent crown corporation would provide quite a different regime from either contracting out or a departmental corporation. This option is described and assessed below.

The option: Under this option, CWARC would cease to be part of the Department of Communications and be established as a parent crown corporation. It would be wholly owned but partly funded on a continuing basis by the federal government and report to Parliament through the Minister of Communications. An Act of Parliament would be necessary to establish such a corporation.

Board of Directors: As was would be the case with a departmental corporation, such a crown corporation would be run by a board of directors representative of its industry, users, university and government clients. Sub-committees of the board could be struck to oversee specific programs in the broad area of workplace automation and informatics. A separate university sub-committee could be charged with the responsibility to oversee directed fundamental research.

As recommended by the Wright Task Force, the board and its sub-committees would have actual decision-making responsibilities as opposed to the advisory powers contemplated under the first three options considered in this chapter.

Involvement in marketplace: CWARC would be established as a crown corporation under Part 1 of Schedule C of the Financial Administration Act. Though such a crown corporation could be partly dependent on a Parliamentary appropriation, it would have to be involved in the marketplace and draw part of its revenues from the marketplace. In other words, it would have to receive part of its revenues from non-government sources -- through R & D contracts with users, Canadian manufacturers, provincial governments, foreign institutions, etc. Such a dependence on the margin would enforce a real market discipline on the new corporation.

Accountability to government and reduction in micro-management: As a crown corporation, CWARC would be under a very different accountability regime than it would be as a departmental corporation.

There are a few similarities, of course. In both cases, the Governor-in-Council would appoint the board of directors and contracts with government departments -- including the Department of Communications -- could be employed to assure a clear-cut client relationship between the government and the corporation.

The differences are more important, however. Each year, a crown corporation has to submit its operating budget, corporate plan and capital budget to the appropriate Minister for approval by the Treasury Board and/or the Governor in Council. Any deviation from that plan must also be approved. It would also be subject to the government's power of direction under the Financial Administration Act, though this would only be used in fairly extraordinary circumstances because of the safeguards built into the legislation. However, a crown corporation does not have to seek approval for its operational plan from the Minister, the Department, Treasury Board or the government, nor is it is as subject to Treasury Board rules with respect to contracts. These represent a significant diminution in micro-management.

Such a crown corporation would also be designated as a separate employer under the Public Service Staff Relations Act. As a result of this designation and its differences from a departmental corporation, such a crown corporation would not be subject to either Treasury Board or Public Service Commission rules or guidelines with respect to its personnel management and personnel classification. Within the limits imposed by its Parliamentary appropriation and its other revenues, it would be almost completely free to determine the proportion of its operational budget to be spent on salaries or programs.

Assessment: This option will be assessed in light of the seven principles defined in Chapter 2.0 and applied to the DOC research program in Chapter 4.0.

1. **R & D is a unique endeavour requiring unique managerial practices:** A crown corporation would be free from the kinds of micro-management arising fromTreasury Board and Public Service Commission rules. Indeed, beyond seeking annual approval for its business plan, operational budget and capital budget and within the limits of its Parliamentary appropriation, the management of the crown corporation would be pretty well free to manage as they wished. In large measure, this situation would be consistent with the recommendation of the U.S. Federal

Laboratory Review Panel that laboratory managers have a specified budget but not be controlled with respect to person/years.

2. **Optimal university links require commitment to directed fundamental research:** With university representatives on the board of directors and on a sub-committee overseeing directed fundamental research, the formal links with universities would be very strong. Indeed, as would be the case with a departmental corporation, university representatives would have a strong influence over the direction of the research program -- especially in the area of directed fundamental research -- rather than simply playing an advisory role as would be the case if the program remained within the Department under the first three options. In addition, the government, because of its power to appoint board members, might possibly be in better position to assure strong university representation than it would if the function was contracted out to a consortium whose membership might be hard to predetermine.

3. **Fundamental research vs. applied research and development:** Within the new corporation, we would expect to see a clear separation in at least budgetary terms between directed fundamental research and applied research, including development.

4. **The primary focus of government labs -- applied research or long-range development:** There would be a number of mechanisms available to ensure that such a crown corporation would meet government and departmental needs -- government control of appointments to the board of directors, annual approval by the government of the corporation's business plan and capital budget, the power of direction and its over-all dependence on a Parliamentary appropriation. R & D for other federal departments and agencies could be carried out a cost-recovery basis, which would enforce a certain responsiveness to their needs.

   However, it should be noted that a crown corporation would be considerably more independent than a departmental corporation. In other words, in comparison to the board of a departmental corporation, there can be little doubt that the board of directors of a crown corporation would be more likely to develop eventually its own mix of priorities and be less responsive to Departmental perceptions of government needs, even if the meeting of government needs formed part of its mandate.

5. **Role vis à vis industry:** This option would involve significantly stronger links with industry than any of the options under which CWARC would remain part of the Department, with the possible exception of contracting out. A crown corporation's greater freedom from bureaucratic constraints might help ensure that such a corporation was more responsive to industry needs than a departmental corporation.

   In addition, simply because it would be easier to ensure through government appointments that the corporation's board of directors was representative of industry than would be the case with a consortium, the links with industry might be stronger than if the CWARC function was contracted out. Indeed, given the vigorous competition in the office automation and informatics fields, it would be far easier to have a board representative of industry and users than it would be to secure a similarly representative group in the more intimate confines of a consortium to which the R & D function would be contracted out.

However, the crown corporation's greater dependence on the market could cut both ways in terms of its capacity to meet industry needs. On the hand, the very fact that such a corporation was in part subject to market discipline might contribute to a more effective R & D program and make it more responsive to industry needs. On the other hand, this very dependence on the market might create a situation where the corporation was competing for contracts and work with the very businesses it was intended to serve. Such a situation could have a direct negative impact on the industry, as well as preventing the crown corporation from creating the kind of co-operative and productive relationship with industry which is so vital to providing any real long-term benefit to this industry.

6. **An international monitoring and domestic dissemination role:** This option would include nearly all of the features of the first four options intended to strengthen this role -- including expanded travel budgets and a clear organizational focus for the performance of this role. More important, it would be much easier to carry out this role than it would be inside the department because a crown corporation is not subject to Treasury Board guidelines with respect to foreign travel.

   Given the greater influence of industry and university representatives over the activities of a crown corporation, one would expect that the performance of this role would more responsive to the needs of these two groups than if the program remained within the department.

   However, in this respect, there could be no guarantees. If the corporation's dependence on the market brought it into competition with the industry it was intended to serve, the basis for providing an information service to industry might disappear.

7. **The quality of vision and the notion of critical mass:** The development of vision can be said to depend in part upon a relative lack of conflicting demands being placed on a research program. It is certainly arguable that a research program located within a government department is subject to many such demands and that many of these can have little to do with the exigencies of developing a strong and coherent R & D. Even a departmental corporation or branch designated as a department is subject to many constraints. In other words, it might be easier to develop such a vision in the context of a crown corporation which is relatively more independent.

   It should be noted that such a vision would tend to place greater emphasis on the needs of industry and universities and less on the needs of government, especially the Department of Communications, than would be case if the research program remained within the Department or formed the basis for a departmental corporation or a branch designated as a department. However, if a crown corporation were established, its board, with representation from industry, universities and government, might provide a focus for the development of a clear strategic vision which, because shared by all major R & D players, would result in a co-ordinated national research program in these strategic technological areas.

   Because a crown corporation would be partly dependent on non-government sources of revenues -- such as contracts outside government -- this vision would likely be more market-sensitive than would be the case if the program remained inside the Department. In addition, if these outside revenues were substantial, they might, when added to the Parliamentary appropriation, create sufficient critical mass to raise the research program to world-class levels.

However, as already noted, there is a danger in such dependence on the marketplace. If this dependence meant the corporation was competing with the industry it was intended to serve, this situation would create a serious obstacle to the creation of any far-reaching strategic consensus involving industry.

5.3.3 Not for profit corporation

An informatics and office automation R & D institute could be established as a not-for-profit corporation jointly owned by the federal government and the private sector and utilizing CWARC as its nucleus. The features of this option are described and assessed below.

The option: According to the consortium of consultants, led by Price Waterhouse, who prepared the CCIS feasibility study, "Given the importance of research and development to the success of informatics companies and the modest R & D resources of individual Canadian firms in the field, the concept of a largely government-funded but commercially-oriented Informatics Institute or Agency is an interesting one. There are strong arguments that any such Institute should be outside the departmental structure of government in order to make it easier to:

- redirect contract funds or adjust the level or mix of staff in response to market trends;
- contract-in to meet industry requirements without lengthy delays or cumbersome procedures;
- compete internationally for research talent, which may be available only at salaries beyond those which a government department could normally consider; and
- provide for industry involvement as a major element in its priority-setting process, for example through a Board of Directors with both industry and government representation."[1]

There are a number of organizational models available for such an institute. The CCIS feasibility study suggested that it could be set up as a Departmental corporation under the Financial Administration Act -- an option which has already been discussed -- or a non-profit corporation under the Canada Corporations Act.[2] In fact, it would now have to be established under the Canadian Business Corporations Act.

There are some clear advantages to incorporation under the Canada Business Corporations Act. While it would require an Act of Parliament to establish a departmental or crown corporation, the normal procedures for

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1 Ibid., p. 15.

2 Ibid., p. 18.

establishing a private-sector corporation would obtain under the Canada Business Corporations Act. This could take as little as three months.

The key issues are, of course, the funding, ownership and structure of such a not-for-profit corporation. Clearly, a major portion of the on-going funding for such a corporation would come from the Government of Canada, whether in the form of block grants or contract fees or some other form. Contracts with other levels of government, the private sector and foreign institutions represent another source of funding.

Given that the federal government would be providing a large proportion of the ongoing funding for the corporation and that government needs should be an important driving force in in such a research program, government should play an important role on the board of directors and have a strong ownership position -- at least in the medium term. Given that the charter of such a corporation can be amended with two-thirds of the voting shares under the Canada Business Corporations Act, government should clearly hold at least more than one third of the voting shares. This proportion should be higher to the degree that government wishes to play a role in determining the direction of the program.

The remaining shares, and seats on the board of directors, could be held by the private sector and possibly provincial governments. It would also be desirable if there was university representation on the board of directors to ensure university input into the program.

Assessment: This option will be assessed in light of the seven principles defined in Chapter 2.0 and applied to the DOC research program in Chapter 4.0

1. R & D is a unique endeavour requiring unique managerial practices: The proposed not-for-profit corporation would not come under either the Financial Administration Act or any of the legislation administered by the Public Service Commission. As with a corporation in the private sector, R & D managers would have considerably more flexibility in determining research priorities and allocating resources and people than would be possible if the lab remained in the department or became a departmental or a crown corporation.

   Nor, as would be the case with the previous option, would this particular option involve the complexities of figuring out how to draft, administer or fulfill the terms and conditions of an umbrella contract governing the operation of the laboratory.

2. Optimal university links require commitment to directed fundamental research: If control over the research program was a function of having voting shares in the corporation, it seems unlikely that representatives of the university research community would have a decisive influence. Special arrangements would have to be made to give university representatives some influence, or at least -- more probably -- a key advisory role with respect to the research program. There is also the possibility that, if the university role in this respect was not sufficiently strong, directed fundamental research might be de-emphasized, as would formal links with the rest of the university research community.

Another means of strengthening the university role would be to draw researchers -- especially in the area of directed fundamental research -- from the university research community on an exchange basis.

3. **Fundamental research vs. applied research and development:** The new corporation would be expected to maintain an organizational and budgetary separation between directed fundamental research and applied research, including development. However, if the role of university representatives in the policy-making and management of the lab was too much diminished, it is conceivable that in the long run this organizational and budgetary separation might break down.

4. **The primary focus of government labs -- applied research or long-range development to meet government needs:** If the government owned sufficient voting shares in the corporation and played a strong role on its board, the over-all framework would be in place to ensure that the corporation was responsive to government needs. Ongoing government funding of the corporation, especially in the form of contracts, would represent another important means of ensuring that the corporation's R & D met government needs. However, such a corporation would likely be less responsive to government needs as defined by the Department than if the program remained within the Department or formed the basis for a departmental or crown corporation.

5. **Role vis à vis industry:** If companies in fact purchased shares in the new corporation and as a result had strong representation on its board of directors, industry would clearly be in a strong position to determine the corporation's policies and the direction of its research program. Much of the research staff could also be drawn from industry on an exchange basis.

   It is worth noting, however, that if influence on the board was a function of voting shares held by a company, care would have to be exercised that small and medium-sized companies in the informatics field would have a role. As Chapter 4.0 noted, such companies are less able to fund R & D themselves and should constitute the primary beneficiaries of government-funded research. This disadvantage would not arise in the case of a departmental or a crown corporation because the government could appoint the board members and ensure that they were representative.

   In addition, to the degree such a corporation was dependent on revenues earned in the marketplace, it could be in direct competition with the very industry it was intended to help.

6. **An international monitoring and domestic dissemination role:** The charter of the corporation could in fact include the performance of such a role. To the degree the corporation retained a major focus on applied research and long-range development, with a minor emphasis on directed fundamental research, it would be in a position to carry out such a role.

   Its effectiveness in providing an information service which met the information needs of the industry as a whole might well be partly dependent on how representative its board was of that industry. Similarly, the degree to which the corporation was able to meet the needs of the university research community would be dependent on the role and influence of university representatives in the corporation.

Certainly, it would be more difficult in the case of such a corporation to ensure that departmental information needs were met than would be the case if the program remained within the department or was spun off into a departmental or crown corporation.

However, to the degree the corporation was in competition with industry, its capacity for and interest in meeting industry's information needs would be limited.

7. **The quality of vision and the notion of critical mass:** At least potentially, this option has one fundamental advantage over all the other options discussed in this chapter. It might generate a significant increase in the amount of resources available for R & D in the areas of workplace automation and informatics. In other words, with contract fees and private sector investments over and above the amount available from the federal government, it might be possible to generate sufficient critical mass to have a world-class R & D program in these critical fields.

   A program working in the areas of only workplace automation and informatics would inevitably have a more focussed vision than one covering the entire field of communications. With its mixed ownership and extensive involvement by industry in policy-making and management, the corporation might well be in a position to develop a vision of its work which could be shared by industry, as well as perhaps users. Care would have to be taken to ensure that small and medium-sized companies and the university research community had sufficiently meaningful participation to be able to help shape that vision and thus share in it. In addition, to the degree such a corporation was competing with domestic industry, its ability to reach a strategic consensus on its role with industry would be limited.

   Essentially because such a corporation would be less a creature of government than a departmental research arm, a departmental corporation or a crown corporation, the vision of a not-for-profit corporation might be less responsive to government needs than would be the case with these other alternatives.

5.4.0 CONCLUSION

The assessment of organizational options is always a difficult and speculative exercise because organization is only one of the factors which can determine the future of a research program. In this chapter, we have considered eight organizational formats -- and 26 different options for the entire research program, taking into consideration all the varying combinations of organizational formats which could be applied to both the CRC and CWARC.

In our view, the number of real options is much more limited.

For example, we do not think a persuasive case can be made for treating the CRC and CWARC in a substantially different manner. In our view, this would add an undesirable complexity, in both organizational and accountability terms, to the way the department -- and its client groups -- relate to the research program. In addition, CWARC already represents an interesting experiment upon which a promising beginning has been made. It would reflect a premature and somewhat perverse adherence to the adage about change for the sake of change to abort this experiment before any meaningful basis for evaluation exists. For this reason, we can set aside the three CWARC options outlined above, as well as the many combinations of differing organizational formats for the CRC and CWARC.

We also think that the losses would far outweigh the gains if the Research Sector was eliminated and its constituent parts joined to the Technology and Industry Sector and the Spectrum Management Sector. This option ignores entirely the vital and important links which should exist between all aspects of the research program and the Policy and Cultural Affairs Sectors. For the reasons given in the assessment of this option, we also believe that the absorption of the research program by sectors whose main priority is other than research might eventually erode to the point of no return the integrity of the research function within the Department.

We are left, then, with three real options:

- the modified status quo,

- the expanded program with strengthened accountability mechanisms, and

- quasi-autonomous status as a departmental corporation or as a branch designated as a department.

The first would give the program's clients and users of its research a clear advisory role with respect to the direction of the program. The second would give Departmental clients of the program actual influence over the direction of the program. The third would give industry and university representatives such influence, as well as government representatives -- at least to the degree each was represented on the board of directors of the new agency and its funding was provided through the contractual mechanism.

Figure 5-1

DOMINANT CLIENT RELATIONSHIPS

WITHIN THE DEPARTMENT OF COMMUNICATIONS

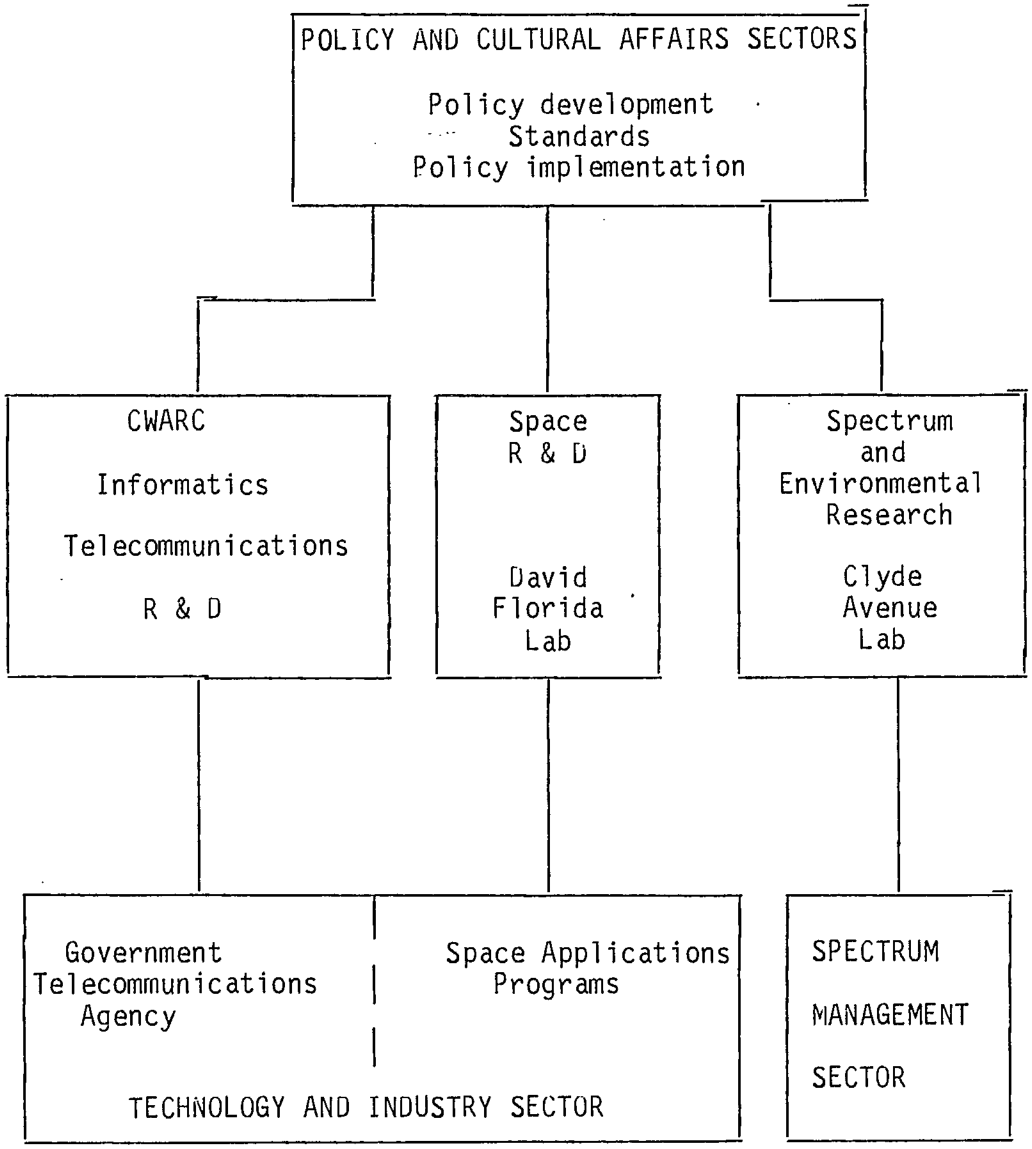
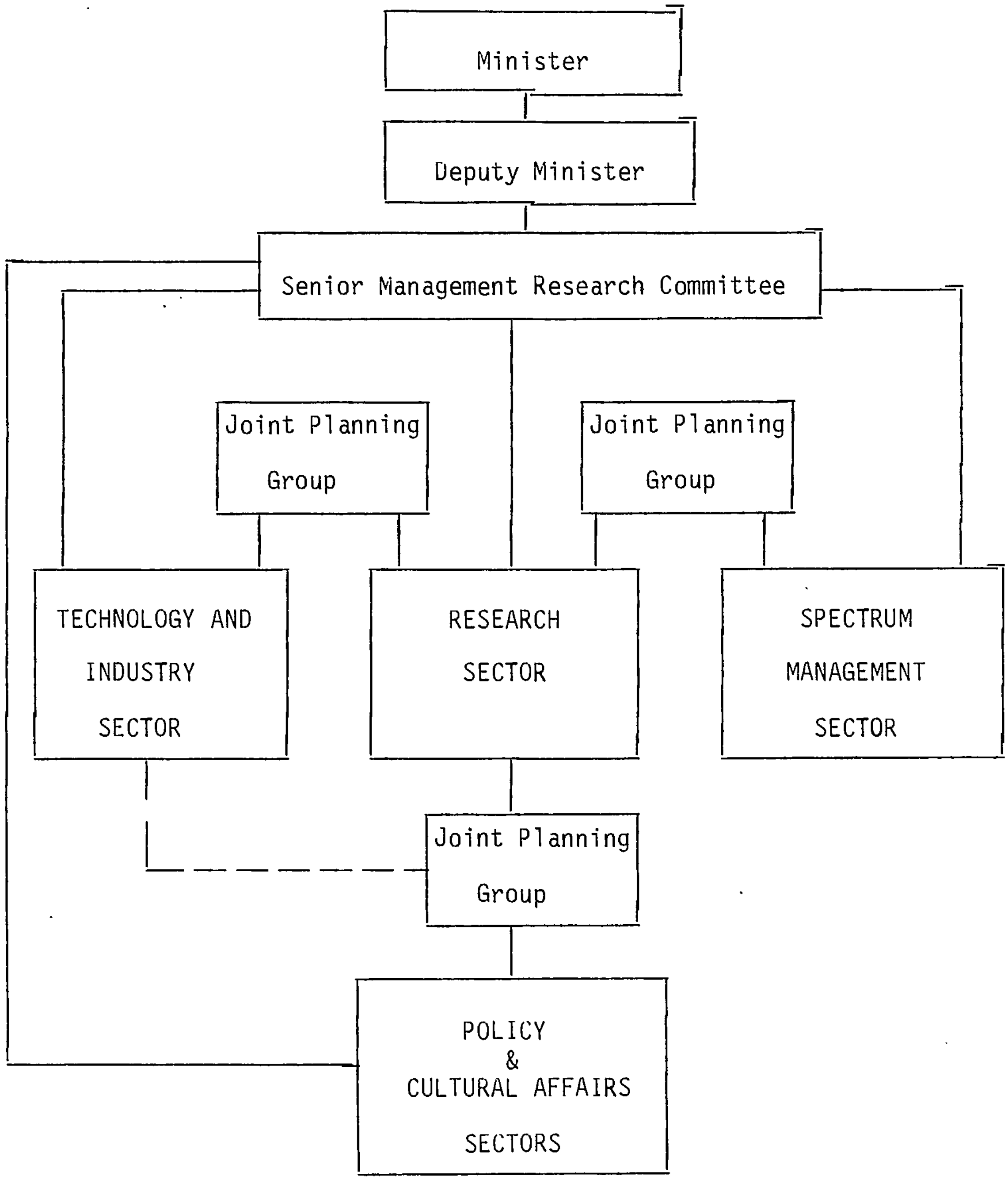


Figure 5-2

JOINT PLANNING AND CONTROL STRUCTURE



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Chapter 6.0

CONCLUSION AND ACTION PLAN

Whatever organizational option is selected for the DOC research program, there can be little doubt that some significant changes will have to occur. This observation is supported by the broad findings and conclusions of the review, as laid out below. These also indicate the direction which might be taken in such a realignment and provide the basis for immediate action over the next year.

6.1 FINDINGS AND CONCLUSIONS

This review has attempted to answer in broad and practical terms the question, "What should be the role of government communications, informatics and space R & D in the 1980s and 1990s?" In this endeavour, the review has examined the broad national and international environment in which such R & D might be conducted. It has surveyed the literature on R & D and the best practices and procedures of public and private sector labs, with a view to defining general principles which should govern the conduct of government R & D and the role which government labs should assume vis à vis government users and clients, industry and the university community. It has examined the historical evolution of the DOC research program and assessed that program in light of the general principles described above.

6.1.1 The existence of a role

There is a role for the government in the conduct of R & D in the areas of communications, informatics and space. This role derives from the nature of the technology and the broader national and international environment in which we find ourselves, as well as the existence of government activities which require R & D support.

The pace of technological change in the areas of communications, informatics and space is continuing to accelerate. At the same time, global competition in these areas is intensifying, and no domestic market can be regarded as safe from foreign penetration. Increasingly, a competitive edge in this environment depends upon a country's capacity for innovation.

As a result, in Japan, the United States and Europe, there is a growing realization that their commitments to R & D must rise and these commitments will involve planning frames 10 to 15 years from the product or service implementation phase. Because no country has the resources to cover all technological areas, there is also an increasing tendency to be selective and focus on strategic technological areas. The evidence shows that government labs represent an important instrument in this endeavour because their unique and specialized expertise can provide a focus for R & D support aimed at particular strategic technological areas. Such support is especially important to the small and medium-sized companies on the cutting edge of innovation -- and even larger companies -- are usually unable or unwilling to undertake the higher-risk and longer-range research and development which is crucial to their competitiveness over the long term.

However, it is increasingly recognized in most of these countries that government labs can only be effective in this catalytic role if their links with users of their research and other R & D players are close, formal ongoing and characterized by co-operation. Indeed, it is these links which are viewed as the best means of ensuring that, across the country, there is critical mass in the R & D effort within specific technological areas of strategic importance.

The very fact of this emphasis by our major trading partners argues that Canada can do no less. Indeed, given that in absolute terms Canada's R&D commitment represents a drop in the global bucket and that in proportional terms we also fall significantly behind, even in the broad communications area -- despite the existence of a wide range of R & D incentives to industry -- it is an urgent priority that the specialized intellectual resource represented by government labs be utilized as effectively as possible to target support in areas of critical importance.

This urgency is particularly intense in the broad communications area which is increasingly recognized as a key component of Canada's economic infrastructure and a major factor in future productivity improvements within the Canadian economy. Because of Canada's very real strengths in the communications area, it is also widely regarded as central to any future technology development strategy in the information technology area. According to the Loecus Consulting Group in a working paper prepared for the Science Council, such a "strategy should seek to encourage the existing telecommunications players to continue to develop in ways they have developed and already proved successful. Also, it should encourage and provide incentives for the players in the other high technology sectors and new starters to move to telecommunications related products and services."[1]

The industry is now dominated by the Bell Northern - Northern Telecom - Bell Canada complex, but there are other important players such as Microtel Ltd. and Gandalf. However, there is a large and growing number of smaller, medium-sized companies which find it increasingly difficult to keep abreast of the rapid technological change which characterizes these areas and must focus most of their R & D efforts on the near-term and product development ends of the R & D spectrum. Even the larger companies are sometimes hard-pressed to keep abreast.

Because of funding and other pressures, university researchers are also unable to fill this gap. Most observers feel Canada lags behind the United States and many of its other competitors in the degree to which it has been able to establish effective university-industry links. In addition, according to the recent Bovey Commission report, the capacity of Canadian

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1 Loecus Consulting Group Inc, Computer and Communications Technologies: Priorities and Opportunities for Canada (Working Paper prepared for Science Council of Canada, May 1984), p. 28.

universities to carry out sponsored R & D declined by 30 per cent in real terms between 1971 and 1981.

At the same time, the government itself -- and, in particular, the Department of Communications -- has a crucial need for R & D support, as well as technical advice and information, as it carries out its responsibilities with respect to the development of policies, regulation, standard-setting and procurement and industrial support in a communications area characterized by such a high rate of technological advance and innovation. Procurement is especially important because it is used with considerable effectiveness by virtually every other industrialized country. Procurement-related R & D of a relatively long-term nature, which industry is less interested in carrying out, has the potential to increase substantially government purchases of products and services from Canadian companies. Clearly, government labs, because of their greater familiarity with government needs, are uniquely fitted to perform applied research and long-range development intended to meet those needs.

The DOC research program is the second largest in the country within the broader communications area. It is uniquely positioned to carry out R&D to meet government needs, but there can be little doubt that its work should complement, rather than duplicate, that of industry and the university community. Indeed, given that government labs should generally occupy the middle range of the R & D spectrum -- between universities and industry -- a sizeable government research program such as that at DOC is in a strategic location to encourage a more effective marshalling of our relatively small and scattered national R & D effort in the broad communications area. Beyond this, small and medium-sized Canadian companies in high technology areas clearly need additional, carefully targetted support in an environment characterized by intensifying competition and an ever increasing pace of technological advance.

In light of these considerations, the DOC research program would seem to have a legitimate role:

- as a performer of R & D which meets government needs and is not primarily of direct interest to industry or university researchers,

- as an intermediary and catalyst of co-operation among major Canadian R & D players in these strategic technological areas, with a view to encouraging a more integrated national effort, and

- as a supporter of small and medium-sized Canadian companies which generally lack the resources to keep up at the forefront of this increasingly competitive and rapidly evolving technological area.

6.1.2 The major focus of the research program

The assumption of such a role does not mean that the DOC research program should do every conceivable kind of R & D in the areas of communications, space, informatics and workplace automation. There are quite clear-cut areas where government labs can be more effective than industry and university labs. There are other, equally clear-cut areas where government labs have no such advantage.

Beyond the ambit: For example, the literature overwhelmingly supports the view that government labs are not nearly as effective as industry labs in the conduct of near-term development, the stage of the R & D cycle at which market variables assume a decisive importance. The reason is quite simple: government labs tend to be insulated from the marketplace and are not very responsive to it. For this reason, **government labs should not conduct near-term or product development in house.** In fact, the DOC research program has been moving out of the areas of near-term and product development, which had assumed considerable importance in the late 1970s and early 1980s.

At the other extreme of the R & D spectrum is, of course, fundamental research. Its purpose is to advance our knowledge, and clearly the centre of such curiosity-driven activity should be in the universities which, presumably, should have as one of their major missions the achievement of that objective. Our survey of the literature would seem to indicate that the conduct of fundamental research is also crucial to what must be central mission of the universities -- the provision of higher education. The advancement of knowledge for its own sake, though a large and compelling goal, clearly cannot be a rationale for the existence of a government lab. Rather than usurping the role of the universities, a government lab should seek to complement their activities and, in a time of increasing restraint, focus on work which has more immediate and definable pay-offs. For this reason, **the major emphasis of a government research program, such as the one now at DOC, should not be on fundamental research.** In fact, the DOC research program expends only negligible resources on fundamental research.

The major focus -- applied research and long-range development to meet government needs: The exclusion of near-term development and fundamental research as major emphases of government labs would seem to leave them with a focus on the middle range of the R & D spectrum. The literature supports this view. There was virtually unanimous agreement that **the major emphasis of government research programs, such as the one at DOC, should be in the area of applied research and long-range development -- areas which are too practical for the university researcher but where the risk is too high or the pay-off too remote to be of interest to industry.** In fact, most of the work carried out by the DOC research program can be classified as applied research or long-range development.

Applied research and long-range development, by their very nature, must be driven by clear-cut objectives and/or a precise sense of client needs. To the degree industrial labs engage in such activity, it is the market which provides the direction and discipline so vital to their effectiveness. But, as already noted, government labs are insulated from the market. Where, then, are government labs to find this direction and discipline? Or, to put the question another way, if dependence upon the market provides a vantage point from which industry labs can carry out commercial R & D effectively, what characteristics of the vantage-point possessed by government labs would permit them to carry out effective R & D.

The vantage-point of government labs has one dominant reality: they are all part of government. Far more than industry labs, they are dependent upon government, driven by government priorities, enveloped by government concerns. The DOC research program is no exception: it is an arm of a line department, is funded through the economic and regional development envelope and is subject to the full gamut of Treasury Board and Public Service Commission guidelines. This situation confers certain opportunities.

In particular, as a creature of government, the DOC research program is uniquely positioned to achieve a full understanding of government needs and thus to carry out applied research and long-range development which meets those needs. All the literature on R & D agrees that a government lab can be very effective when its research program is driven by a clear sense of government needs. For this reason, **the major emphasis of the DOC research program in house should be upon applied research or long-range development to meet government needs.** In fact, a large proportion of the present research budget is spent on serving government needs, though there are deficiencies, as shall be seen below.

Specific government needs: These needs fall into two categories: the needs of government as a user-demander of the results of applied research and development, and the need of government for applied research and development as a means of contributing to policy objectives. It should be emphasized that, according to the literature, applied research and development by government labs is much more effective when the government itself is a user-demander of the technology.

The Department of Communications in particular has a special need for R & D support, both as a government user of the results and as a means of contributing to the fulfillment of policy objectives. The Department's areas of responsibility -- communications and a cultural sector which is largely dependent on communications media -- have been, are and will continue to be profoundly affected by technological change. Indeed, as already noted, the pace of technological change is probably more rapid in these areas than in any other sector of the economy.

For example, the DOC research program can play a key role in developing technology to meet policy objectives. Work at the CRC -- on Alouette, ISIS, Hermes and Anik B -- helped lay the technological basis for meeting a fundamental policy objective, that of extending communications and broadcasting services to Canadians wherever they live in this large country. This commitment to policy-driven applied research and long-range development must continue and become more responsive to cultural policy concerns.

In the exercise of its responsibilities for policy development, standards-setting and spectrum management, the Department must have direct access to a high level of technical expertise and information which is neutral with respect to the special interests in the highly competitive fields of communications and culture. In our view, it is important at this time for the Department to undertake a strategic review of standards policy, with a view to developing comprehensive policy framework for standard-setting activities which takes user and industrial considerations into fuller account.

In addition, at a time of government restraint and a growing emphasis on governmental efficiency, governmental procurement of office automation equipment and systems can substantially enhance the government's over-all productivity, while at the same time generating strong benefits for domestic industry.

The Department of Communications is uniquely positioned to play a key role in this area. It is responsible for the on-going development of a national policy framework for telecommunications systems and services. It is responsible for the delivery of those services within government through the Government Telecommunications Agency. Through the CRC and especially the Canadian Workplace Automation Research Centre, it is the most important centre within the federal government of technical expertise and research capabilities on the cutting edge of these technologies.

Indeed, the Department, because of its research program, its policy responsibilities and GTA, is perhaps the only agency of the federal government which has the expertise to develop procurement-related R & D strategies in the office automation area, with a view to maximizing Canadian industrial benefits. The same is also true in the broader communications, space and informatics areas.

The DOC research program has long provided R & D and technical support to meet the needs of other federal departments and agencies -- most notably, the Department of National Defence, the Department of Transport, the Department of Energy, Mines and Resources, the National Research Council and the Department of Supply and Services, as well as Teleglobe Canada and the CBC. Most of these relationships should be continued, though perhaps on a more productive basis, as shall be seen below.

Beyond this, it should be noted that the definition of government needs and the means of meeting them through applied research and long-range development is by no means a clear-cut affair. This issue was addressed in Chapters 4.0 and 5.0, and it should be emphasized that it demands formal links with government users which permit them to have a dynamic and ongoing interaction with the research program. The way these needs are met also has important implications for the industrial benefits flowing from the research program.

The commercial connection -- near-term development must be done by industry: The definition of government needs, and the applied research and long-range development route chosen to meet them, can have a significant commercial and industrial impact, or it can have none. The result can be a unique or unsaleable product or service, or it can be something with significant commercial potential in an area where Canadian industry has the necessary capabilities.

In our view, to the degree practicable, **the DOC research program should focus on applied research and long-range development at the intersection of government need and commercial potential.**

The reason, of course, for emphasizing commercial potential is to maximize the Canadian industrial benefit. As all the literature agrees, the companies which should be targetted for such support should be small and medium-sized. These companies are at present the major recipients of support from the DOC research program. There are many such companies in Canada within the broad communications area, and generally they lack either the interest or the resources to undertake much applied research or long-range development. However, most have a heavy commitment to, and a substantial capability in, market-driven near-term and product development.

For this reason, all the near-term development needed to meet government needs should be carried out by industry, with a view to transferring the technology to industry. For the most part, the research program has moved away from the developmental emphasis it had during the late 1970s and early 1980s, but it may well be that there are still in-house activities of a near-term development nature; a review of these activities, with a view to establishing whether any could be contracted out to the private sector would be desirable and in accordance with the recommendations of the Wright Task Force.

In fact, the evidence would seem to indicate that the most effective mode of technology transfer is contracting out, and it is used extensively by the DOC research program. By and large, the evidence also indicates that the DOC research program, because of its mission orientation and willingness to take risks, has an enviable record in the area of technology transfer, at least in comparison to most other government labs. Nevertheless, as the Wright Task Force has pointed out, government labs generally do not have an especially good record in the area of technology transfer. For this reason, it would be very useful to undertake a review of the program's technology transfer activities, with a view to defining the sources of success and failure in this area and codifying how best to proceed in transferring technology to the private sector.

The major focus: It can be seen, then, that the major focus of the DOC research program in house should be on applied research and long-range development intended to meet government needs in a manner which maximizes the Canadian industrial benefit. These government needs can be for the actual or potential results of the research -- whether in the form of a product, system or service to be purchased, or in the form of technical advice, expertise or information -- or for work which contributes to the fulfillment of government policy objectives.

As has been seen, these needs are particularly intense for a government agency such as the Department of Communications, whose areas of responsibility are profoundly affected by the rapid pace of technological change. But, given the enormous positive impact many of these technologies can have on productivity, procurement-related R & D should assume growing importance to the entire Government of Canada, especially during a period of deficit reduction. The Department of Communications, with its responsibility for the Government Telecommunications Agency, its Workplace Automation Research Centre and its expertise at CRC in the broader areas of space, informatics and communications, is strategically positioned to meet this need.

The research program, in meeting these government needs, must maximize the Canadian industrial impact -- especially by small and medium-sized companies. For this reason, the highest priority should be attached to choosing the research route to meet government needs which has the most commercial potential for small and medium-sized Canadian companies with the capability to carry the technology forward into the broader marketplace. Given these companies' emphasis on and capabilities in near-term and product development, all near-term development intended to meet government needs should be done by the private sector, with preference given to the contract mechanism as the most effective means of technology transfer.

6.1.3 International monitoring and domestic dissemination role

The DOC research program must assume responsibility for the monitoring of research and development around the world and assuring its dissemination to Canadian policy-makers, industry and university researchers.

At present only two per cent of the world's R & D in the broad communications area is carried out in Canada. The remaining 98 per cent of the R & D is carried out in other countries.

Given that the communications markets of the future are determined by today's R & D effort and that keeping abreast of new developments in information technology is vital to our own high technology industry and the long-term productivity of the entire economy, Canada must have access to the most recent technological developments in this strategic area.

At present, this access is limited. Both the Economic Council of Canada and the Science Council of Canada have noted recently that the rate at which foreign innovations diffuse into the Canadian economy is slower than that of most of our major trading partners. Though larger Canadian companies such as Northern Telecom are able to keep abreast, small and medium-sized companies often lack the resources and are therefore at risk.

Canadian policy-makers -- especially in the Department of Communications -- must also have a grasp on the most recent technological developments. Otherwise, their policies will be reactive rather than proactive.

The persons best equipped to collect and disseminate this information are the researchers in government labs, and for the broad communications area, those in the DOC research program. First, in addition to having the technical expertise to grasp and select such information, they have a reasonably sophisticated sense of both the information needs of DOC, other federal departments and agencies, and Canadian industry. Second, because publication of such information generally lags at least two years behind its first mention at an international scientific conference, these conferences represent the best forums for gathering such information in a timely manner. However, the most valuable information is often gathered informally at such conferences in exchange for other technical information; only people with genuine technical expertise can participate successfully in this process of information exchange.

Limited travel budgets and a cumbersome conference travel approval process place serious constraints upon the capacity of the research program to gather information at international scientific conferences. This situation should be rectified. Beyond this, there is a need for a systematic study of the precise mechanisms which should be used in setting up such a technical information service in a manner which would complement other such services. Finally, it will also be necessary to conduct a study of the information needs of the Department, industry and the university research community.

6.1.4 Micro-management and accountability

The travel approval process is not, of course, the only form of control to which the DOC research program is subjected.

As the arm of a Department, the DOC research program is subject to the full gamut of Treasury Board and Public Service Commission rules and guidelines. In addition, most of the technical and administrative services available on site at the program's two laboratory centres are provided by the Personnel and Administration Sector of the Department. As noted in Section 4.1 above, both the Wright Task Force and the U.S. Federal Laboratory Review panel characterize many of such constraints as "micro-management". In their view, micro-management tends to inject a rigidity and caution into an R & D function which should be characterized by flexibility, creativity and a willingness to take risks. There is evidence that this observation is applicable to the DOC research program. For this reason, as well as others, Chapter 5.0 suggested a number of organizational options which would reduce the burden of "micro-management" upon the research program.

The main rationale for such arrangements with respect to finance, administration and personnel is, of course, the need to assure both control of, and accountability for, the expenditure of public money within the research program. In fact, there is no doubt that these arrangements do permit a narrow financial and administrative control and accountability, though at considerable cost in terms of the effectiveness of the research program.

In our view, however, they do not provide the basis for a meaningful accountability. Though they involve a policing function and can provide a fine-grained picture of the allocation of funding and person/years among projects and activities, they cannot, by their very nature, explain the significance or nature of these projects and activities. Even the traditional operational plans are insufficient for this purpose, containing as they do opaque descriptions of highly technical projects which are related to objectives and key result areas so vague as to be almost meaningless. **In short, the traditional accountability mechanisms employed in government do not provide a basis for the meaningful accountability of the DOC research program or any government lab.**

6.1.5 Improved links with the outside -- the real basis for accountability and complementarity

At present, the DOC research program possesses insufficient meaningful, formal links with the outside which would permit effective input on the direction of the research program by industry, university researchers and government officials which are dependent upon it for research results or for R & D which contributes to the fulfillment of policy objectives. In our view, it is the ongoing advice and oversight of the program by outsiders which can assure, and provide a continuing measure of, the relevance and importance of the research program. For this reason, **it is the existence of such formal links with outsiders, and the advice and assessments they** generate, which can provide the only meaningful basis for accountability of the research program to senior management within the Department, the Minister and the government as whole.

The creation of such formal links would have another important benefit. As noted previously, Canada's national R & D commitment in these strategic technological areas is in absolute terms a mere drop in the global bucket and in relative terms falls below that of our major trading partners. There is also no strategic consensus governing all our R & D players which would permit them to co-ordinate their efforts and concentrate resources in key areas. The existence of such formal links is a basic first step towards creating such a strategic consensus between the DOC research program -- the second largest in the country -- and the major R & D players within these areas in industry and the universities.

Formal links inside government: As already noted, the major focus of the research program should be upon applied research and long-range development to meet government needs. Fundamental to its accountability, therefore, are formal links with government users of its research results and government policy-makers for whom the work of the research programs represents a means of contributing to policy objectives. Such links also represent the only means of identifying in a systematic fashion the government needs which must drive the work of the research program.

These links are especially important within the Department of Communications where responsibilities such as policy development, policy implementation, spectrum regulation, standards-setting and the provision of government-wide telecommunications should be strongly dependent on the research program because both communications and culture are so strongly affected by the rapid pace of technological change.

At present, the only systematic formal links are vertical through ADMR to the DM and Minister, though there are a number of less systematic horizontal links which tend for the most part to be on an informal basis. The only systematic and thoroughgoing, though informal, consultations on the the program's operational plan take place with the Spectrum Management Sector, though these are beginning to emerge with the Technology and Industry Sector. Present interaction is not sufficient to lay a basis for meaningful accountability and impose a stronger results discipline and client orientation on the research program. It is, in fact, crucial that systematic, formal links -- which would permit real input into the direction of the research program by other sectors -- exist between the research program and the Technology and Industry Sector, the Spectrum Management Sector, the Policy Sector and the Cultural Affairs Sector. Chapter 5.0 puts forward a number of organizational options for how these links might be achieved.

The research program also carries out work for a number of other federal departments under a wide variety of arrangements. As suggested in Chapter 5.0, in order to enhance the accountability of the research and impose upon it a clearer results discipline and client orientation, such work should be undertaken on a full-recovery basis, or on a shared-cost basis in special circumstances.

The research program's largest client other than DOC is, of course, the Department of National Defence. This relationship has been an uneasy one, virtually since its inception in 1969, though DND has made no complaint about the technical quality of the work carried out by DOC. There are now significant problems in the functioning of the DND relationship, as well as important industrial opportunities arising from the conduct of defence-related research in the communications, space and radar areas. In our view, the DND relationship should be reviewed, with a view to placing this defence-related research on a firmer footing within government.

Outside the defence area, government procurement activities in the areas of office automation, informatics, communications and space are growing at a significant rate. In an era of deficit reduction, it can be expected that such purchases will rise even faster, essentially because these technologies -- especially those in the area of office automation -- are seen more and more as fundamental to any enhancement of the productivity and efficiency of government. In terms of the larger economy, these are now acknowledged to be strategic technologies, essentially for the same reason; and the further development of Canadian industrial capabilities is increasingly regarded as vital to Canada's long-term economic health. As the Wright Task Force has stated and industrialized countries around the world have recognized, government procurement represents a key instrument in strengthening those industrial capabilities.

As already noted, the Department of Communications is uniquely positioned among federal departments and agencies to ensure that these procurement needs are met in a manner which maximizes the benefits to Candian industry. Through its responsibility for the Government Telecommunications Agency, it is responsible for the procurement of telecommunications services across the government and, through its new Workplace Automation Research Centre, will be developing expertise in the office automation area in the context of government and industrial needs. The research program has a better record than most government labs with respect to the transfer to the private sector of space, communications and informatics technology, and can be assisted in this respect by the Technology and Industry Sector.

For all these reasons, <u>it is suggested that the Department and the research program be designated by Cabinet as the federal government's centre of expertise with respect to procurement-related R & D in these strategic technological areas. Because of this designation, other federal departments and agencies would be expected to consult with the Department and the research program with respect to their procurement-related R & D needs in these strategic technological areas in order to ensure that these are met in a manner which is cost-effective and maximizes the benefit to Canadian industry</u>.

<u>Links with industry</u>: As noted above, the major focus of the research program must be upon applied research and long-range development which meets government needs in a manner which maximizes the benefit to Canadian industry. The maximization of the Canadian industrial benefit from such work involves consideration of market potential, the financial, technical and marketing capabilities of small and medium-sized Canadian companies, the fit between a particular technological development and corporate strategies, and host of other factories.

These are complex questions, and they are not easily resolved by a government lab which is insulated from market discipline. To some degree, the advice of the Department's Technology and Industry Sector will be important. However, there can be little doubt that a critical input will be information and advice from industry itself, to whom decisions on such matters can be a matter of life and death.

Since the demise of the Communications Research Advisory Board, the research program has had no formal links with industry other than through contracts, though a range of informal interaction does take place between individual researchers and industry representatives. For this reason, it is virtually impossible to measure the influence of industry on the direction of the program, though from our interviews it would seem that such influence is not substantial.

As a consequence, the organizational options set out in Chapter 5.0 outline a number of organizational options which would permit industry to exercise a clear advisory role -- or even have a measure of decision-making power -- with respect to the direction of the program. These mechanisms should make the program significantly more responsive to industry needs. They are also intended to permit the exercise of an oversight function by industry, thereby providing an important measure of the relevance of the program. For this reason, these formal links with industry can be regarded as central to the achievement of full accountability by the research program.

Links with universities: The other major R & D player in these strategic technological areas is the university research community. It is, as the Wright Task Force pointed out, a crucial link in the innovation chain. For this reason, it is vital that the research program have formal and effective links with the university research community so that it can provide valuable input on the direction of the program and an additional measure of its relevance as a basis for enhanced accountability.

At present, the DOC research program lacks formal mechanisms to assure such university input. Individual DOC researchers have a number of informal contacts and the university research/centres of excellence program permits some limited formal interaction on a contractual basis, but only on projects pre-defined by the Department. Research Sector interviewees generally agreed that the university research community exercised no significant influence over the direction of the DOC research program. It is to rectify this situation that Chapter 5.0 puts forward a number of organizational options which would provide a formal framework for meaningful links with the university research community.

However, it should be emphasized that organizational mechanisms will probably not be sufficient to assure meaningful interaction with the university research community. At the heart of university research and educational activities is the conduct of fundamental research, though there is a growing but still peripheral interest in applied R & D. If interaction with the university community is to be meaningful, it will be necessary in our view to assure that a proportion of the work carried out by the DOC research program is consonant with the mainstream of the university research effort. For this reason, it is our view that, from 10 to 15 per cent of the resources of the DOC research program should be committed to directed fundamental research -- that is, fundamental research at the nexus of government need and commercial potential -- conducted in co-operation with the university research community. The U.S. Federal Laboratory Review

Panel also argued for a commitment to basic research in government labs -- an emphasis which has been taken up by the Reagan Administration.

Beyond providing the basis for meaningful interaction with the university research community, such an emphasis would have important benefits for the DOC research program and for the national R & D effort in these strategic technological areas. As is the case with most government labs, the average age of researchers in the DOC research program is above that in most industry labs; if the program addressed fundamental research questions closer to the heart of university students' and professors' concerns and if the other measures suggested in this report are taken, the program's negligible recruitment efforts on university campuses would be significantly enhanced. In addition, the university community is very much the arbiter of scientific prestige, and some emphasis on research matters of interest to the community would no doubt significantly significantly improve the scientific prestige of the laborator and thus its over-all effectiveness.

Most important of all, an emphasis on directed fundamental research, by providing the basis for meaningful interaction with the university research community, would also enable the DOC research program to exercise some influence on the direction of university research in these strategic technological areas, thereby ensuring that university researchers would undertake research which would complement the work of both government and industry labs. In this way, the over-all Canadian R & D effort would become more cohesive and characterized by complementarity -- a vital necessity, given the small size of that effort in the global context.

6.1.6 The need for a new vision

Research and development is most successful when it is driven by a clear, realistic and compelling vision of its ultimate importance to its users. It is central to the internal health and coherence of a research program. If provided in the context of active and energetic leadership, it can be a key force in motivating personnel, a fundamental consideration in an area such as R & D which is so dependent on the morale and creativity of its human resources. More important, such a vision, when married to a precise strategy, should provide the focus for a research program -- a coherent view of what it is about, and thus a shield against the multiplication of small and irrelevant projects which seems to afflict so many government labs. In other words, the vision itself can help ensure that an R & D program has sufficient critical mass in key areas.

Such a vision, when fleshed out as a strategy and as a range of specific research programs in light of public need and specific requirements, should be comprehensible enough to serve as the basis for the accountability of a research program to the government as a whole, to industry and to the university research community. Indeed, if sufficiently compelling, it can serve as the basis for a more cohesive and complementary approach to strategic technological areas by government, industry and university establishments. Such complementarity can, of course, increase the critical mass of the national R & D effort in those areas.

Two compelling visions of potential applications in the 1970s provided a focus for much of the DOC research program and supplied the basic rationale for a significant growth in its resources.

The first of these focussed on space and flowed from the clear and compelling need, formulated in public policy terms, to extend telecommunications and broadcasting services to Canadians in rural and remote areas. This R & D vision, and the resulting strategies and programs, led to the fulfillment in large part of that public policy need and in the creation of a Canadian space industry.

The late 1970s saw the emergence of the Telidon vision. This videotex technology was seen as the first mass-market application of a new transformative information technology, and the DOC objective was essentially to make sure that Canadian industry would be on the leading edge of this new technology. The Telidon vision was enormously energizing for the DOC research, and the program did achieve many of its objectives. Telidon was accepted as part of the world and North American videotex standards. A somewhat uncertain Canadian Telidon industry with a specialized business market did emerge, though the expected mass market has yet to materialize. Videotex and Telidon were clearly not the first real mass-market application of the new information technology. Personal computers won this honour and, ironically, Telidon may yet find a larger market as an enhancement to personal computers. Because of DOC support, the Canadian Telidon industry may be in a position to take advantage of that commercial opportunity.

These visions no longer provide a compelling focus for the DOC research program. Telidon ended in March 1985, and since 1983 most of the Telidon activity has been the responsibility of the Technology and Industry Sector. This same sector is also responsible for most of the high-profile space activity -- the prime contractor support activities, MSAT, L-SAT and the operation of the David Florida Laboratory. While there is a very active space R & D program in response to the needs of DOC and other federal departments and agencies within the Research Sector's Space Technology and Applications Branch, a clearer definition of the branch's role is needed to provide a cohesive sense of mission.

Since the early 1980s, the DOC R & D program has in fact been searching for a new focus. The work on a five-year plan by the Research Sector in 1982 was in many ways an attempt to find a focus for the Sector's activities — away from near-term development work and into long-range development and applied research supported from the Sector's A-Base. But, before it came to fruition, this effort was superseded by the Departmental reorganization and the CCIS feasibility study, another effort to find a new focus for the research program. Neither of these exercises resulted in the formulation of a new vision.

Thus, whatever the cause, there is a growing sense that the research program lacks vision and is too diffuse — in other words, is engaged in too many small projects and activities which lack over-all significance and do not form a coherent whole.

6.2 THE NEED FOR REALIGNMENT

There would seem to be a real need for a realignment of the DOC research program.

As just noted, the program has for the past few years lacked a clear-cut strategic vision of its activities, with the result that there is increasing danger of involvement in too many small projects, sacrificing the change for critical mass in strategic areas. This difficulty is exacerbated by the absence for the most part of formal and effective links with industry, university researchers, government users of research results and government officials for whom R & D represents a means of achieving public policy objectives. The CCIS feasibility study revealed that there was a widespread ignorance among industry and university interviewees of the general thrust of the program; our own interviews revealed a similar ignorance among officials in the non-research sectors of the Department of Communications.

Probably as a result of this situation, private sector interviewees were largely negative about the over-all situation of the program, though many had praise for specific projects and areas -- likely those in which they were directly involved. According to the CCIS Feasibility Study, "There is concern about the aging of key personnel, the continuation of lines of research whose relevance has diminished, a lack of results orientation and management discipline, the absence of a sense of strategic direction or purpose, and rigidities due to public service personnel and budgetary practices."[1]

These negative assessments did not arise from any systematic examination of the research program and in fact are largely based on ignorance of the program, though a number of these criticisms are supported by this review. Whatever the validity of the rest of these criticisms, they would seem to reflect a widely held perception. In our view, they represent a <u>crisis of legitimacy</u> for the program.

Reorganization of the program will not resolve this situation. Indeed, whatever organizational option is chosen for the program, the only means of responding to such a situation is to undertake a major realignment of the program in a manner which fully involves industry, the university research community, government users of research results and government officials for whom the work of the program represents a means of achieving public policy objectives. The objective of such a realignment would be to reposition the research program so that it could:

1. ensure that the applied research and long-range development done by DOC is focused in areas of government need where there is commercial potential and Canadian industrial capability, thereby meeting the needs of government users of research results, government officials for whom the work of the program represents a means of achieving public policy objectives, industry and the university research community.

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[1] Price Waterhouse, <u>op. cit.</u>, p. 5.

2. co-ordinate and catalyze the national R & D effort in order to assist users -- including government -- in the definition of their communications, space and informatics needs so as to to give Canadian industry the opportunity to compete at the national and international levels.

3. ensure that consultation and collaboration occurs, both with the private sector and the university research community, not only to obtain their views, but to seek their participation in the elaboration, execution and evaluation of the research done by DOC.

4. continually update -- with the assistance of government clients, industry and the universities -- a long-range-scientific plan to which this community can relate and in relation to which it can develop its own activities.

5. create in Canada a synergy that will permit the development in this country of a pool of expertise with critical mass in strategic technological areas, in order to ensure that the economic benefits of communications and related technologies accrue to Canada.

6. establish close linkages and efficient transfers of technology to users -- in particular, government, industry and universities -- through the undertaking of joint projects and through the exchange of personnel.

7. ensure that the federal government develops a knowledge base which will enable it to use its buying power to support Canadian industry.

6.3 IMMEDIATE ACTION PLAN

In light of these objectives, the realignment will be a large and complex undertaking involving extensive consultations within government, as well as with industry and the university research community. To this end, the following represents an immediate action plan for bringing about such a realignment of the program and renewing its legitimacy:

6.3.1 Discussion of organizational options

In order to provide a basis and starting point for this realignment, it is suggested that senior management hold preliminary discussions to narrow the range of organizational options outlined in Chapter 5.0. Such a decision will give a clear indication to all users of the kind of open relationship between the program and its users which the government deems to be important in the future operation of the program. In this way, such a decision will provide a firm foundation for their participation in the process of realignment.

6.3.2 Convene a meeting of the CCIS Steering Committee

At the last meeting of the CCIS Steering Committee, the Department undertook to conduct this strategic review and return to the committee with its findings and conclusion. The convening of a meeting with the steering committee to discuss this review, the organizational options and the broad approach to realignment would fulfill this commitment and provide input into our decision on an organizational option. This consultation has now taken place, and the option preferred by the majority of committee members was some form of quasi-independent status.

6.3.3 Seek Cabinet approval

With input from the CCIS Steering Committee and the Department's further deliberations, the Minister could in Autumn 1985 seek Cabinet approval for the broad role and organizational option selected for the research program.

6.3.4 Preparation of preliminary scientific plan

The Department should establish a committee of DOC experts to develop a scientific plan in light of the best possible picture of present and future developments in the broad communications area. While existing technological expertise and people available at CRC should be a consideration in the development of such a plan, this cannot be a decisive consideration. Much more important should be the imperative of focussing resources in fewer areas in order to create critical mass in key technological areas at the strategic nexus of present and future government need, commercial potential and Canadian industrial capability.

6.3.5 Intensive domestic consultations

In order to validate the scientific plan, intensive consultations should be held with industry, the university research community, government users of research results and government officials dependant upon the research program for its contribution to the fulfillment of public policy objectives. The first step in such a consultation should be a second meeting with the CCIS Steering Committee on the substance of the scientific plan. Additional consultations could involve symposiums, meetings with key associations and interviews with selected individuals and institutions. A consultant might be used to keep a record of the the consultations for possible publication. The object of these consultations would be to achieve a refinement and re-elaboration of the scientific plan reflecting a realistic assessment of clients' present and future R & D needs.

6.3.6 International consultations

With a view to validating the re-elaborated scientific plan which would result from the consultations, consultations would also be undertaken with world-class experts in the relevant technological areas in order to seek their comments on the revised plan and their views on how these technological areas will be evolving over the next 15 years. A consultant might be used in this context to keep a record of the consultations for possible publication.

6.3.7 Review of DOC/DND relationship

The Department should undertake a thorough review of its relationship with DND, taking into account DND's continuing uneasiness with the relationship, the growing industrial significance of military procurement, the relatively poor record of DND in the technology transfer area, the advantages arising from the synergy and critical mass which stem from having all government communications research concentrated in one laboratory centre, and the balance between civilian and defence R & D which should obtain within the research program.

6.3.8 Review of role vis à vis industry

The Department should undertake an evaluation of the effectiveness of its activities in the area of technology transfer and of its utilization of internal services when contractual services could be sought.

6.3.9 Implementation plan for information role

The Department should call for tenders for preparation of an implementation plan for its assumption of a role in the monitoring of research information available in other countries and the domestic dissemination of that information. This plan should focus on the best mechanisms available for the performance of this role and on the kinds of information which are needed by government, industry and the university research community.

6.3.10 Strategic review of standards policy

The Department should conduct a strategic review of its role in the standards area, with a view to developing a comprehensive policy framework which takes into account the needs of interested parties, including manufacturers and users. For this purpose, a working group should be struck -- with membership from the Policy Sector, the Spectrum Management Sector, the research program and the Technology and Industry Sector.

ANNEX A

PERSONNEL DEMONSTRATION PROJECT

NOSC/NWC PERSONNEL DEMONSTRATION PROJECT

Area of Interest:

Demonstration Project
(An Experiment in Federal Personnel Management)

Background Statement

Under Title VI of the Civil Service Reform Act (CSRA) of 1978, there were provisions for federal agencies to obtain approval from the Office of Personnel Management to conduct a demonstration project to determine if the removal of personnel management constraints and changes to personnel regulations could increase effectiveness and efficiency in the work force. By law, such experiments were limited to a total of 10 active projects, could last for a maximum of five years, and were limited to a maximum of 5,000 employees.

To date only one project has been approved, and that is the Navy's joint Naval Ocean Systems Center/Naval Weapons Center Demonstration Project, initiated in July 1980. The Project allows waiver of certain personnel-related laws and regulations; however, it does not waive leave, insurance, annuity, Hatch Act, or EEO rules or regulations. Basically, it is a revised personnel management system providing simplified position classification, performance linked pay and appraisal, and performance based retention.

The following Executive Summary provides basic information on this Center's personnel Demonstration Project. Its purpose, description, and operating policies are covered. If you would like more detailed background on the Project, a suggested contact is:

Contact:

Bob Glen
Demonstration Project Manager (Code 0902)
Extension 3196

Executive Summary

Personnel management under the Civil Service system has experienced a number of problems; key examples are:

(1) Classification—complex and outdated position standards which delay recruitment and promotions, limit organizational flexibility to administer personnel resources, and place personnel staffs in an adversarial role with line management mission, product, and service obligations.

(2) Performance appraisal—unsatisfactory pay incentives to reward good and penalize poor performance, and the inability, through performance planning and mutual employee-supervisor goal setting, to objectively establish and measure employee effectiveness in relation to organizational goals.

(3) Merit pay—lack of sufficient incentives and flexibility in dealing with all levels of the work force and in offering recent college graduates and other potential employees pay which will keep pace with professional growth, performance and responsibilities demonstrated.

(4) Reduction-in-force—inability to recognize performance as a major criterion in RIF situations and to avoid adverse effects upon good performers who happen to have low retention standing or who may be recently-hired female or minority employees.

The NOSC/NWC Demonstration Project was established to address the above problem areas within the existing personnel system and to show that the effectiveness of federal organizations can be enhanced by allowing greater line management control over personnel functions.

Purpose

The intent of this Project is to permit increased line management involvement in major personnel-related decisions, such as recruitment, compensation, training, appraisal, and rewards. The line manager is the primary decision maker on personnel issues of pay, classification, merit, and job assignments which have important effects upon motivation, performance, and organizational effectiveness. To accomplish these changes, the Demo Project includes (1) a more flexible, manageable, and understandable classification system which aggregates several GS grade levels into broad pay bands; (2) a performance appraisal system that links performance goals, compensation, and organizational effectiveness; (3) an expanded application of the CSRA merit pay concept for both supervisory and non-supervisory employees; and (4) an emphasis on performance as a primary criterion in the retention process while retaining tenure, veterans preference, and length-of-service factors.

Types and Number of Participating Employees

In keeping with the 5,000 employee limit in the Project, the two Centers have included the following full-time personnel in the Demo Project:

	NOSC	NWC
Scientists and Engineers, and Senior Professional Staff	1,284	1,444
Technicians	332	588
Administrative Specialists	223	305
Technical Specialists	171	183
Clerical	360	--
	2,370	2,010

4,980

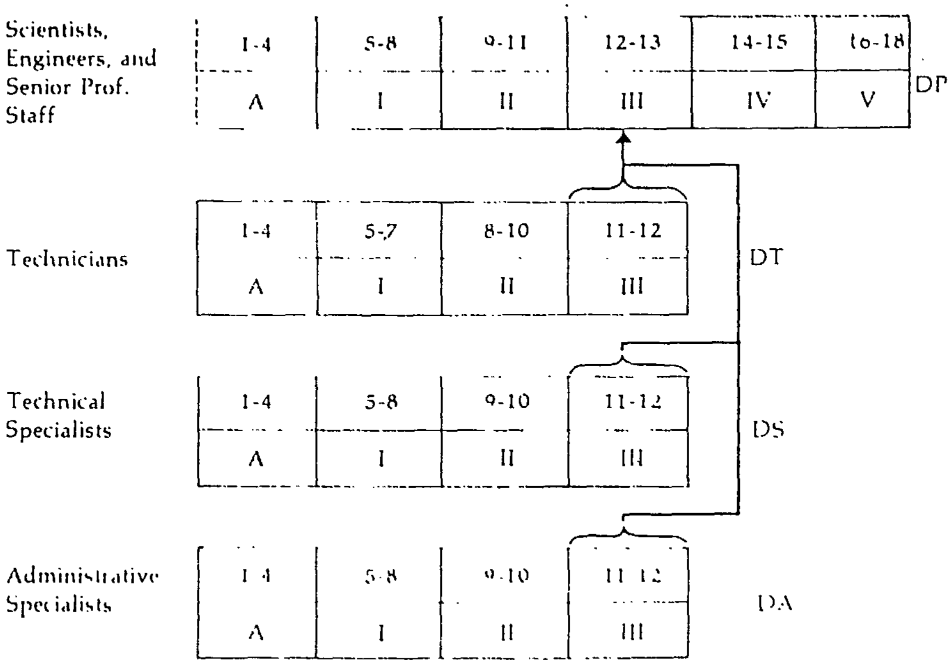
Scientists and engineers and all GS-13-15 personnel entered the Project when it began in July 1980. The GS-12 Administrative and Technical Specialists entered the Project in January 1981 with the Technicians following in August 1981 and the GS-11 and below Administrative and Technical Specialists being included in August 1982.

Since both Centers' clerical population could not be added to the Project without exceeding the 5,000 person limitation, it was decided to include only NOSC's clerical personnel in August 1982, in order to ensure an opportunity for full evaluation of the Project's concepts for all of the above career paths.

Basic Features

Implementation procedures for the Project vary somewhat between the two Centers in relation to unique management needs and styles. However, both Centers have a similar basic approach to pay, performance appraisal, and position classification. Under the experimental effort, both Centers have grouped 16 pay and classification grades (GS-1 through GS-16) into broad levels as noted below for the applicable career path:

Career Path Identification by Classification Level as Related to Current Grade Levels



The separate career paths incorporate at least two grades within each path. Performance appraisal serves as the basis for determining incentive pay adjustments in terms of classification standards and performance objectives established. Each career path is a competitive area for reduction-in-force purposes, and retention is determined primarily on the basis of performance appraisal.

Classification and Pay System

Each class of positions covered by the Demo Project (scientist and engineer, technician, technical specialist, and administrative specialist) reflects career progression of those having similar qualification requirements and lines of work. Pay bands in each career path reflect entry, trainee, and journeyman levels of work for that occupational group. Series levels are included in the DP career path.

The classification system recognizes both the rank-in-person concept reflecting unique aspects of matrix and line management plus sponsor relationships as well as the rank-in-position distinctions through classification in broad classification levels. The first line supervisor is involved with classifying positions by using simplified standards for each pay level. Typical duties, responsibilities and levels of difficulty of work at each classification level are listed in a "menu" format. Supervisors then select from the appropriate classification standard for a given level. To acknowledge personal contributions and capabilities of individual employees as well as duties and responsibilities of positions, the traditional position description or PD has been retitled "Personal Activities and Capabilities" or PAC. The classification standards are computerized to allow for automatic listing of menu items, and the resulting PAC is identified by special code and stored for record purposes. PACs are quickly prepared and approached with maximum line supervision involvement and provide clear distinctions between functions, specialties and classification levels.

Scientific and engineering salaries are established consistent with labor market conditions and the applicant's experience and education. However, since the basis for the Project pay system is the General Schedule, scientists' and engineers' pay rates for the various levels of responsibility are directly keyed to the special salary rates for scientists and engineers.

Performance Linked Pay

Employees can be paid no less than the minimum pay rate established for the pay band to which assigned. The broad band has been divided into increments between the highest and lowest salary of the level (i.e., GS-12/1—13/10 for DP level III and 24 increments, each equaling approximately 1.5% of the highest salary level). Increases in pay are based on performance within available resources, and the Center's annual merit payout has been approximately 2.4% of Demo Project payroll. This figure has been derived from monies that formerly would have been paid to deserving employees in the form of QSIs, SSPs, and within-level promotions.

Employee performance is evaluated on the basis of five incentive pay groupings from performance that is demonstrably exceptional to that which is substantially below fully successful. The following identifies performance rating definitions and payout choices in terms of whether or not comparability pay (federally determined) and increments are awarded for the various levels of performance indicated.

Performance Ratings/Payout

Rating	*Definition*	*Pay*
1	Performance that is demonstrably exceptional—clearly deserving of recognition equivalent to a within-level promotion.	$c + 4i$ or $c + 3i$
2	Quality performance that exceeds the fully successful standards.	$c + 2i$
3	Fully successful performance—meets the expected results of the performance plan. Growth and progression normal for NWC	$c + i$ or c
4	Below fully successful. Corrective action needed.	$c/2$
5	Substantially below fully successful. Serious performance deficiencies. Needs significant improvement for work to meet established standards.	0

Employees who exceed performance expectations receive incentive pay increases substantially exceeding government-wide comparability increases. Employees who fully meet performance expectations receive at least comparability, while those who do not fully meet performance expectations receive either one-half or none of the comparability increase.

Employees' salaries advance to the upper limit of a pay bank only through performance, not time-in-level. A lump sum bonus payout, corresponding to the payout shown above, is given to those employees whose salaries are at the top of the level or the pay cap. If, on the other hand, an employee receives no or limited pay increases due to marginal performance, and the minimum salary of the current pay band exceeds the present salary, the employee "migrates downward" to the next lower level. This occurs without specific adverse or performance-based action. In this manner, higher performing employees are rewarded in consonance with their contributions and poorer but minimally adequate performers have their salaries held constant. Employees whose performance is unacceptable may be removed or changed to a lower level as a performance-based or adverse action.

Reduction-in-Force

The Demonstration Project's major change in RIF procedures is the ranking of employees within each competitive level, based primarily on performance rating groupings and secondarily on the elements of tenure, veteran's preference, and length of service. The intent is to increase the probability of retaining the highest performing employees in their positions and displacing the lowest performers. "Bumping" is limited to the career path to which the employee is currently assigned. Thus, if engineering positions are abolished, clerical, technician, specialist and administrative personnel would not be bumped.

Employees can retreat to the career paths through which they progressed. Retention standing within a competitive level is determined by performance rating groups, and the high retention group(s) is placed at the top of the register in standard tenure, veteran's preference, and length of service order. Employees in lower retention groups are placed at the bottom of the retention register, using the same standard order and are the first to be released from the competitive level. Individuals in higher retention groups always displace those in the lower group(s).

Implementation

A task team approach has been used to develop implementation ideas and create "ownership" of these important changes to the federal personnel system. This has involved representatives of career paths and various skills at the Center who are affected by the Project. Task teams involving pay, classification, performance evaluation, and communication are examples of representative groups from both managers and employees affected by the Project. They have made significant contributions to Center policies affecting all implementation aspects of the Demo-Project. Special employee groups to review provisions affecting career paths, such as technicians, have been used, also. These groups have influenced changes which have been made to pay bands, performance appraisal, and the new position classification approach. Task team policies have been developed in conjunction with NOSC task team counterparts.

As career paths have entered the Project, training has occurred in some depth on the basic features of the new system, how it works, and the responsibilities and expectations of supervisors and employees. Training sessions on performance planning and assessment, compensation, classification, and general system operation have been conducted by employees who have been trained by Personnel Department representatives. Specific topics other than those above included goal setting, motivation, communication, handling conflict, and performance monitoring. Essential to the understanding and acceptance of the Project have been efforts on communication and descriptions of the departmental Performance Review Boards (PRBs) where final performance evaluation decisions for employees are made.

Evaluation

To assess the Project results and evaluate the feasibility of applications to other federal organizations, evaluation efforts by OPM contract and internal evaluation groups at both Centers are underway. Coopers and Lybrand were awarded the OPM contract ($100 K with each Center paying one-fourth of the cost) and will provide their first report in September 1982. This Center's internal evaluation effort is headed by Dr. Ed Alden (Code 08203). The external evaluation effort will monitor the implementation of the Project and assess anticipated and unanticipated effects. The firm fixed price contract is for one year with four renewable options of one year for the five year evaluation period. To help isolate effects of the Project, changes at the two participating Centers will be compared with data from two other Navy labs, NADC and NSWC.

Factors as recruitment success, turnover, and Personnel Department performance will be evaluated, along with management issues of equity, motivation, satisfaction, mobility, line management flexibility/

accountability, and changes in the number of adverse actions. Attitude surveys are being conducted by both the internal and external evaluators, plus management audits, exit interviews, and other analyses involving recruitment, mobility, and sponsor satisfaction. OPM's major objectives for measuring the success of the Project include recruitment success, increased high performer retention, improved personnel function performance, and expanded performance-based pay systemization.

Benefits of Project

The Project is expected to demonstrate that a genuinely management-centered personnel administration process will lead to more efficient and effective use of the resources of the participating laboratories. In addition, by providing a means of real-world testing for models of improved and simplified classification and performance evaluation systems, the project will have results that can be applied throughout the federal service. Some examples of anticipated effects caused by the proposed changes and corresponding measures for evaluating these effects are depicted in Table 1.

Table 1.

Some Examples of Anticipated Effects Caused by the Proposed Changes, With Measures for Evaluating These Effects.

Change	*Anticipated effects*	*Evaluation measures*
Classification and pay	Increased recruitment success EEO commitment Flexibility of workload assignment Increased personnel effectiveness	Cost per recruit, recruit quality and quantity Cost, quantity and quality of recruits Time, cost of reassignments and transfers Cost, management and employee satisfaction
Performance appraisal	Correlation of pay and performance Improved EEO relations Increased employee commitment Decreased turnover of "desirable" employees Increased turnover of low performers Increased organizational effectiveness and efficiency	Perceived equity Increased retention of high performance minorities and women Satisfaction and commitment instruments Turnover rate of critical employees Turnover rate Peer, sponsor, and user evaluations, cost to conduct business
Retention	Retention of high performers Increased EEO effectiveness	Retention rates Retention rates of minorities and women
Adverse action	Increased adverse action effectiveness	Cost, rate of successful actions